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Theme session Report

Spatial management, climate change and biodiversity

Conveners: Catarina Frazão Santos (Portugal), Andrew Kenny (UK), Tundi Agardy (USA)

Rapporteur (optional): Andrew Kenny (UK)

Over the past two decades, the concept and practice of marine spatial management has spread widely around the world to promote sustainable ocean use and conservation. Formal marine spatial planning (MSP) initiatives are under development in over 70 nations and will likely keep expanding across ocean basins in the forthcoming decade. The role of other area-based management approaches to support a healthy ocean (e.g., other effective area-based conservation measures – OECMs) is also expanding around the globe.

Under a changing ocean, however, areas where human activities are most amenable under present conditions, together with conservation areas, are likely to be modified, thus challenging established marine spatial plans and sectoral area-based management tools. There will be new use-use conflicts, new environmental pressures and new legal issues. To respond to these changes and effectively support a sustainable and equitable use of the ocean, marine spatial management initiatives will need to be “climate-smart”, integrating climate-related information and foreseeing adaptation pathways, along with being “conservation smart”, truly supporting biodiversity and ecosystems health.

However, to date few of the existing marine spatial plans and sectoral area-based management tools consider climate change explicitly. This is a critical oversight in a rapidly changing world. At the same time, a new 10-year strategy for nature conservation is being negotiated as part of the United Nations Convention on Biological Diversity (CBD). The strategy requires that governments and other regulatory bodies protect and conserve at least 30% of coastal and marine areas by 2030 – the so called “30 by 30" target – to maintain healthy oceans, support ecosystem resilience against climate change, and improve food security. The CBD recognizes that both MSP initiatives and area-based fishery management measures (ABFMs) can play an important role in protecting biodiversity, and that if such benefits can be demonstrated and sustained, they have the potential to make a significant contribution to meeting the “30 by 30" target.

In this theme session, we promoted a critical debate around the multiple pathways, challenges, and benefits of ensuring a healthy and resilient ocean in the age of climate change through the development of climate-smart MSP initiatives and the implementation of ABFMs that support biodiversity. We also raised awareness among marine managers, planners, and decision-makers on the key relevance of these topics.

The following main topics were discussed:

(a) The integration of knowledge on climate change into marine spatial plans (e.g., modelling and mapping tools, risk and vulnerability analyses, sea-use scenarios); and, ways to support dynamic and flexible ocean planning and management initiatives (e.g., dynamic ocean management, anticipatory zoning, adaptive law, adaptive governance);

(b) The identification and quantification of biodiversity benefits associated to ABFMs (e.g., closures to protect essential fish habitat, vulnerable marine ecosystems, fish spawning and nursery areas); and, pathways to support effective, equitable and sustainable ocean management and governance, particularly in the context of OECMs.

Conclusions

During the session two online polls were conducted to seek views on two issues, namely; i. the degree of protection that marine protected areas should have, and ii. the integration of marine spatial planning into fishery management plans.

- With respect to the first issue the question "how protected should MPAs be, is strict protection actually more bout effective management and not necessarily about the outright exclusion of all human activities?" was asked. There were 68 responses in total to this question with 60 of them either strongly agreeing or generally agreeing with the above statement, but noting there could be some exceptions.
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- With respect to the second issue, there were 7 responses all indicating the "very high importance" of integrating fishery management plans into marine spatial management plans where they exist.

Contents

CM 11: Lyme Bay Offshore Mussel Farm – an OECM case study

Llucia Mascorda-Cabre, Phil Hosegood, Martin Attrill, Emma Sheehan

Bivalve aquaculture has traditionally been established in shallow, sheltered waters in inshore areas generating notable negative environmental impacts due to the accumulation of waste products. The recent global expansion of the offshore industry is perceived to have a lower environmental impact coupled with a higher growth potential. As ecosystem engineers, mussels can positively contribute to marine ecology through carbon storage, nutrient remediation, coastal defence and enhancing biodiversity. Hence, the development of offshore aquaculture has the potential to provide one of the most sustainable sources of protein to feed our growing population.

Since 2013, the University of Plymouth has been monitoring the UK's first large scale offshore mussel farm in Lyme Bay, UK. Using a range of underwater survey vehicles and sampling techniques, the study has been valuable in showing the farm's potential to increase ecosystem value and contribution to the production of the area. Results to date show large aggregations of benthic and pelagic organisms beneath and around mussel ropes relative to control sites. The farm is acting as a fish aggregation device (FAD), shelter, refuge, nursery, food source and creating a hard-bottom reef-like habitat in historically heavily fished ground.

Offshore mussel farms such as the Lyme Bay present the exclusion of fishing activities (mobile and static gear) from farmed grounds, which may not only provide the potential to enhance both commercial and non-commercial species producing a spill over effect but, present the prospect for benthic habitats to be restored to previous state, serving as a de facto MPAs.

As marine biodiversity continues to decline, it is paramount to reconcile nature conservation and the sustainable development of the oceans. If we want to meet international marine conservation targets such as Aichi Target 11 and Target 6 by 2030, and the SDG 2 and 14, the Blue Economy and in particular, aquaculture as the fastest growing food industry, must move forward together. In addition to no-take-zones, we need every area that protects biodiversity at any level to meet the right environmental, social and economic sustainable goals. Offshore mussel farming might be preferable to other destructive extractive activities such as trawl fishing already happening in multi-use MPAs and PPAs whilst it presents as a sustainable alternative to overfishing. With the prospective to recover damaged habitats, boost ecosystem services and provide effective *in-situ* conservation of biodiversity if effectively managed, offshore mussel farms may have the ability to become part of a wider marine conservation strategy as OECMs. With this in mind, the Lyme Bay mussel farm was used as a case study on the ICES/IUCN-CEM-FEG Workshop on testing OECM practices and strategies presenting its potential as an OECM.

Keywords: Offshore aquaculture, mussel farm, ecology, oceanography, food security, OECM, conservation

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CM 29: Requirements and availability of prey for north-eastern pacific southern resident killer whales

F. Couture, G. Oldford, V. Christensen, L. Barrett-Lennard, C. Walters

The salmon-eating Southern Resident killer whale (SRKW) (*Orcinus orca*) population currently comprises only 73 individuals, and is listed as 'endangered' under the Species at Risk Act in Canada. Recent evidence suggests that the growth of this population may be limited by food resources, especially Chinook salmon (*Oncorhynchus tshawytscha*). We present spatio-temporal bioenergetics model for SRKW in the Salish Sea and the West Coast of Vancouver Island from 1979-2020 with the objective of evaluating how changes in the abundance, age-structure, and length-at-age of Chinook salmon populations has influenced the daily food consumption of the SRKW population. Our model showed that the SRKW population has been in energetic deficit for six of the last 40 years, and that the net population growth and survivorship of the population was significantly lower in years where daily prey energetic requirements were not met. Our results also suggested that the abundance of age-4 and age-5 Chinook salmon abundances are significant predictors of energy intake for SRKW. We estimated that the annual consumption (April-October) of Chinook salmon by the whales between 1979 and 2020 ranged from 166,000 216,300. Over the past 40 years, the model estimated that the contribution in the SRKW diet of Chinook salmon originating from the Columbia River has increased by about 34%, and decreased by about 15% for Chinook salmon stocks originating from Puget Sound. Overall, our study provides an overview of the requirements and availability of prey for SRKW over the last 40 years, while supporting the hypothesis that SRKW were limited by prey abundance in the study period.

Keywords: Southern resident killer whales, bioenergetics, fish stock assessments, Chinook salmon

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CM 35: Fine-scale oceanographic drivers of pelagic biomass around a tropical coral atoll within the Chagos Archipelago Marine Protected Area

Dannielle Eager, Edward Robinson, Nataliya Stashchuk, Vasiliy Vlasenko, Benjamin J Williamson, Philip Hosegood, Clare B Embling

The Chagos Archipelago Marine Protected Area (MPA) protects 640,000 km^2 of ocean incorporating numerous seamounts, islands and atolls. This large-scale MPA aims to enhance the biodiversity within the region by removing anthropogenic activities, such as fishing, protecting an area that is home to a variety of threatened and endangered species. However, it is important to also understand the oceanographic drivers of high diversity and biomass to inform the management of the MPA. Within this study, we investigated the fine-scale oceanographic processes that promote pelagic biomass and biodiversity in the MPA. With a focus on pelagic fish distributions at Egmont Atoll, multiple *in situ* and modelled variables were measured over a repeated transect covering variable topography for 24 hours using acoustic instruments combined with oceanographic moorings. A Simrad ES70 fisheries echosounder with a combined 38/200 kHz transducer was synchronised with a Nortek Signature 100 kHz Acoustic Doppler Current Profiler to collect information on pelagic biomass and current data throughout the water column, respectively. Oceanographic moorings provided information on the water properties and alluded to more regional based processes that occur in the central Indian Ocean. Hydrodynamic model data were also derived from previous oceanographic data collected in the region over multiple cruises. Data were analysed using Generalised Linear Models with Generalised Estimating Equations (GLM-GEE). Biological response variables were used to test if oceanographic and environmental parameters were driving the distribution, abundance and behaviour of both schooling fish and individual fish targets around Egmont atoll. Fine-scale model simulations of vertical current velocities correlated with the distribution of fish biomass suggesting that fine-scale oceanographic drivers are influencing fish distributions, supported by *in situ* acoustic data. Biological aggregations were primarily located over two canyons with depths of over 400 m. Current direction in the upper 50 m of the water column determined the number of schools present whilst current magnitude and topography also played a key role influencing fish behaviour. This multidisciplinary approach identifies fine-scale oceanographic drivers of fish distribution and behaviour that promote biomass and biodiversity around tropical atolls. Understanding the environmental drivers of biota will allow us to understand the spatial variability of species which is key for informing spatial management plans for current and future MPAs.

Keywords: acoustics, pelagic biomass, oceanography, fish, Chagos Archipelago, Indian Ocean

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CM 40: Jointly modelling Atlantic bottlenose dolphin distributions and prey species: evidence of strong ties to drumming prey species and temperature

First author: Sarah M Roberts

Co-authors: Ann-Marie Jacoby, Patrick Halpin, Andrew Read, Janet Nye

Understanding the distribution and abundance of marine organisms is a fundamental question in ecology and essential for effective management of mobile upper-trophic-level species that face a variety of anthropogenic threats including noise, ship strikes, bycatch, and climate change. Current work in the North Atlantic has largely focused on modeling the distribution and abundance of upper-trophic-level species, such as marine mammals, in relation to a suite of environmental variables. However, biotic interactions can largely drive distributions of predators. Using a joint modeling approach, we assess how the distribution of a common top predator, the bottlenose dolphin, is influenced by both the environment and known prey species. We find that, regionally, dolphin distributions are largely associated with temperature and one family of fishes, the Sciaenidae, or drumming fishes. This tight coupling of dolphins with temperature and drumming prey is essential for predicting dolphin responses to ocean changes – from ensuing ocean warming to increased offshore wind infrastructure. For example, the many offshore wind farms proposed within the range of dolphins in the Northwest Atlantic may change the distribution of key prey species, either through disrupting their migration routes or acting as a pseudo fish aggregating device as has been documented in the Northeast Atlantic, which will ultimately influence the distributions of their predators. This joint modeling approach can be further used to understand the relative contributions of both biotic and abiotic factors on the distributions of multiple marine predators from sharks to seabirds to marine mammals.

Keywords: Joint species distribution models, predator-prey models, climate change, marine ecology.

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CM 49: Can High-Seas Fisheries Closures Qualify as Other Effective Conservation Areas?

Andrew Kenny, Ellen Kenchington, Anna Downie[a], Mar Sacau[c]

The Northwest Atlantic Fisheries Organization (NAFO), in line with other Regional Fisheries Management Organisations (RFMOs), has the responsibility for managing fisheries to promote the long-term conservation and sustainable use of the fishery resources in the high seas within its Regulatory Area of operation. NAFO is also committed, as set out in its Convention, to apply an ecosystem approach to fisheries management that includes "safeguarding the marine environment, conserving its marine biodiversity, minimising the risk of long term or irreversible adverse effects of fishing activities, and taking account of the relationship between all complements of the ecosystem".

In order to achieve this commitment, and in response to the United Nations General Assembly Resolution 61/105, NAFO has established a number of fishery closures to protect Vulnerable Marine Ecosystems from the impacts of bottom trawling activities. In particular, several deep-sea closures protecting large sponges (*Geodia* sp.) have been implemented which are estimated to protect >90% of the large sponge biomass found within the fishing footprint of the NAFO Regulatory Area.

Large sponge VME in NAFO has been extensively mapped and studied to better understand its functional significance and the biodiversity benefits it provides, such as water quality and production functions, and providing important habitat for fish. This together with the strict management control and exclusion of bottom fishing activities makes the sponge VME fishery closures an ideal candidate to be considered for OECM designation.

What are the benefits of achieving OECM protected status? - The Convention on Biodiversity (CBD) Decision 14/8, adopted in 2018, is the foundational document for OECMs. An OECM is 'a geographically defined area which is governed and managed in ways that achieve positive and **sustained long-term outcomes** for the in-situ conservation of biodiversity, with associated ecosystem functions and services and where applicable, cultural, spiritual, socio–economic, and other locally relevant values". In the context of VME fishery closures the primary benefit is in recognising a **long-term** commitment to protect the site by maintaining an appropriate level of enforcement and management of the site. In addition, OECM status provides a level of recognition of the site's importance beyond the jurisdiction (and sectoral interests) of NAFO. It contributes to area-based targets which CBD State Parties are required to achieve under Aichi Target 11 and in the case of NAFO would help ensure the protection of sites from activities other than bottom fishing, such as oil and gas exploration and production activities, which are also operating in the area.

Keywords: Biodiversity, protection, fisheries, conservation, management, spatial.

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CM 54: Deep-sea silver scabbardfish Lepidopus caudatus ecology, biology, and fisheries in the Azores

Gloria Mariño-Briceño, Ualerson Iran Peixoto, Wendell Medeiros–Leal, Mário Pinho, Régis Santos

The deep-sea fisheries are of important economic value even though the deep-sea species are of very low productivity. Because of this, it is necessary to generate biologically and ecologically based fishing plans to make this fishery sustainable in time. The species of interest in this study is the silver scabbardfish (*Lepidopus caudatus*), a demersal fish that lives in temperate seas around the world on the continental shelf and the slope from 100 m up to 600 m deep. This species is captured by Azorean demersal fisheries using hook and lines, valued at 0,5 M € on average per year. Despite this, the scientific knowledge on biological and ecological traits, as well as the current stock status of the Azorean population are limited. The biological and ecological traits of *Lepidopus caudatus* were studied using collected data from surveys across the Azorean waters (1996-2019), commercial catches (1990-2017) and official commercial landings (1985-2020). The aim of this work was to explore survey and fishery-dependent data to determine biological and ecological characteristics of the silver scabbardfish in the Azorean waters. The aspects studied include the (1) spatial distribution, (2) size structure, (3) growth parameters and (4) mortality rates. Our results show the size and depth range in which the species was observed: 25-198 cm fork length and 50-1000 m depth. This species showed relatively large sizes, slow growth, and low natural mortality rate, indicating high vulnerability to overfishing. As a result, conservation and fisheries management measures should be implemented to ensure the sustainability of the resource.

Keywords: fisheries, ecology, deep sea, silver scabbardfish

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CM 58: Developing a subseasonal forecasting tool to reduce fisheries bycatch in the Northeast US

Kelsey E. Roberts[1], Julia E.F. Stepanuk[2], Lesley H. Thorne[1], Hyemi Kim[1], Carolina Chong-Montenegro[3], and Janet A. Nye[4,1]

Climate change is causing significant alterations in the distributions and interactions of species in the world's oceans. In light of such broad changes, managers and stakeholders require accurate information on the consequences of environmental changes for habitats and species in order to pursue sustainable harvests or design effective conservation measures. For fisheries management in particular, this involves a substantial, data-intensive effort to both quantify the biophysical links driving species distributions and develop predictive tools that can be adjusted based on environmental conditions. Nontarget catch, or bycatch, can have numerous and potentially severe economic and ecological consequences. Combining species distribution models with oceanographic forecasts could provide commercial fisheries with a proactive tool for reducing nontarget catches. Here, we focus on a population of anadromous fish known collectively as river herring (alewife and blueback herring), as they have subsequently declined dramatically over the past several decades and are known to be at high risk of bycatch. Using bottom trawl survey data and subseasonal forecasts of sea surface temperature, we constructed a bycatch risk model to generate probabilistic predictions of river herring distributions within the mid-water trawl fishery territory. Assessment of model skill shows that our model does a good job at predicting the biological response of river herring and the forecasts are effective at 1- and 2-week timeframes. Results show a clear seasonal change in forecasted bycatch risk throughout the Northeast US region, with risk potential especially high in winter months. Most importantly, we highlight that variability in risk is detectable at the weekly timescale and our model can distinguish specific areas and times that fishers should avoid in order to decrease their likelihood of bycatch. Understanding and predicting seasonal distributions of living marine resources in the Northeast US is critical as this ecosystem has experienced some of the highest rates of warming in the last few decades. The developed bycatch risk tool can therefore be used in tandem with existing management strategies to keep mid-water trawl fisheries below bycatch thresholds and boost resiliency in river herring populations.

Key words: distribution modeling, generalized additive models, river herring, bycatch, subseasonal forecasts, dynamic management

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CM 96: Vulnerability Analysis of the Western Baltic Small-Scale Fishery

Vanessa Steinweg, Marie-Catherine Riekhof, Heike Schwermer, Daniel Unverricht, Rüdiger Voss

Many economies and communities are dependent on fisheries for nutrition, income and also socialcultural. Climate change and its associated impacts are altering the productivity of aquatic ecosystems. The fisheries sector of the Western Baltic Sea (WBS) is already facing some of climate change associated impacts as well as multiple socio-economic drivers of change like shifts in market access, management frameworks and demographics. To examine these changes in detail, our work focuses explicitly on the example of the WBS and its small-scale fisheries (SSF).

We conducted a vulnerability analysis focussing on the near-coast districts of Schleswig-Holstein (SH) and Mecklenburg-Vorpommern (MV). Our analysis is based on freely available fishery data (e.g., landings by area, number of fishing boats) and socio-economic data (e.g., GDP, tourist overnight stays) within a time frame from 1990-2019.

To get a holistic view of the situation of the Western Baltic Sea we have included different stakeholders and their multiple knowledge. The panel of stakeholders consisted of participants from various groups such as fisheries, eNGO and administration. Beyond that an algorithm-based analysis of the compiled indicators was carried out to analyze which of the compiled indicators have a strong influence on developments in Western Baltic SSF.

The aim is to investigate which regions of the Western Baltic SSF are particularly vulnerable or adaptive to the ongoing changing conditions (e.g., climate change, management frameworks, demographics). Spatial vulnerabilities are visualized as *Vulnerability Index* using a GIS-based approach. Our results show that the *Vulnerability Indexes* fluctuate over time but are ranging currently at a high level for the area studied. Some regions like Nordwestmecklenburg (MV) and Rendsburg-Eckernförde (SH) could be identified as particularly vulnerable in recent years.

Our comprehensive analysis shows that the SSF is distributed differently in the coastal regions, being more adaptable near tourist hotspots with direct marketing having a positive effect. Furthermore, two possible future scenarios of the Western Baltic SSF for the years 2025 and 2035 will be calculated and discussed. From that conclusions for local management approaches will be drawn in order to support policy in guiding the Western Baltic SSF into a sustainable future.

Keywords: Western Baltic Sea, small-scale-fishery, vulnerability analysis, fisheries management

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CM 127: An ecological assessment to determine Vulnerability of the Portuguese Fisheries to climate change

Francisco Leitão1; Juan Bueno-Pardo2; Marta Albo-Puigserver[1], Fernando Cánovas3, Miguel Pinto[1], Maria A. Teodósio[1]

The structure of all marine communities varies in space and time in response to many physical and biological factors, and the extent to which these different factors influence ecosystem function is one of the fundamental issues of ecosystem ecology and coastal fisheries. The concern about climate change (CC) in marine fisheries is growing, but it would be a mistake to conclude that the effects of fishing are, therefore, less important. Using exposure, sensibility, and adaptability dimension we estimate the vulnerability of commercial species to CC across three distinguished oceanographic regions of the Portuguese coast (north, centre and south). The latter dimensions include the use of ecological traits and other fishery information (stock status, fishing pressure, etc.) to determine each species ecological vulnerability score. Based on species vulnerability information we estimate the effect of CC in fishing sectors and estimated the likely changes in landings and economic revenues due to CC. The 74 species considered are responsible for 95, 70 and 70% of the seine, trawling and artisanal fishing. Most of the species, including bivalves, cephalopods, crustaceans, fish and sharks taxa, were ranked with low, very-low and moderate vulnerability to CC predictions (2040-2060 period for RCP4.5 and RCP8.5) with exception of three species that were high vulnerable regardless of the coastal region: *Palinurus elephans*; *Anguilla anguilla*; *Squallus acanthias*. The fishing fleet vulnerability, based on ecological results, were low regardless of the gears or regions. Nevertheless, CC will impact less on trawling landings than in purse seine and artisanal fleet. The high vulnerability found in multi-gear fleet landings was compensated by diversification of the species caught. Purse-seine also record a low vulnerability of the landings but presented a high fishery dependence on a single species. The results highlight the importance of combining ecological vulnerability with fishing gear landing catch composition (target fisheries Vs multispecies fisheries) for species/fishing prioritization aiming adaptation plans under CC. Overall, CC will negatively affect landings (3.7 to 7%) and economic revenues (3.7-5.7%) of fish landings, but these impacts are expected to be minimum when considering intra-annual variability induced changes recorded in past period (2000-2019).

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Keywords: ecological vulnerability, fisheries impact; climate change, fisheries management, fishing communities, governance, adaptive capacity

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CM 128: Socio-economic vulnerability assessment of Portuguese fisheries to climate change

Miguel Pinto[1], Marta Albo-Puigserver[1], Juan Bueno-Pardo[2], Maria A. Teodósio[1], Francisco Leitão[1]

Understanding regional, ecological, and socio-economic vulnerabilities is a crucial step to develop and implement adaptation strategies aiming to enhance the resilience of marine resources and fishing communities to changes in the environment and increase quality of life. This requires the need to assess ecological and socioeconomic vulnerability at local level to develop adaptation plans to each region. The Portuguese coast is a transition zone between colder waters in the north and temperate sub-tropical waters in the south, with clear 3 distinct oceanographic regions (North, Centre, south). These conditions lead to a very high diversity of commercial species distributed differently across these regions which are caught mostly by small-scale coastal fisheries. Socio-economic realities are also different within the fishing communities along the Portuguese coast, with different levels of fishing dependency varying across ports. To account for all the specific characteristics of each fishing community and evaluate its resilience capacity to the impacts of climate change, we assess the climate vulnerability of 17 coastal ports, covering Portuguese fishing communities from north to south. We developed socio-economic and ecological indicators to measure the exposure, sensitivity, and adaptive capacity of fishing vulnerability to Climate Change by combining i) environmental projections ii) information from fishing communities (enquiries at ports) along the Portuguese coast iii) indirect data, including landings and socio-economic data from official statistics offices. Differences in vulnerability across regions were associated with fishing gear types (trawl, purse-seine or multi-gear). In terms of exposure the ports in the south presented a higher exposure while for sensitivity and adaptive capacity no clear pattern was observed from North to South. High household economic and cultural dependence in fishing was observed in all ports which contributed greatly to vulnerability to Climate Change. The willingness to passively adapt and change capture composition due to Climate Change was higher than the possibility of changing gears. The results of our study identify key vulnerability aspects of the Portuguese fisheries at local level and for each fishing sector. Such information will enable fishing communities and decision makers to respond in a timely manner to changes in the environment caused by Climate Change, developing inclusive adaptation measures and improving the resilience of the marine socio-ecological system in Portugal.

Keywords: Socio-economic vulnerability, resilience, regional vulnerability, climate change, fisheries management, fishing communities, governance, adaptive capacity

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CM 137: Retrospective forecasting of seasonal spatiotemporal dynamics to identify bycatch hotspots in the yellowtail flounder fishery on the Grand Banks

First author: Alessandra Gentile

Co-author: Jin Gao

Bycatch is the incidental catch of non-target species and is a long-standing and common problem in commercial fisheries. Bycatch inflicts unnecessary mortalities effecting ecosystem balance and potential economic loss. An economically important bottom trawl fishery with bycatch is the commercial yellowtail flounder fishery on the Grand Banks of Newfoundland. Short-term species distribution forecasts are a proven way to mitigate bycatch by identifying distribution hotspot thus inform fishery practices. Including habitat variables has proven to be informative to predict the distribution for demersal fish. We create a multi-species vector auto-regressive spatio-temporal model (VAST) model to retrospective forecast 1-,2-, 3-, 4-, and 5- year seasonal dynamic bycatch hotspots for the yellowtail flounder fishery and respective bycatch species (cod, witch flounder and American plaice). We find that adding habitat covariates (temperature, depth and substrate type) to the model improves the short-term seasonal forecasts in this region to identify dynamic bycatch hotspots. Thus, this model may be forecasted to increase the efficiency of the yellowtail flounder fishery leading to more sustainable fishing practices.

Keywords: distribution shifts, short-term forecast, spatio-temporal model, bycatch hotspot, yellowtail flounder, Grand Banks

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CM 155: Exploration of life cycle spatial distribution and dependencies of the European hake in the Gulf of Lion, Western Mediterranean Sea

Stéphanie C. Hopkins, Sigrid Lehuta, Stéphanie Mahevas, Sandrine Vaz

Several seasonal spatial closures have been proposed to speed up the effect of recovery on European hake in the Gulf of Lion, whose stock is considered collapsed, through focusing on protection areas of hake juvenile and spawner concentrations. However, one of the greatest limitations in assessing the effects of fisheries management tools on the hake stock for the region, is also shared across the entire range of the Western Mediterranean Sea. This is the lack of in-depth knowledge of its population dynamics. Often models used to evaluate the effectiveness of management measures on the population, have therefore relied on historic trends, which often require ambiguous hypotheses and assumptions, in order to project future stock levels. While these models are still quite useful in assessing effort related management effects on hake population biomass, more robust knowledge of spatial-temporal population dynamics are yet needed in order to identify future closure areas.
Based on various datasets, we identify and test several ecological hypotheses on hake population demographic structure in the Gulf of Lion, such as spawner canyon dependencies with uniform distributions throughout the region, and the aggregation of juveniles along riverine marine interfaces. We investigate the dispersal range and distribution of juvenile, and adult age-classes, via the analysis of capture recapture experimental data and scientific survey datasets, while further exploring population age density patterns with logbook and VMS data that has been standardised and validated via commercial category analyses. Investigation of the external forcing that may lead to these patterns, through the exploration of local environmental conditions, such as temperature and Mediterranean Oscillation Indices (MOI), and habitat structuring, such as proximity to river outputs, sedimentation characterisation, and circulation patterns are also conducted. This gained understanding in the overall functioning of the hake population in the Gulf of Lion will eventually serve as a basis to structure future spatially explicit stock management models, and better assess future spatial management by the means of closure areas or selectivity.

Keywords: habitat structuring, population recovery, spatially explicit modelling, life cycle spatial dependencies, mapping population density distributions.

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CM 157: Other Effective Area-Based Conservation Measures and the North-East Atlantic Fisheries Commission - science needs

Gunnstein Bakke[1], Darius A. Campbell[2], Andrew Kenny[3]

The presentation will highlight the interactions between science and policy in the practical implementation of area-based conservation in the marine environment. How can evidence be provided to help understand how existing area-based fisheries measures in the high seas match up to the criteria set out by the Convention on Biodiversity (CBD) for Other Effective Area-based Conservation Measures (OECMs). OECMs are designations that provide benefits similar to those aimed at by Marine Protected Areas (MPAs).

The area-based measures in this case are those established under the North-East Atlantic Fisheries Commission (NEAFC). NEAFC is a regional fisheries management organization. It adopts management and control measures for various fish stocks as well as measures to protect other parts of the marine ecosystem from potentially negative impacts from fisheries.

In 2021 NEAFC set up a process to see how relevant NEAFC area-based measures correlate to the concepts of OECMs and MPAs. The existing measures include those based on protection of Vulnerable Marine Ecosystems (e.g. sponges and corals) from bottom contact fisheries, as well as area-based measures such as those protecting spawning grounds or juvenile fish (i.e. Rockall haddock).

The presentation will outline the potential policy questions that arise, and the evidence needs related to these. These questions include:

Overlap between OECMs and MPAs: CBD expects no double counting of the total areas of OECM and MPA. While there is the simple issue of avoiding double counting of areas looked at in 2-dimensions, complexities exist in the 3-dimensional realities of oceans, with seabed and water column designations and differing measures protecting differing elements of biodiversity. Apart from the policy questions, science questions arise on how the protections in seabed ecosystems and in the water column ecosystems may interact, including what may be considered a significant link or interaction in the differing biogeographic regions.

The long-term nature of measures: some fisheries measures may be in place for decades rather than in perpetuity. Is there evidence in some cases for 'irreversible' ecosystem or biodiversity benefits of any long term - but ultimately time limited - measures?

Effectiveness; the level of evidence of protection and recovery: The effectiveness of measures in fisheries are often assessed in terms of the impacts of the activity through monitoring and enforcing compliance. What evidence and degree of confidence can be attributed to biodiversity benefits by extrapolation of such enforced measures? What is the likely (minimal) biodiversity monitoring required to substantiate such evidence?

Keywords: fisheries management, Other Effective Area-based Conservation Measures, OECM, MPA, regional fisheries management organisation, RFMO; vulnerable marine ecosystems, VME.

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CM 161: Consequences of model assumptions when projecting habitat suitability: a caution of forecasting uncertainties

Cameron Hodgdon, Mackenzie Mazur, Kevin Friedland, Nathan Willse, Yong Chen

Climate change is continuing to influence spatial shifts of many marine species by causing changes to their respective habitats. Habitat suitability as a function of changing environmental parameters is a common method of mapping these changes in habitat over time. The types of models used for this process (e.g. bioclimate models) can be used for projecting habitat if appropriate forecasted environmental data are used. However, the input data for this process must be carefully selected as less reliable results can incite mis-management. Using American lobster (*Homarus americanus*) of the Gulf of Maine as a case study, this research elaborates on how choice of extrapolation data, spatial scale, environmental parameters, and appropriate subsetting of the population based on life history are key factors in determining appropriate biological realism necessary for robust bioclimate model forecasts. This research highlights the need for appropriate understanding of biological realism as it is shown that false assumptions can lead to habitat forecasts that appear reliable, but are in fact unrealistic. We expand upon these effects in the context of fisheries management and discuss both how this process is exacerbated by climate change and how these effects may be mitigated. Ultimately, we conclude that greater lack of ecosystem/species knowledge raises the inherent risks of false spatial management of marine species.

Keywords: habitat suitability index, bioclimate modelling, spatial forecasting, data input assumptions, data uncertainty

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CM 167: Future projections of suitable habitat for vulnerable species and commercial fish around north western Europe

Bryony Townhill, Elena Couce, Jonathan Tinker, Susan Kay, John Pinnegar

Future climate change is expected to result in shifts to distributions of marine organisms, including vulnerable species and commercial fish. We ran an ensemble of species distribution models using downscaled climate projections for different climate change scenarios, with a focus on the north-west European shelf. This provides projections of the future suitable habitat for 21 vulnerable and protected species, and 49 species of commercially valuable fish and shellfish. Of the fish species examined, around half were projected to have consistently more suitable habitat in the future, and for the rest the seas will become less suitable. Of the vulnerable species, which included biogenic reef-building species and ecosystem engineers, decreases in suitable habitat were seen in some sensitive invertebrate species, while for some other species, the models showed an increase in suitable habitat. The increases tended to be in the north and central North Sea, with decreases in suitable habitat in the English Channel and the Irish Sea. These modelling studies tell us which areas may continue to be suitable for certain designated features (species or habitats) in the future, or which may support commercial fisheries. Slow-growing benthic species are particularly vulnerable to trawling, dredging and other fishing activities that disturb the seabed, and as such are often designated for protection within closed areas. By modelling a timeseries into the future, it's possible to assess whether existing human activities create barriers to movement, and whether existing spatial management provides the necessary habitat for movement or whether more protection is required. This information is crucial to ensure that spatial management measures have longevity and remain relevant to the species or habitat that may be present in the future.

Keywords: climate change, bioclimate envelope, protection, modelling

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CM 171: Taking urgent action to combat climate change and its impacts through marine Area-Based Management Tools

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This study explores the contributions of Area-Based Management Tools (ABMTs) to the achievement of Sustainable Development Goal (SDG) 13 "Taking urgent action to combat climate change and its impacts" as set out under the United Nations 2030 Agenda for Sustainable Development. ABMTs are spatial instruments for conservation and managing different forms of ocean use. A multitude of ABMTs exists in marine areas within and beyond national jurisdiction, ranging from tools for the regulation of specific human activities (e.g. fisheries, shipping, or mining) to cross-sectoral tools (e.g. such as marine protected areas, MPAs, and marine spatial planning, MSP). By applying expert elicitation and reviewing scientific and grey literature we evaluate the contribution of ABMTs to SDG 13 and to the other SDGs, including SDG 14 that directly addresses the conservation and sustainable use of oceans, seas, and marine resources. We find that several ABMTs can significantly contribute towards combating climate change and its impacts, and minimizing and address the impacts of ocean acidification (SDG target 14.3). For instance, the adaptive management of fishery closures and spatially-based rights towards climate-induced shifts of fish stocks can promote long-term resource stewardship. Targeting climate refugia to identify new marine MPAs is also a promising action to improve ecosystem resilience and to adapt to the effects of climate change. Moreover, there is high complementarity and synergy among different ABMTs for most SDG 14 targets and other SDGs, with the exception of SDG target 14.6 "Prohibit fisheries subsidies" and SDG 7 "Affordable and clean energy". Context-specific factors that relate to political and legal factors, enforceability, transparency, governance structure, and inclusivity are crucial for unlocking the full potential of ABMTs of attaining multiple SDGs, as shown through examples. The major challenge to face in the next decade is ensuring durable and equitable outcomes from ABMT implementation by coordinating ABMT initiatives established by different organisations and responsible authorities. It is also critical that outcomes are monitored and evaluated across environmental, social, economic, governance, and health dimensions, with indicators addressing management effectiveness towards adaptation and mitigation of climate-induced effects.

Keywords: Area-based management, climate change adaptation and mitigation, ocean governance, cooperation mechanisms, areas beyond national jurisdiction, biodiversity conservation, sustainable development, marine/maritime spatial planning, other effective area-based conservation measures.

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CM 198: Improved transdisciplinary science for effective ecosystem-based maritime spatial planning and conservation in European Seas - MarinePlan

Vanessa Stelzenmüller*, Stefan Neuenfeld, Ibon Galparsoro, Stelios Katsanevakis, Wesley Flannery, Michael Eliott, Jeroen Steenbeek, GerJan Piet, Simonetta Fraschetti

One of today's most pressing challenges is to halt the loss of biodiversity and ecosystem functions, while simultaneously ensuring ecosystem services from which society obtains goods and benefits provided by marine ecosystems. In Europe, Maritime Spatial Planning (MSP) is the main governance process that aims to allow and integrate sustainable activities with marine conservation measures. This requires knowledge acquisition and the adoption of processes to support marine protected area (MPA) designation into a MSP framework, considering connectivity among individual MPAs (network), and requiring transboundary coordination. Herewith we would like to introduce the newly funded EU project MarinePlan, which will co-develop with stakeholders of eight archetypal European planning sites, a Decision Support System (DSS) for ecosystem-based maritime spatial planning (EB-MSP). The MarinePlan planning sites vary from coastal ecosystems to open ocean and the deep sea, across local to trans-boundary scales. These sites represent a wide range of MSP processes, in terms of scale, purpose of designated MPAs, major threats locally affecting marine-coastal biodiversity and the most important ecosystem services and societal benefits. A central piece of the MarinePlan DSS will be an EB-MSP process template that will guide the assessment of ecological and socio-economic system attributes and potential risks of biodiversity loss. The DSS embraces operational criteria for ecologically or biologically significant marine areas (EBSA), enabling the designation of conservation and restoration areas at various scales in complex marine areas with multiple uses, while accommodating the effects of climate change. EBSA criteria will address dispersal and movement corridors of different life stages (i.e. structural and functional connectivity) as well as biodiversity and/or productivity hot spots. Through an adaptive co-development process, MarinePlan will evaluate existing governance settings, recommend adaptations to foster EB-MSP, and identify pathways for transdisciplinary knowledge to support integrated planning. The DSS will also encompass tools for prioritization and integrated planning to develop future scenarios and planning options, and to enable transparent tradeoff analyses. Applying the DSS will enable consideration of realistic planning scenarios, thereby creating key actions to achieve the EU Biodiversity Strategy, and policy recommendations to enhance EB-MSP implementations in European Seas. Results will be presented to decision-makers at horizontal (between sectors) and vertical (from local to European) levels to enable the transfer of knowledge to areas in differing socio-ecological settings. MarinePlan puts emphasis on communication and will therefore adopt and further develop an immersive and model-driven underwater visualization environment (OceanViz). The improved natural and social science base will enable more effective policy making and a greater coherence in implementing environmental policies and planning for maritime sectors.

Keywords: co-development, conservation and restoration measures, cumulative impacts, Decision Support System, ecologically or biologically significant marine areas (EBSA), integrated planning, trade-offs, scenarios, visualization

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CM 248: Spatial and temporal variability of meroplankton transport with Atlantic waters to the Arctic during present climate change

Weronika Patuła, Sławomir Kwaśniewski, Marta Ronowicz, Piotr Kukliński, Anna Olszewska, Agata Weydmann

The occurrence and composition of meroplankton reflect the ongoing climate changes in the polar regions, as environmental conditions (e.g., temperature, salinity) influence larval development, impact their settlement success, and colonization of new areas by affecting benthic invertebrates distribution and survival. West Spitsbergen Shelf is a good model system to study changes in ecosystems driven by accelerated warming, because of presence in the area of water masses from different currents, carrying warm and salty Atlantic Waters, and cold and fresher Arctic Waters. Our aim was to investigate the temporal and spatial distribution of meroplankton and their variability in the West Spitsbergen Current (WSC), which is the main conduit of Atlantic waters to the Arctic and can be used as a model system under the pressure of rapid climate change. Our goal was to answer the following questions (1) were there changes in spatial and temporal variability in meroplankton transport in the WSC during the observation period and (2) were there changes in composition and abundance of meroplankton along the environmental gradient in the WSC? To answer those questions, we used a unique dataset on meroplankton composition which was obtained from several summer stations situated in the WSC between 74 to 77 °N, on which meroplankton was collected with WP-2 net from 200-0 m layer between 2001 and 2014. Data were analyzed with the use of multivariate statistical methods, which allowed us to trace meroplankton diversity during the recent rapid climate change and to critically look at their role in the Arctic ecosystem.

Keywords: Atlantification, meroplankton, West Spitsbergen Current, time-series changes, Svalbard Archipelago

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CM 344: Ocean planning in polar regions: A way forward

David Santos, Rui Rosa, Renuka Badhe, Charles Ehler, Susie Grant, Kevin Hughes, Anton Van de Putte, José Xavier, Catarina Frazão Santos

The Arctic and Antarctic regions are two of the Earth's most unique places, both enshrining a range of environmental, scientific, historic, and intrinsic values that need to be protected. With the acceleration of global environmental change, and the increase of human activities and related pressures in these regions, developing sustainable marine spatial planning planning (MSP) and governance processes is crucial. Several studies have addressed the benefits and challenges of developing MSP in polar regions. However, and despite MSP global acceptance, no formal MSP initiatives are envisioned for the Antarctic and Southern Ocean. Concomitantly, while benefits of developing sustainable MSP have been recognized for the Arctic Ocean, a much needed "Pan-Arctic" MSP initiative is still to be developed. This is a critical oversight in a rapidly changing world.

The present study analyses and discusses how to support the development and implementation of sustainable, ecosystem-based, climate-smart marine spatial planning (MSP) initiatives in Polar regions. More specifically, it does so by (1) investigating the existing MSP initiatives and governance mechanisms for the Arctic and the Antarctic; (2) identifying the main challenges, issues, and constraints related to such initiatives; and (3) pinpointing a set of recommendations to overcome identified challenges and support a sustainable use of the ocean in polar regions supported by MSP mechanisms, especially under a changing climate. The study builds on a global survey conducted online, specifically on MSP and Polar Regions, which collected over 200 responses from c. 31 countries. Overall, survey respondents were very knowledgeable about the Arctic and the Antarctic, but less familiar with the concept of MSP. Results highlight that the most identified human pressures and challenges in these regions pertained to climate change and the loss of ice-dependent species, followed by new navigation routes and the demand for new conservation areas. As for respondents' knowledge on MSP initiatives applicable to the Arctic and the Antarctic, a number of initiatives were identified, although many did not correspond to actual marine spatial plans. The most identified challenge for the development of MSP initiatives in polar regions pertained to realpolitik factors, followed by the integration of social and cultural dimensions, or access to monitoring and evaluation tools. At the same time, the Antarctic Treaty System has been considered as a successful example of international governance. Nevertheless, to respond to climate change and the increasing demand for economic development, new specific goals and objectives need to be established.

Keywords: marine spatial planning, polar regions, Arctic, Antarctic, ocean sustainability, ocean governance, climate change.

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CM 438: Management for sustainable cephalopod fisheries in Europe: what are the options?

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Although cephalopod fisheries are of world-wide importance, in Europe, because cephalopods are not quota species under the EU's Common Fisheries Policy, there is currently no requirement for assessment or management at European level. Small-scale fisheries for cephalopods are regulated at national/regional level but even in these cases there is usually no routine assessment. Given increasing interest in targeting cephalopods in Europe, there is a risk that they will be fished unsustainably. Although there have been recent review papers on progress in stock assessment and fishery forecasting for commercially fished cephalopods there has been no recent review of cephalopod fishery management. We aim to fill this gap, with a particular focus on European cephalopod fisheries.

Cephalopods present particular challenges: they are short-lived, fast-growing and highly sensitive to environmental conditions (as individuals and as populations). Abundances fluctuate widely from year to year and climate change is likely to result in range shifts. In addition, stock structure is not well-understood - many species are migratory during at least some part of their life, although more spatial structuring is expected in the less mobile species.

We review potential barriers to sustainable fishing and reasons why management of cephalopod fisheries differs from that for finfish fisheries, e.g. due to the high inherent volatility and the possibly cyclic nature of year-to-year variation in cephalopod abundance, reflecting their short lifespan, rapid growth and high sensitivity to environmental conditions. We review fishery management approaches in important cephalopod fisheries worldwide (e.g. in the USA, Japan, Falklands, South Africa and Australia) and current management of small-scale cephalopod fisheries in Europe. We identify knowledge gaps and limitations to current monitoring programmes and stock assessments and discuss the options available for cephalopod fishery management in Europe, considering the suitability or otherwise of catch and effort limits, use of closed areas and seasons, restrictions on sizes caught and types of fishing gear, and the ole of market-based sustainability pathways.

Keywords: cephalopod, fishery, management, climate, spatial structure

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CM 348: Distribution of demersal species and their hot spots of aggregation in the Adriatic Sea under climate change

Diego Panzeri, Simone Libralato

Under a global and climatic changes, support management and conservation of marine ecosystem by mapping biodiversity and hot spot of aggregation of marine species now and in the future, is crucial. Many of these projections are based on species distribution models (SMDs), that have the potential to integrate species monitoring with oceanographic variables and other factors to best predict areas of aggregation of key stages for optimal management. This work aims at identifying the hot-spot areas in the Adriatic and Western Ionian Sea (Geographical Sub Areas 17, 18 and 19 of the Mediterranean Sea) for adult and juvenile stages of 10 marine demersal species, i.e., European hake, red mullet, Norway lobster, European horse mackerel, anglerfish, deep rose shrimp, common sole, common cuttlefish, Southern squid, mantis shrimp. The identification of key species-specific areas of aggregation is based on average distribution of species as determined through an ensemble of Species Distribution Models (e-SDM) applied to trawl survey data of the last decades. Data derive from Mediterranean International trawl survey (MEDITS) and from the beam trawl survey Sole Monitoring (SOLEMON), were combined with relevant oceanographic and biogeochemical variables from the operational physical-biogeochemical model for the Mediterranean Sea (OGSTM-BFM) (depth, temperature, salinity, chlorophyll-a, dissolved nutrients, particulate organic carbon, oxygen, pH). A training and testing procedure was applied to estimate the best model ensemble using past observations from 1999 to 2018. Successively the model ensemble was used to project SDM over a near and a far future periods using OGSTM-BFM under RCP 8.5 climatic conditions. The hot spots of aggregation in the current (1999-2018) and future periods (2031 to 2035; 2046 to 2050) were determined for each specie and stage using the Getis-Ord Gi* statistics applied to results of the e-SDM. Results allowed to evaluate modification of the distribution of each species synthesized by the center of gravity of the e-SDM maps, the areas where species will likely disappear as well as areas of new colonization. Analysis of areas of the domain are quite stable to climatic change (cumulative or by species) are suggested for classical spatial management, while hot spots in new colonized areas support dynamic spatial measures. Our results can be important and useful to improve and support the spatial management of the area under present and future scenario.

Keywords: species distribution models, ensemble model, oceanographic variables, management, climate change, hot spot.

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CM 367: Environmental effects on assemblages and biological characteristic of demersal community in the Flemish Cap

Krerkkrai Songin, Fran Saborido-Rey, Graham Pierce

Demersal species have been found to be spatially and temporally affected by their environment regarding their distribution and life history. The Flemish Cap seamount is inhabited by multiple species with diverse habitat preferences and ecological roles, but their assemblage zones and environmental associations have not been thoroughly defined. This study describes relationship between demersal assemblages, biological characteristic and environmental variables in the Flemish Cap. Groups of 28 demersal species and their assemblage zones based on species biomass and abundance distribution are classified using hierarchical cluster analysis. The spatial association between the assemblages and environmental variables, including depth, bottom temperature, surface temperature, salinity and chlorophyll concentration is investigated through canonical correlation analysis. The environmental effect on biological characteristic of 7 main species is observed through multiple linear regression (MLR) models using 27 years time series data. Average Fulton´s condition factor is treated as dependent variable while average oceanographical conditions in two seasons being independent variables. For the results, species groups and assemblage zones are defined by both biomass and abundance distribution. Member species within groups classified by biomass differ from those that defined using abundance as criteria. The zones classifications are also significantly variated by the different criteria used, as observed through the allocation of sampling locations among clusters. Significant canonical correlations are presented between environmental conditions and species assemblages across all 5 dimensions with depth being the most prevalent factor on the distribution in the first dimension. Other variables have increase contribution to the correlation in other dimensions. Significant MLR models present in all 7 main species with different magnitude of variant explainability and significant independent variables. The highest explainability model is *S. norvegicus*, having the adjust R^2 of 0.66 while the lowest adjust R^2 (0.14) is found in *R. hippoglossoides* model. Salinity, chlorophyll concentration and bottom temperature in July are most consistently present across MLR models. In conclusion, demersal assemblage is not homogenous across the seamount and can be classified into zones. Assemblages are correlated to environmental conditions. Temporal environmental effect can be observed on biological characteristic. This information should be taken into consideration for spatial management, especially with the context of climate variability.

Keywords: spatial ecology, North Atlantic, environmental effects, cluster, canonical correlation, multiple linear model.

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CM 383: Global perceptions on the need for climate-smart marine spatial planning

Catarina Frazão Santos, Tundi Agardy, Francisco Andrade, Diogo Caeiro, Helena Calado, Sara García-Morales, Elena Gissi, Michael Orbach, Rui Rosa, Carina Vieira da Silva

Spatial planning of marine areas is vital to balance multiple human demands and ensure a healthy ocean, while supporting global ocean goals. To thrive in a changing ocean though, marine spatial planning (MSP) must effectively integrate climate change. In effect, properly addressing and integrating climate effects in MSP is vital to keep plans viable, relevant, and useful in the long term. Moreover, when developed with explicit climate-related considerations, MSP can notably contribute to minimizing climate impacts, support adaptation actions and play a role in climate mitigation.

However, few marine spatial plans properly or explicitly consider climate change. This is a critical oversight in a rapidly changing world. To address this challenge and identify solutions to overcome it, an in-depth, thorough conversation is needed both within the scientific community and with decisionmakers. In July 2020, an online survey was launched globally (and remained operational for 9 months) to explore and collect the perceptions of people knowledgeable on MSP (e.g., scientific community, marine planners, managers, decision-makers, industry, NGOs, interested members of the general public) on how MSP could be affected by, and adapt to global climate change. The ultimate goal was to identify the reasons hindering the development of "climate-smart" MSP initiatives and unravel solutions to address the identified challenges. The survey collected 194 responses from over 50 countries/territories around the globe. While most respondents acknowledged climate change as a major and urgent challenge to MSP, perceptions were that such urgency was well recognized by the scientific community, but the same did not apply to decisionmakers (which largely ignored the topic). Respondents identified "climate vulnerability and risk analyses" and "adaptive management and governance" as important approaches to support the development of climate-smart MSP, and further recognized the need for "guidelines/best-practices" on the topic. However, when asked about specific examples of MSP initiatives addressing climate change, only one third of the respondents provided positive answers. Still, several initiatives were identified, some not easily detectable through literature searches. Finally, while most people shared an overall agreement on the high importance of MSP to support climate adaptation, for climate mitigation opinions were more divided (many people believe mitigation requires more global solutions).

In this work, we will present and discuss the results obtained with the global survey, particularly considering their relevance to support the development of a decision-support document on climate-smart MSP (to be produced by the end of 2022 under project OCEANPLAN).

Keywords: marine spatial planning, climate change, global survey, solutions, ocean sustainability

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CM 385: Contrasting the VMS vs. AIS coverage on the fishery dynamics of the tropical tuna purse-seine fleet

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One of the essential parameters to manage fisheries effectively is the effort developed by fleets. In recent years, the Automatic Identification System (AIS) arises as an alternative monitoring tool to the common Vessel Monitoring System (VMS). Such novel tool provides a higher-resolution time-scale (tracking positions each few minutes against to the average 1-hour provided by VMS) to deal with complex fisheries behaviours. However, some handicaps could constraint the coverage of this novel technology, as for example the turn-off of AIS transistor to avoid piracy, AIS machinery efficiency or satellite reception.

In this sense, the present contribution is focused on the contrast of VMS *vs*. AIS coverage providing an overview about the usefulness and limitations of the emergent AIS fishing monitoring system. The spatio-temporal comparison has been conducted pooling the 8-years (from 2012 to 2019) big-data sets (VMS and AIS) from the Spanish and French tuna purse-seiners fleets, as one of the most important worldwide and the most important EU fisheries operating across Atlantic and Indian Ocean.

The spatial heterogeneity analysis detected a big coverage gap across the Indian Ocean, where AIS underestimated in thousands of hours the fishing effort provided by VMS. Piracy and the behaviour to hide the fishing grounds could be related to this inter-oceanic pattern. A better coverage was observed across Atlantic Ocean, although AIS mainly underestimated oceanic areas while coastal areas were overestimated. Such pattern may be explained by the lower satellite coverage in oceanic areas and the signal reception support of terrestrial at coastal areas.

The aforementioned patterns were maintained along study period (2012-2019). However, the AIS coverage experienced a significant increasing trend over the years providing an encouraging scenario where AIS could become in a useful and high-detailed monitoring fishery and spatial management tool to deal with complex fisheries dynamics in a changing ocean increasingly affected by climate change.

Key words: fishery dynamics, fishery monitoring, tropical tuna purse-seine fleet, spatial management

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CM 394: Addressing long-term changes in Plankton using 'pelagic' and 'food web' indicators in the North-East Atlantic

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To assess direct anthropogenic and global change pressures on marine ecosystems, the development and monitoring of indicators are fundamental for monitoring changes in the environment. Phytoplankton primary production is susceptible to these changes as it integrates a large number of environmental variables. It is directly linked to CO_2 uptake and the energy transfer though the food web from phytoplankton to fisheries. In the North-East Atlantic, plankton components were assessed through Pelagic Habitats and Food Webs indicators within OSPAR region II 'the Greater North Sea' and region III 'the Celtic Sea' over the period 1960–2019, to address long-term changes at a resolution well-exceeding basin scale. In this resarch, we focused on two indicators: the PH2 'changes in phytoplankton biomass/zooplankton abundance' and the FW2 'changes in primary production. For both biomass and productivity, regular monitoring at the local scale (i.e. time-series at fixed stations) addressed changes in coastal areas, whereas the Continuous Plankton Recorder and ocean colour products from remote sensing provide a view at the regional scale for offshore and shelf waters. Both indicators revealed that there is a marked and general decline in primary production, phytoplankton biomass and zooplankton abundance in the North-East Atlantic. While the decline in primary production concerned both the Celtic Seas and the Greater North Sea, phytoplankton biomass showed a decreasing trend in the Celtic Seas but increased in the Greater North Sea. Zooplankton abundance presented the opposite trend with a decline in the Greater North Sea and an increase in the Celtic Sea. The productivity, abundance and biomass data at local scales were also used for compared to the previous OSPAR assessment. Around the United Kingdom and in the Norwegian Trench there was an increase in phytoplankton biomass and zooplankton abundance, whereas in the Kattegat , there was a decrease in productivity. Future investigations within OSPAR will connect plankton changes (in terms of biomass, abundance and productivity) observed at different spatial scales to pressure changes. This will ultimately establish a framework that will help separate anthropogenic and natural pressures from climate change to explain the biomass-production patterns that vary across ecosystems.

Keywords: climate change, food webs, indicators, MSFD, OSPAR, pelagic habitats, plankton, time-series

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CM 396: A dominant effect of species richness on community biomass in a benthic ecosystem

David Clare

Species richness generally has a strong positive effect on ecosystem functioning under controlled experimental conditions, suggesting that biodiversity loss could have a major impact on the benefits humans derive from nature. There is also growing but inconsistent evidence that species richness is of comparable functional importance to abiotic drivers in natural ecosystems, though the functional importance of species richness compared to other biotic drivers such as organism abundance is unclear. Using infaunal and epifaunal assemblages from a benthic ecosystem in the English Channel, this study assessed the relative importance of species richness as a driver of community biomass, a fundamental component of ecosystem functioning. The effect of species richness was generally greater than or comparable to that of community abundance and the abundance of functionally dominant (high biomass) species. Only for infauna did an abundance metric – the population density of the sea potato *Echinocardium cordatum* – make a larger unique contribution than species richness to variation in community biomass. Incorporating key local abiotic drivers into the analysis indicated that the environment influenced community biomass only indirectly, via its influence on species richness. These results provide support for a dominant effect of species richness on biomass stocks in a natural ecosystem and suggest that protecting environments that favour high biodiversity is key to sustaining ecosystem functioning.

Key words: benthos, biodiversity, ecosystem function, environmental protection

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CM 409: Benthic community distribution pattern in a Southern Norwegian fjord-coastal system

Manoj Kumar Chand, Juan C. F. Pardo, Hilde C. Trannum

Benthic macrofauna plays a crucial role in carbon and nutrient cycling, decomposition, and as prey items for higher-level consumers. Along estuarine gradients, communities tend to change in relation to physical and biogeochemical habitat features. Under a climate change scenario, it is crucial to better understand and monitor the benthic fauna to support environmental assessments. Here, the distribution and composition of macrofauna were studied in seven stations along a fjord-coastal system in south Norway, the Sandnesfjord, Agder. Sediment grab samples (three/four replicates per station) were collected to characterize the macrofauna communities, with additional grabs to estimate supporting environmental parameters (e.g., total organic carbon, nitrogen, and grain size). A total of 3422 individuals and 100 species were recorded along the system. Similar to other fjord systems, polychaetes and bivalves were the most abundant groups and with highest biomass, followed by other common groups (e.g., gastropoda, echinoidea, crustacea, ophiuroidea). Abundance ranged from 103 to 1172 in the inner and outer stations, with polychaetes, such as *Pectinaria belgica, Pseudopolydora pulchra, Paramphinome jeffreysii, Scalibregma inflatum, Polycirrus plumosus, Jasmineira caudata,* and *Galathowenia oculata,* the bivalves *Thyasira flexuosa,* and *Corbula gibba,* and the gastropod *Turritella communis*, showing higher relative abundance. Several of these species tend to be associated with organic loads, which could be attributed to the riverine inputs and associated nutrients, as supported by the high carbon and nitrogen values. The clustering and ordination of the communities indicate that the mid-inner communities are the most similar, while both outer stations are low in similarity. The diversity increased from the inner shallower to the outer deeper regions, it reached a maximum at the intermediate sites. The study is one of the first descriptions of a macrobenthic fjord gradient in a pristine Southern Norwegian system. Further cross-temporal and site evaluations are needed to gain a broader understanding of this key ecological group.

Keywords: benthic communities, climate change, fjord gradient, pristine locations

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CM 422: Effects of climatic changes and alternative fisheries management measures in the Adriatic Sea

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Spatial management of fisheries is considered one of the pillars to reach a sustainable exploitation of marine resources. Yet climatic changes are affecting oceanographic conditions in space and in time, making spatial management even more challenging. In the Adriatic Sea (one of the most fished basins worldwide), a small portion of the total exploitable area has been protected in the course of last decades. Recently, a large Fisheries Restricted Area (FRA) was established for Jabuka-Pomo Pit and other spatial restrictions are in an implementation phase or under scrutiny. However, proposals lack of comprehensive assessment of effects of past and future restricted areas on the ecosystem and fisheries. Quantifying immediate, medium- and long-term ecosystem effects of spatial fisheries management actions, conversely, might help to support discussions on the adoption of these measures, possibly facilitating their acceptance in participatory processes. In the Interreg Project FAIRSEA (Fisheries in the Adriatic Region – a Shared Ecosystem Approach) a complex spatially explicit ecosystem model of the Adriatic Sea was used to assess the potential bio-economic effects (i.e. on stock status and fisheries performance) of some spatial protection measures already in place or under discussion, including the proposed Bari Canyon FRA, the North Adriatic Sanctuary (NAS) and the ban of trawlers within 6 NM from the Italian coast. The model was calibrated over the past data (2004-2018) using fishery dependent and independent data, as well as results from stock assessments and outcomes linked with oceanographic variables obtained from an operational physical-biogeochemical 3D model. Effects of single and combined management spatial measures were highlighted by contrasting predicted stock biomass and catch of long-term (up to 2100) simulation scenarios. Results highlight a general increase of target species due to fishing restrictions within the protected areas, with cascading negative effects on their prey. However, only the Pomo FRA showed significant effects at the basin scale for both European hake and Norway lobster stocks with also long-term positive effects on fisheries, the latter due to rebuilding of commercial stocks. Some of these effects are also observed from spatial analysis of scientific surveys data (MEDITS). The model predicts lower benefits on stocks and fisheries associated to the other spatial measures (such as NAS and ban of trawlers within 3 and 6 nm). Results, presented as a sensitivity analysis respect to several spatial measures provide insights for current and future management actions and highlight pros and cons of their enforcement.

Keywords: ecosystem modelling, oceanographic variables, fisheries restricted areas, management, climate change, Ecospace

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CM 427: Climate change affects the distribution of diversity across marine food webs

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Many studies predict shifts in species distributions and community size composition in response to climate change, yet few describe how these changes could affect the distribution of diversity across food webs. Bridging this gap is critical to better anticipate and quantify system-level change. We predict how climate change will affect the habitat suitability of marine fish species across a range of size classes with different habitat and feeding requirements (i.e. feeding guilds) in the northeast Atlantic shelf seas. There were contrasting effects on feeding guilds, with spatially extensive decreases in the species richness of consumers lower in the food web (planktivores) but increases for those higher up (piscivores). Changes in fish community composition also affected spatial patterns in mean-maximum length and predator-prey mass ratios. Such change could influence nutrient uptake, its transformation, transfer efficiency and food web stability, and thus profoundly alter ecosystem dynamics and functioning. Substantial uncertainty, particularly when predicting the distributions of planktivorous fish and species juvenile life-stages, highlights the need for concerted international effort to better understand the habitat requirements of fish critical to maintaining ecosystem functioning.

Keywords: ecosystem structure and function, biodiversity, fish feeding guilds, species distribution modelling, habitat suitability, climate change scenarios

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CM 428: Spatiotemporal trends of Chamelea gallina (Linnaeus, 1758) recruitment in the Adriatic Sea using a Bayesian hierarchical modelling approach

Giulio Barone[1], Giada Bargione[1], Massimo Virgili[1], Alessandro Lucchetti[1]

The Striped Venus clam, *Chamelea gallina* (Linnaeus, 1758), is amongst the most economically and ecologically relevant bivalves in Italy. In the past decades, *C. gallina* stocks experienced significant fluctuations due to high fishing pressure (more than 600 hydraulic dredges in a narrow coastal area), human alteration of the environment (i.e. breakwater barriers, nourishment of sandy beaches etc.), and climate change (i.e. increase in the frequency and magnitude of storms etc.). Therefore, the sustainable exploitation of the resource requires a thorough understanding of the relationship between *C. gallina* and its habitat. In this study, we used a Bayesian hierarchical modelling approach for exploring the relationship between *C. gallina* and its environment over three years in the central-northern Adriatic Sea (an area that accounts for 80% of Italian production). The Integrated Nested Laplace Approximations (INLA) approach, and the employment of the spatial differential equation (SPDE), successfully identified the main drivers and hotspots of *C. gallina* recruitment in the Adriatic Sea. The sediment grain size was the most relevant covariate and identified suitable grounds for the recruitment. Besides, bottom water temperature, salinity and net primary productivity and salinity drove abundance patterns likely influencing pre and post-recruitment dynamics. Although model predictions were accurate, they highlight the need of expanding the suite of variables (i.e. by including pollutants and organic matter) and increase the spatial resolution of this information. Overall, the INLA approach represents a valuable tool for modelling species distribution and abundance patterns and potentially represent a meaningful spatial planning tool for the sustainable use of biological resources.

Keywords: INLA, SPDE, hierarchical generalised linear models, species distribution modelling, *Chamelea gallina*

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CM 434: Distributional changes of marine fish in Irish waters

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The impacts of climate change on marine ecosystems are well documented. Impacts on fish communities may be displayed by changes in distribution, phenology, growth, and survival. Several major commercial fish stocks in Irish waters are found at the northern and southern extremes of their habitat ranges which may exacerbate climate change impacts. To effectively plan, mitigate, and adapt to the effects of rising sea temperatures and ocean acidity over the next 50 years, the fishing industry, managers, and policymakers need detailed knowledge of how fisheries will be impacted by climate change. In this study previous assessments of temporal trends in distribution and climate impacts on Ireland's fisheries were updated. The study used fish biomass data (kg/km^2) from the Irish Groundfish survey (2003-2021) in ICES areas 6a, 7b, 7g and 7j to investigate fish trends at a community level. Kendall correlation analysis was carried out for each taxon in an area. The sample distribution of the Kendall's test statistic (tau) was compared to the expected sample distribution using a distributional Kolmogorov–Smirnov test. Lusitanian species showed increases in all ICES areas while in contrast to previous studies Boreal species showed no significant deviation from the expected distribution. Disentangling whether distributional changes were the result of climate change or fishing effort should be investigated further and further analysis will focus on species of particular concern identified in this initial investigation.

Keywords: climate change, marine fish, Ireland, Lusitanian, Boreal, spatial distribution

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CM 449: Evaluation and characterization of fish nursery habitats in French Guiana tropical coastal habitats

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Mangroves are one of the most productive estuarine habitats. They are known to play an important role in fish nurseries throughout the world. With the high abundance of food and refuge from predation, mangroves are a suitable habitat for many fish species that spend all or part of their life cycle there. Mangroves in French Guiana are relatively well preserved but vulnerable to the increasing anthropogenic impact and global changes. Human activities such as urbanization, deforestation, mining and pollution are increasing in French Guiana mostly due to a fast-growing human population that has nearly doubled in 20 years. Despite the high socio-economic importance of the fishery species associated to mangroves, very little is still known about the nursery role of the different near-shore habitats in French Guiana. This study aims to investigate habitat preference as well as community assemblages and the effect of anthropogenic pressure on early life stages of fish.

Fish larvae and juveniles were collected during the dry and the wet season in the estuarine channels, mangroves habitats and in the adjacent shallow coastal areas (a total of 11 sites). Sampling was performed with different gears depending on the habitat type (plankton nets, bongo nets, epibenthic sleds and fyke nets). Physico-chemical parameters, organic matter content, heavy metals, chlorophyll *a* and nutrients concentrations were measured at each site and season.

Results shows that diversity and abundance of early life stages of fish varied significantly between sites. Four families (Engraulidae, Gobiidae, Sciaenidae and Clupeidae) were predominant in the community and represented almost 90% of the total abundance. Fish juveniles' presence and diversity was linked to the environmental characteristics of the site suggesting that the nursery ground value is strongly dependent on the environmental factors. The results of this study can therefore constitute the bases for the development of an integrated ecosystem-based management plan.

Keywords: mangrove, fish diversity, heavy metal, nutrients, French Guiana, nursery habitats

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CM 466: Blue management under a changing climate: Marine spatial planning and the social-ecological perspective

Sara García-Morales, Yorgos Stratoudakis, Elena Gissi, Francisco Andrade, Catarina Frazão Santos

Marine spatial planning has been used as a holistic, strategic, and operational instrument to support the sustainable use and management of the ocean. Still, marine spatial planning faces several challenges that can compromise its efficacy. Global climate change – one of the most prominent environmental problems nowadays – is one of such challenges, acting as a driving force of change in marine social-ecological systems. From both conceptual and operational perspectives, marine spatial planning can incorporate climate change to ensure more adequate management responses by improving adaptation capacity, building social-ecological resilience, and reducing the risk of maladaptation. However, despite its known transformative potential, marine spatial planning has been criticized due to its implementation practices, which in many cases resulted in exclusionary and undemocratic processes, undermining human dimensions in the marine management and conservation arenas.

The present work focuses on two operational approaches with highly relevant results to promote adaptation to global climate change in marine spatial planning processes: adaptive management and anticipatory zoning. These approaches simultaneously present a high relevance to achieving Sustainable Development Goals 13 and 14, respectively, “Climate Action” and “Life Below Water”, and related targets. The present work highlights the potential benefits of using adaptive management and anticipatory zoning to support climate-smart marine spatial planning, and analyses how these approaches differ from alternative, less appropriate procedures and outcomes (i.e., anticipatory bidding for future use rights). Finally, we assess the adequacy of these approaches to the fulfilment of social equity and propose a number of considerations based on the social sciences’ body of literature.

Decision-making processes related to marine conservation and ocean management must build on integrated and holistic perspectives, and use approaches that simultaneously consider the environmental, economic, social, geographical, and historical settings of the area being managed. In a changing ocean, adaptation approaches that recognise all these aspects are of the utmost relevance to support sustainable marine spatial planning. Therefore, the following question arises: are we ready to commit to responding to these challenges?

Keywords: marine spatial planning, sustainable development goals (SDGs), climate change, ocean management, ocean governance, social equity

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CM 472: Size-structure, growth, and mortality rate of the deep-sea silver scabbardfish Lepidopus caudatus in the Azores

Gloria Mariño-Briceño, Ualerson Iran Peixoto, Wendell Medeiros–Leal, Mário Pinho, Régis Santos

The deep-water demersal fisheries are of important economic value even though the main exploited species are of very low productivity. Because of this, it is necessary to generate biologically and ecologically based fishing plans to make this fishery sustainable in time. The species of interest in this study is the silver scabbardfish (*Lepidopus caudatus*), a demersal fish that lives in temperate seas around the world on the continental shelf and the slope from 100 m up to 600 m deep. This species is captured by Azorean demersal fisheries using hook and lines, valued at 0,5 M € on average per year. Despite this, the scientific knowledge on population dynamics, as well as the current stock status of the Azorean population are limited. The aim of this work was to explore survey (1996-2019) and fishery-dependent data (1985-2020) to determine some population characteristics of the silver scabbardfish in the Azorean waters. The aspects studied include the (1) size structure, (2) growth parameters and (3) mortality rates. This species showed relatively large sizes, slow growth, and low natural mortality rate, indicating high vulnerability to overfishing. As a result, conservation and fisheries management measures should be implemented to ensure the sustainability of the resource.

Keywords: fisheries, population dynamics, demersal, deep sea, NE Atlantic.

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CM 473: Spatial distribution of the silver scabbardfish Lepidopus caudatus in the Azores archipelago

Gloria Mariño-Briceño, Ualerson Iran Peixoto, Wendell Medeiros–Leal, Mário Pinho, Régis Santos

Deep-water fisheries gained great importance in the middle of last century, due to the overfish of shallower resources and the development of fishing technology. In Portugal, and especially the Azores, the deep-water demersal fisheries represent an important proportion of the total catches. One demersal species of commercial interest is the silver scabbardfish, *Lepidopus caudatus*. This species is widely distributed in most of the oceans and there is evidence that some populations are overexploited. In the Azores, the landing trends have plummeted since the 90s until nowadays, nevertheless it represents for the region 0,5 M € on average per year. The knowledge about biology and ecology is a fundamental to provide science-based information for fisheries management support. In this study, we explored some ecological aspects of the silver scabbardfish distribution in the Azores region. Utilizing survey data (1996-2019), we analyzed the relationship between habitat characteristics (latitude, longitude, bathymetry, and substrate type) as predictive variables to the presence-absence and abundance indices of the *L. caudatus* in the Azores. For this, we applied a hurdle (delta) Generalized Additive Model (GAM) due to the presence of a large proportion of zero values in the data (94%). Our results indicated that the presence-absence (binomial) model explained 22.1% of the variance, while the positive catches (Gaussian) model explained 36.7%. The modeled data suggested a high probability of occurrence and abundance at locations situated closer to the islands and seamounts where depths between 200-600 m are mostly available. In addition, abundance given the presence was higher on sandy bottoms. Finally, this study highlights the importance of future fine-scale studies considering the additional collection of environmental data that may affect the distribution of demersal species to improve predictive models of distribution.

Keywords: habitat use, spatial distribution, deep sea, demersal, NE Atlantic

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CM 482: Contributing to global marine biodiversity conservation goals with area-based fisheries management: A typology-based evaluation

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In 2010, the Parties to the Convention on Biological Diversity (CBD) adopted Aichi Biodiversity Target 11 calling for conserving 10% of the oceans through marine protected areas (MPAs) and "*other effective area-based conservation measures"* (OECMs), explicitly recognizing that other types of spatial conservation measures beyond areas designated as MPAs maintain and recover biodiversity. Eight years later CBD Parties adopted a definition and criteria for OECMs, spurring global interest in recognizing suitable fishery measures that allow designation and reporting of OECMs. There is now a need for a common vision of the extent and limits of what these "measures" might include so that managed areas outside of MPAs can be considered for designation as OECMs, and management in place can be guided on needs for on-going implementation requirements. Guidance on these questions would assist countries in delivering on the CBD's targets. This is increasingly important for the Post-2020 Global Biodiversity Framework, if decadal goals incorporate a higher area-based conservation target in which OECMs are to play a larger role. For spatial fishery measures to be recognized as new OECMs, countries require sector specific guidance on recognition and examples of ongoing implementation of OECMs. Here, we systematically review case studies across a broad category of spatial management measures to provide evidence for how they align with OECM criteria, arguing that many with primary objectives related to fisheries sustainability provide co-benefits for biodiversity, and hence biodiversity conservation and sustainable development. The review highlights how fishery measures can help countries achieve a number of the Sustainable Development Goals alongside the CBD's global targets for biodiversity.

Keywords: Convention on Biological Diversity, OECM, fisheries, spatial management, biodiversity conservation

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CM 497: Do the management units of *Sebastes mentella* in the North Atlantic comply with its biological units identified by genome-wide SNP data?

Atal Saha[1], Benjamin Planque[2], Torild Johansen[2]

Sustainable management of exploited marine species can be promoted by establishing management unit boundaries that are biologically meaningful. Unfortunately, the identification of isolated populations in widely distributed marine species is complicated by low levels of genetic differentiation. Modern genetic approaches now allow for the isolation of thousands of genetic markers, therefore improving the power to identify biologically meaningful management units. Beaked redfish (*Sebastes mentella*) are migratory and commercially important fish species in the North Atlantic. The species geographical range is divided into several management units throughout its' distribution range, though the genetic population structure is not completely resolved. The question of consistency between management units and genetic population structure remains. The present study is aimed at testing for genetic structure of the species within the Northeast Atlantic. We apply genome wide sequencing technologies to identify markers (Single Nucleotide Polymorphisms, SNPs) that are most discriminatory between sites across the species geographical ranges. Unprecedented levels of genetic differentiation was found among the previously defined 'shallow pelagic', 'deep pelagic' and 'demersal slope' groups, with overall mean F_{ST} = 0.047 and 0.24 in neutral and outlier SNPs, respectively. Bayesian computation estimated a concurrent and historical divergence among these three ecotypes and evidence of local adaptation was found in the *S. mentella* genome. Overall, these findings imply that the depth-defined habitat divergence of *S. mentella* has led to reproductive isolation and possibly adaptive radiation among these ecotypes. Additional sub-structuring was detected within the 'shallow' and 'deep' pelagic groups. Our work shows that the current management units of beaked redfish in the North Atlantic are in line with the biological units.

Key words: ddRAD sequencing, Hierarchical genetic population structure, genomics

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CM 510: A systems approach to marine spatial planning

Amanda T. Lombard, Jai K. Clifford-Holmes, Estee A. Vermeulen

Marine Spatial Planning (MSP) processes and the United Nations Sustainable (UN) Development Goals are two high-level responses to the deteriorating state of global ocean health and the need for integrated management. MSP has gained traction as a governance framework for integrated ocean management and has received significant uptake across governance scales from local to regional. MSP's popularity stems from its purported ability to address the complexity of the marine environment and the silo-driven current structures involved in ocean governance and management. However, we have identified four tensions that MSP is failing to address adequately. These include (i) navigating between the often-competing priorities of 'blue growth', environmental sustainability, and equitable access to marine resources in a way that enables inter-connections to be simulated and trade-offs to be evaluated; (ii) prioritising expedient development of *plans* over the slower processes of participatory *planning;* (iii) pragmatically recognising the prevailing status quo as inevitably part of the initial conditions that planning departs from, without being 'locked-in' to past decisions and system structures; and (iv) finding the balance between detail and utility. We argue that MSP will be more robust if it adopts a systemic approach to navigating these four tensions at conceptual, methodological, and pragmatic levels. We present a conceptual framework to address these tensions and apply the framework in two case studies: one for a bay in South Africa to advise national planning, and one for the Western Indian Ocean to inform regional planning (a study commissioned by the Nairobi Convention of the UN Environment Programme). We use system dynamics (SD) modelling as a visual modelling approach because it is suited to multi-stakeholder contexts and can integrate varying levels of qualitative and quantitative data and operate in data scarce environments. We build SD models within a participatory modelling process that promotes ecosystem-based approaches to MSP while aiming to foster collective action by improving communication among stakeholders and across management and governance sectors. By modelling the social-ecological dynamics of the main human uses of marine resources we simulate the influence that these uses have on one another and on marine sustainability. We identify trade-offs among different management interventions that are collaboratively identified and tested under a range of scenarios, including climate change. We conclude with recommendations for how a systemic approach to MSP can address the four tensions we identify, thus enabling it to deliver transparent user-useful products at the science-policy-practice interface.

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Keywords: marine spatial planning, systems approach, system dynamics modelling, participatory modelling, integrated ocean management

CM 526: A two-fold spatiotemporal approach reveals cross-scale environmental drivers across metapopulation subunits

Georgios Kerametsidis, James Thorson, Vincent Rossi, Diego Álvarez-Berastegui, Cheryl Barnes, Gregoire Certain, Antonio Esteban, Encarnacion Garcia, Angelique Jadaud, Safo Piñeiro-Rodríguez, Miguel Vivas, Manuel Hidalgo

Current management frameworks for marine stocks often fail to incorporate spatially and temporally variable processes, which are central to the development of climate-smart Marine Spatial Planning (MSP) initiatives and the implementation of Area-Based Fisheries Management measures (ABFMs) that protect biodiversity and promote the sustainability of harvested populations. To reveal the spatiotemporal dynamics of marine resources and explore their responses to fishing pressure and climate change, movements and connections among stock sub-units as well as spatially structured environmental processes driving stock dynamics must be estimated. Here, we used the red mullet *Mullus barbatus* as model species in the north-western Mediterranean, where its populations are managed in two separate units, the Eastern Spanish coast and the Gulf of Lions in France. As the first step towards exploring connectivity patterns among and within the two management units, we employed a two-fold spatiotemporal approach: i) abundance-sampling data from scientific trawling were used to obtain the principal modes of density variability in the Spanish coast and Gulf of Lions using a generalization of empirical orthogonal functions with a spatiotemporal model and ii) monthly landings per unit effort (LPUE) data from commercial trawling were used to apply DFA to explore synchronies in seasonal dynamics and long-term trends. The dominant mode of variability for the stock of the Spanish coast, explaining 93.9% of the total variance, was highly correlated with the regional climate, namely the Western Mediterranean Oscillation (WeMO), local variation of chlorophyll-α concentration and deep-water convection events of the north-western Mediterranean. The dominant mode of variability for the Gulf of Lions population (var. exp. 62.5%) was associated with Sea Surface Temperature (SST) while the second mode of variability (var. exp. 37.5%) was associated with locally averaged chlorophyll-α concentrations of the Eastern Spanish coast and deep-water convection processes. These results were complemented by Dynamic Factor Analysis that allowed us to associate groups of fishing ports with the different modes of variability and a series of environmental variables. Following this two-fold approach we were able to identify the spatiotemporal dynamics and the associated underlying environmental drivers thereof for a high-value demersal resource. Persistent hotspots of high densities were detected in both areas thus providing scientific evidence to support the design of permanent and dynamic ABFMs. This spatiotemporal approach can be of elevated utility in fisheries oceanography as, by defining modes variability at single-stock or community levels, it facilitates the exploration of latent environmental processes.

Keywords: *Mullus barbatus*, empirical orthogonal function, dynamic factor analysis, Mediterranean Sea, vector autoregressive spatio-temporal model

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CM 562: Evaluating the role of Geomorphology in Modelling Suitable Habitat for Adult Snow Crab (Chionoecetes opilio) in Atlantic Canada Under Future Ocean Climates

Emmeline Broad, Nancy Shackell, Craig Brown, Katleen Robert

Oceanographic conditions in Atlantic Canada are predicted to change in response to future climate scenarios, modifying the range and distribution of numerous marine fauna. Poleward range shifts are predicted for many marine taxa linked with increased seawater temperature.
Benthic marine fauna can show an affinity for seabed geomorphology, specifically bathymetry and substrate are often important in explaining variance in community structure. Due to a lack of regional seabed mapping data, measurements of geomorphology at suitable scales are not considered when projecting climate driven benthic range shifts. Therefore, it is not known if adequate habitat is available to support benthic fauna in areas where future range is predicted.
We aim to evaluate the role that seabed geomorphology plays in defining suitable benthic habitat under present and future climate conditions for key benthic fauna. Oceanographic measurements are derived from a regional ocean circulation model in a hindcast simulation (1990 – 2019) and projected simulations using two future climate scenarios (2055 and 2075). Values from all time points along with metrics of seabed geomorphology are explored in habitat suitability models. Preliminary results focus on a comparison between present and future habitat suitability maps of adult Snow Crab in Atlantic Canada.

Keywords:
Geomorphology, Habitat Suitability Modelling, Climate Change, Benthic Habitat Mapping

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CM 570: Combining multiple sources of evidence to quantify the spatial and temporal dynamics of seabird prey fish in the North Sea

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During the breeding season seabirds are central place foragers and are critically dependent on the distribution of certain key prey fish species such as sandeels. In the North Sea populations of both seabirds and their fish prey have declined over the past 20 years. It has been shown that seabirds have been declining due to breeding season prey shortages. However, the reasons for the declining fish populations have been harder to understand. Prior to the population declines in the early 2000s sandeels were the largest single species fishery in the North Sea and overfishing and resource competition remain major concerns. To investigate the mechanistic role of overfishing on sandeel populations, a better understanding of predator-prey relationships is needed, which requires detailed prey distribution models. ICES DATRAS fishery-independent trawl surveys were combined into a single database covering the entire Greater North Sea. Newly available HERAS acoustic surveys were also available for sprat and mackerel. Using this database, we applied relatively novel Bayesian spatial modelling techniques using R-INLA, which is a fast and efficient method to fit a Bayesian model using the Stochastic Partial Differential Equations (SPDE) approach. This method accounts for spatial and temporal autocorrelation and allows the estimation the fine scale spatial-temporal distributions of small pelagic fish biomass across the entire North Sea. This will then feed into the next stage of the project, to model seabird consumption rates using multi-species functional response models to quantify the predator-prey relationship at varying prey densities, as well as providing a public data product freely available to other research projects studying the North Sea pelagic ecosystem.

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