SYMPOSIUM 2025

OPERATIONALISING EUROPEAN ECOSYSTEM BASED FISHERIES MANAGEMENT

BOOK OF ABSTRACTS

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Session 1: Why do we need Ecosystem Based Fisheries Management and what is holding us back in operationalisation?

Keynote: Confronting comfortable chimeras: an advisory perspective on EBFM implementation

Mark Dickey-Collas, Marine Science Consultant (mark.dickeycollas@gmail.com)

EBFM is central to progressive fisheries management in a changing world. My talk will highlight how we find ourselves encumbered by our legacy. It will stress the importance of evidence-informed decision-making and will consider four key chimeras of western fisheries management which must now be challenged to implement EBFM.

1. Destructive influence of balance. The notion that the ecosystem approach is about balance and holistic understanding leads to the idea of win-wins in management solutions with an overt focus on assessing status. This prevents us from highlighting threats and opportunities for managers. Solution: change the narrative to prioritisation, risk and transactional approaches.

2. Equality across management objectives. Our natural sciences training leads us to ignore the diversity of perceptions on objectives. There is an underlying assumption of homogeneity in management objectives as if all share the same intrinsic values. This leads to the notion that once you get around the table with all the evidence, trade-offs are straight forward. Solution: embrace concepts and analysis from social science and reject concepts like ‘scientific objectives’.

3. Stagnation by science. Fisheries science is our strength and our weakness. We have sold a false sense of certainty which has been embedded into legislation as rigid management frameworks (e.g. MSY, relative stability). It is easy to stall management action by calling for more data and better science. Solution: be honest and develop tools that reflect that honesty and assume change is an inherent property of all systems.

4. Blindness to governance. In the realm of EBFM, researchers’ naivety about governance is no longer acceptable. Our evidence and advice need to impact. National and international priorities and measures are shaped by complex institutional structures and bureaucratic machinery. Ministries and departments not only compete internally, but also speak with fragmented voices in global forums, usually without coordination. Solution: governance awareness training for researchers and high-level champions for systemic transformation.

Session 2: Sustainable management of social systems

Keynote: Carbon impact of fisheries: From mitigation towards a fair carbon management

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Operationalising Ecosystem Based Fisheries Management needs to contribute positively to climate mitigation and adaptation. However, this requires a better integration of complex bidirectional impacts between climate and fisheries. From a mitigating perspective, fishing is not only contributing to rising greenhouse gas emissions through fuel use, but also disrupting the role of marine vertebrates in the ocean carbon cycle causing disturbance and damage to the carbon-rich seabed, among other interrupted ecological processes. I will review both current knowledge and gaps at four important labels impacting our understanding on the carbon impact of fisheries: fish, fisheries, seabed and emissions. Marine fish are essential to carbon cycling and ocean's biological pump through a diversity of physical and biological processes, including consumption and transfer through food webs. However, there is a range of variation between species and fisheries, highlighting the need for empirical research on carbon transport and sequestration rates. Fisheries have also a critical influence on the ocean's ability to sequester atmospheric carbon by reducing fecal pellets and deadfalls or modifying vertical migrations, which alter carbon cycling and export. Geographic and fisheries differences will be also illustrated along with the interacting effects with others climate change impacts. As organic carbon reaches the seafloor it is sequestered in marine sediments and can remain locked away for centuries; if undisturbed by fishing. However, there is still much uncertainty around how much carbon is emitted due to fishing disturbance. Finally, beyond direct emissions from fisheries, contrasting examples will illustrate that the carbon footprint of fish becomes higher when considering the full lifecycle of the product. I will conclude by discussing the critical role of carbon impact of fisheries on the ocean-climate-biodiversity-people nexus, focusing on the importance of trade-offs assessment needed to avoid 'malmitigation' and to achieve a realistic and fair implementation of carbon management into EBFM.

Regional cooperation in EU Fisheries Management: Insights from Joint Recommendation Processes including stakeholders' visions

Katia Frangoudes, UBO Brest, (Katia.Frangoudes@univ-brest.fr)

Fisheries management is an exclusive EU competence, and—aside from limited exceptions—its waters are treated as a shared resource under the Common Fisheries Policy (CFP). This policy requires regional cooperation to impose fishing restrictions in areas used by multiple member states. To meet environmental directives, several member states have introduced or are planning fisheries restrictions in Natura 2000 areas to comply with EU environmental directives. Such measures must be coordinated through Joint Recommendations, developed collaboratively among concerned states and submitted to the European Commission for adoption as binding law. This process involves both national stakeholders and, indirectly, those from other member states. Drawing on a desk study of the process of three Joint Recommendation cases (Denmark, Belgium, France) and interviews with stakeholders from these countries, the Netherlands, and EU relevant authorities, this presentation examines how Joint Recommendations are shaped. It identifies both national and cross-cutting narratives, organized around two themes: process dynamics – including perceptions of legitimacy and the role of scientific input and wider management challenges – such as fragmented marine protected areas and shrinking fishing grounds. The presentation concludes with reflections on the implications of these findings, especially from the perspective of fishers and other stakeholders engaged in current and future policymaking.

Predicting public demand for fisheries regulation in Europe

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The quest to address the threats from unsustainable fishing practices has resulted in a considerable suite of regulation in Europe, but much remains to be understood about the extent and nature of public demand for it. We examine the demand for key components of fisheries regulation by employing original data gathered from a representative sample of citizens in three countries, the United Kingdom (UK), Bulgaria (BG) and Malta (MT) with access to the Atlantic Ocean, the Mediterranean Sea and the Black Sea respectively. Using econometric techniques, we synthesise the data into a single factor variable and estimate a model of demand for fishery regulation. A few findings emerge clearly, namely that fisheries regulation is strongly supported by the general public in three very diverse countries in Europe, and that resistance to fisheries regulation is more likely to come from people with low environmental sentiment and low trust in the European Union. We also note a distinction between the general public and stakeholders: people who work in coastal areas, or whose family work in the marine sector, or who fish more frequently than the average citizen are more likely to resist regulation, while those who live by the coast are more likely to support it. These findings allow the EcoScope project to make recommendations for emergent policy in Europe.

Fisheries Restricted Areas (FRAs) and social acceptability of selected management measures: the case of the Adriatic Sea

Matteo Chiarini, COISPA, (Chiarini@fondazionecoispa.org)

In the Mediterranean, Fisheries Restricted Areas (FRA) are established by the General Fisheries Commission for the Mediterranean (GFCM) as a management measure to protect marine biodiversity and manage fish stocks, through spatio-temporal restrictions on fishing effort. The governance process of FRAs is based on interconnected steps according to the GFCM Recommendations and related policy actions. To provide insights on the effectiveness and social acceptability of this management measure, this study mapped the main steps (i.e. submitted proposal for a FRA, scientific institutional and stakeholder consultations, submission to GFCM Commission) and actors of the governance processes for establishing FRAs in the Adriatic Sea, considering mainly the available recommendations, resolutions, meeting reports and other decisions of the GFCM bodies (Working Groups, Sub-Regional Committees, Scientific Advisory Committee). This approach was complemented through questionnaires to elicit key stakeholders' viewpoints from the sub-region. Results showed that respondents think the governance process is conducted in a transparent and inclusive manner, with key actors involved in the different steps. The survey underlined the crucial role of the implementation of FRAs to protect fragile habitats and reduce the pressure on key fishery stocks and their life stages. For example, results in Jabuka-Pomo Pit's FRA were considered effective towards attaining management objectives. The strength of FRAs is also that these are promoted through participatory processes, although the decision process was considered quite long. In addition, the survey highlighted that FRAs and MPAs cannot replace each other but are complementary. Respondents also highlighted the need to enhance surveillance protocols. The current overarching result, in terms of fishery policy actions, is that with three established FRAs, the Adriatic Sea has the highest coverage of seabed protection in the Mediterranean, a crucial goal for fisheries sustainability.

Assessing fisheries governance quality in Greek waters through triple helix stakeholder perceptions

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Good governance is a fundamental element in achieving sustainable fisheries, ensuring long-term ecological balance and socio-economic stability. Effective governance requires active engagement and collaboration among diverse stakeholders, enabling them to communicate, coordinate efforts, and participate in decision-making processes. In this study, we use Q methodology to assess fisheries governance in Patraikos Gulf (Greece), with 20 Q sorts completed by stakeholders from different organizations and sectors, representing triple helix actors. The analysis revealed four distinct discourses, each reflecting different viewpoints, yet all shared two key observations: (a) governance characteristics consistently received negative evaluations across all stakeholder groups, indicating dissatisfaction with current practices, and (b) all discourses raised concerns about the future viability of the fisheries sector. Regarding the marine environment and fisheries resources, particularly hake, a crucial species for the region's ecosystem and economy but critically overfished, stakeholders felt existing measures were largely ineffective. The study concludes that the Patraikos Gulf social-ecological system is in decline and that the governance system is largely unresponsive to the needs of regional/local actors. Weak top-down governance is a key factor linked to low trust in fisheries management, low compliance, and lack of cooperation among fishers, particularly in the SSF sector. With 2025 proclaimed the "UN International Year of Cooperatives," acknowledging their contribution to SDGs, it offers Fisheries Local Action Groups (FLAGs) a timely platform to promote cooperative values, key enablers for inclusive growth, community resilience, and bottom-up governance.

Enhancing bio-economic models, with fisher behaviour models

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Bio-economic models are key to forecast management strategies' impacts on marine resources and identify biological, ecological and economic trade-offs. Assumptions, however, frequently oversimplify the socio-economic dynamics, for instance, by assuming stable fish prices and ignoring the fishers' behavioural responses to management. This research uses enhanced economic sub-models on fish price dynamics, by metier-specific costs and fishers' behaviour developed in the SEAwise project, to evaluate the socio-economic response to management across alternative future socio-economic and climate change scenarios. The models are parameterised for Large Scale Fishery (LSF) and Small Scale Fishery (SSF) in the North Sea, Celtic Seas, Bay of Biscay and Mediterranean Sea. The key operational indicators considered include SSB, Gross Value Added, carbon emissions (kg CO_2) per kg of fish landed, number of adult meals served and carbon emissions per meal. The enhanced sub-models were used with a wide range of management measures (FMSY, PGY - through effort quotas, landing obligation and catch limits-, change in selectivity, spatio-temporal closures and effort reallocation) and provided more informed projections on the impacts of management combined with climate change scenarios. Following the Representative Concentration Pathways and Shared Socio-economic Pathways approach, the scenarios supporting technological advancement and localized sustainability (favourable fish price trends and improved stock conditions) consistently performed best across the various case studies for both SSF and LSF. In addition, the association of fishing strategies with a corresponding objective function (e.g. minimization of the fuel consumption) was modelled to evaluate the impact of the spatial management measures on fuel costs and carbon emissions due to the consequent effort re-allocation. The integration of such behavioural sub-models represents a significant step forward in investigating the effects of fisher behaviour in bio-economic models and predicting social and economic impacts of various management strategies under climate change.

Community-Level Impacts of EU Fisheries Policy: Comparative Profiles of the Guilvinec Fishing Community, France

Katia Frangoudes, UBO Brest, (Katia.Frangoudes@univ-brest.fr)

Since the inception of the European Community fisheries policy in the 1970s and the establishment of the Common Fisheries Policy (CFP) in 1983, market regulation and resource management have remained central objectives. Initially, the social dimensions of fisheries were viewed through a narrow lens, largely reduced to considerations of employment. A shift in perspective began with the 2007–2013 European Fisheries Fund (EFF), which introduced a focus on "community development" under Axis 4. This approach was further advanced by the 2017 Data Collection Framework regulation, which incorporated five basic social indicators: age, education, gender, nationality, and full-time equivalent employment. Although limited in scope, these developments initiated a broader discussion within the STECF WG SOCIAL regarding the feasibility of constructing fisheries community profiles. Such profiles aim to assess the vulnerability of communities to the impacts of conservation policies, the COVID-19 health crisis, political decisions such as Brexit, and other ecosystem-related changes. Contributing to this emerging area of research, a French team participating in the SEAWISE project developed community profiles for three locations: Guilvinec, Boulogne, and the Basque Country. The goal was to standardize a methodology that integrates existing statistical data with qualitative information gathered through desk research and interviews. This presentation focuses on the case of Guilvinec, comparing the findings from a community profile developed in 2008 with those from a more recent profile. The objective is to analyze how the community has adapted to various policy shifts and ecosystem changes, and to identify the resulting social impacts.

Small and large scale fisheries: Management strategy evaluation under future socio-economic scenarios

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The European Commission increasingly acknowledges the social importance of small-scale fisheries (SSF). The subject area "SSF" also stood out as one of the key social and economic aspects of regional fisheries in the systematic review and scoping consultation carried out as part of the SEAwise project in 2022. Still, the EU recognized that the sustainable management of SSF remains a challenge due to the lack of knowledge. This study, firstly, compares the impacts of small- and large-scale fisheries (LSF) on the social system, through specific indicators of social interest (e.g. food security, carbon emissions, employment, wages) across different management strategies. Secondly, the impact of alternative scenarios, differentiated for SSF and LSF, are explored to identify how the management strategies may impact the two fleets across Atlantic's regions (Bay of Biscay, Celtic Sea, North Sea) and Mediterranean's regions (Eastern Ionian Sea, Adriatic and western Ionian Sea) through short and medium trend simulations using bioeconomic models. The simulations allowed evaluating the effects of each management measure to SSF and LSF, that depends on how the two fleets are represented in the different regions and on the fishing gears used, which can significantly differentiate the exploitation patterns of the two fleets. Results indicated that although SSF has generally a landing value lower than the LSF, except in the Eastern Ionian Sea, the number of employees is quite balanced and, in some cases, SSF has a higher number of employees than LSF. In terms of CO_2 emissions per kilogram of fish, SSF can show higher or lower values than LSF, depending on the case study. Regarding food security, SSF contributes approximately 42% of the total number of meals in the studied regions. This analysis helps determine, for each management measure in each region, which fleet (SSF or LSF) aligns more effectively with the objectives of the European Green Deal, and which would require greater effort to achieve alignment.

Session 3: Identifying trade-offs and conflicting objectives

Keynote: Good practices for incorporating environment-productivity relationships and scenarios for Management Strategy Evaluation: A summary of WKECOMSE

John Trochta, Institute of Marine Research, (john.tyler.trochta@hi.no)

Management Strategy Evaluations (MSEs) are current management processes that are key to operationalizing EBFM. In particular, increases in data (types and observations), modelling tools, and expertise have enabled MSEs to expand the scope of investigations into uncertain effects of the environment on stock productivity and fisheries management performance. This progress is denoted by novel and diverse use cases of MSEs (e.g. with climate model projections), but these cases still involve complex and resource-intensive tasks. As part of a joint SEAwise-ICES initiative, a workshop was hosted in 2024 that brought together 55 experts, developers and users of MSE to bridge their experience toward some general guidelines for devising and using environmental scenarios in MSE. Presentations and discussions during the workshop aimed to identify and synthesize approaches for: (1) developing and evaluating predictive environment-productivity relationships for fished stocks, and (2) incorporating these relationships and environmental scenarios within MSEs. A key output of the workshop was a collectively drafted list of steps and “good practices” MSE developers may follow for incorporating environmental factors and quantifying ecological considerations. This talk will present these steps and practices, and highlight the diverse experiences and case studies that provided the basis for this list.

Small fish thrive, large fish compromise: effects of warming on reproductive investment of Northeast Atlantic Sole (Solea solea) populations

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Reproductive investment, defined as “the proportion of total energy or resources allocated to all elements of reproduction”, is a major life-history trait affecting individual fitness. Understanding reproductive investment is crucial to elucidating how populations develop under environmental changes and to sustainably manage them. Although reproductive investment in fish has been studied extensively, how it scales with body size remains a subject of debate. On the one hand, most theoretical growth models assume isometric reproductive scaling, implying that larger individuals have the same relative reproductive investment as smaller individuals. On the other hand, empirical data, mostly from wild populations, showed that hyper-allometric reproductive scaling is common in fish and other taxa, implying that larger individuals have higher relative reproductive investment than smaller individuals. In this study, we investigated how the reproductive investment of common sole (Solea solea)scales with body size and how this is influenced by warming temperature. To this end, we applied a mixed-effects modelling framework to a comprehensive 19-year collection of gonad weights (2004-2022) from four sole populations in the North Sea, Irish Sea, Bristol Channel and Celtic Sea North, and Eastern English Channel. Our findings show that sole’s reproductive investment scaled hyper-allometrically with body size. Additionally, increasing temperature increased reproductive investment in small fish but reduced it in large fish. These insights provide a foundation for future development of a growth model for sole accounting for its hyper-allometric reproductive investment and shed light on how temperature changes impact sole’s reproductive investment.

Climate change may enhance local larval connectivity but increase isolation in marine metapopulations: insights from European hake in the Adriatic and Ionian Seas

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Understanding and predicting connectivity patterns of marine species is crucial for the designation of protection zones and developing management plans for marine conservation. However, integrating marine connectivity into marine spatial planning remains challenging due to the complex interplay between the movement of marine species and environmental drivers. In particular, the effects of climate change on seascape connectivity are still poorly understood. In this work, we reconstructed and assessed the larval connectivity of European hake (Merluccius merluccius), a key commercial species in the Mediterranean Sea, using a Lagrangian simulation approach combined with network-based analyses, focusing on the Adriatic and western Ionian Seas. We explored different time horizons and climate scenarios under two Representative Concentration Pathways (RCP4.5 and RCP8.5) and identified possible sub-populations through community detection techniques, revealing ecologically meaningful management units. Our findings highlight that, despite climate change, the connectivity metrics and communities' spatial distribution across scenarios remain consistent, supporting their potential use as robust criteria for conservation planning. Nonetheless, the increased larval displacement speed induced by warmer waters and a reduction in the larval dispersal period as a metabolic response to climate change in future scenarios may result in stronger, yet more isolated and fragile sub-population structures. Finally, we assign connectivity roles to the nodes of the networks, reflecting their structural position within and across connectivity communities. Together with the identification of consistent connectivity communities across scenarios, this provides a robust basis for spatial management strategies aimed at maintaining population resilience under present and future climate conditions.

Forecasting weight at age using environmental variables

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Weight-at-age may be affected by environmental variables such as spawning stock biomass and water temperature, but forecasting these effects is not always possible. We investigated the potential for forecasting weight-at-age of 27 fish stocks. We investigated mechanistic Von Bertalanffy and Gompertz growth models as well as linear mixed (LMMs) and generalized additive mixed models (GAMMs). We used glmmTMB to fit the GAMMs, a new capability of the package. For model selection of LMMs, we tried both AICc and LASSO methods. For model selection of GAMMs, we used AICc. Our forecast evaluation procedure redid model selection for each validation dataset. We compared the model predictions to a naïve 3-year average. We found that with 15 out of 27 fish stocks at least one method had potential to forecast better than the naïve method. No single method performed the best across all stocks.

Hidden signals of density dependence in Eastern Baltic cod (Gadus morhua L.) revealed through stomach content and growth modeling

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Density dependence (DD) is a well-established concept in population dynamics, influencing vital rates such as mortality and growth. However, in changing ecosystems, patterns resembling DD can arise from other processes unrelated to changes in population abundance. These processes include shifts in prey availability and habitat compression, which can result in similar symptoms—reduced growth and increased mortality—but stem from different causes and may not reverse as abundance declines. The Eastern Baltic Sea population of Atlantic cod exhibits such symptoms. Yet, stomach content data did not reveal DD-typical changes in diet composition or overall energy intake. Instead, there was an increased frequency of benthic prey consumption, accompanied by a reduction in meal size when benthic items were eaten. This counterbalance masked any DD-like shift in average diet composition. By applying a stochastic bioenergetic growth model using numerical probability distributions of energy intake derived from stomach content data, it was possible to estimate the fraction of the population capable of surviving and growing. These findings highlight the extended utility of stomach content data, particularly when integrated into prey-dependent growth models within multispecies or ecosystem frameworks. Moreover, they emphasize the value of a nuanced interpretation of DD in forecasting population-level outcomes.

Integrating consumption by non-fish predators in stock assessments for more nuanced management advice

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Stock assessment of deteriorated stocks can be a challenge, because the quantity of available fisheries data decreases as management restrictions are implemented. In such cases, a good estimate of the notoriously difficult natural mortality (M) becomes increasingly important. Using the Western Baltic (WB) cod as a case study, we link M in the stock assessment to population dynamics of its main non-fish predators: cormorants, seals and harbour porpoises. The WB cod is currently at historic low biomass, despite many years with low quota. We find that predation from the non-fish predators has far surpassed fisheries mortality in recent years, and that M has been steadily increasing for more than a decade. Conservation of birds and mammals is associated with strong opinions and conflicting stakeholder goals. Results pointing to the WB cod being held in a predator-pit are controversial, as stock rebuilding may require predator culling. A better understanding and disentangling of the impacts of these animals on fish stocks is crucial, in order to make sound and effective management decisions.

Spatial variability and climate impacts on red mullet (Mullus barbatus) growth in the Central Mediterranean Sea

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Fish growth is shaped by the interaction between genetic potential and environmental conditions. Variations in factors such as habitat, resource availability, and fishing pressure can lead to spatial differences in growth, even among nearby areas. These differences offer valuable insights into population biology, ecological dynamics, and responses to anthropogenic and climate-induced stressors. Growth, therefore, characterizes each population of a species from a biological point of view (life history trait), but it also has ecological implications. Thus, growth may be an ideal candidate to explore the spatial variability in terms of habitat diversity, influence on the biology traits and ecology of fish species.This study investigates spatial variability in red mullet (Mullus barbatus) growth patterns across three areas within the South Adriatic (east side and west side) and Ionian Sea (Central Mediterranean Sea) by analyzing annual otolith growth increments from 2004 to 2016 using dendrochronological methods. This approach allows indirect assessment of environmental influences on growth over time. Key environmental variables—sea surface and bottom temperature, bottom salinity, oxygen levels, and net primary production—were integrated into the analysis. To explore future trends, climate projections under the RCP8.5 scenario were used to model medium-term (2058) and long-term (2098) growth forecasts. Findings revealed distinct spatial differences in red mullet growth, with higher growth rates observed in the eastern and northwestern South Adriatic areas compared to others. Among the environmental factors analyzed, temperature, both surface and bottom, was the primary driver that explain variability. Projected climate scenarios suggested an overall increase in growth by 2058 across most areas, followed by a generalized decline by 2098, indicating potential long-term negative impacts of climate change on red mullet growth dynamics. These results highlight the importance of considering spatial and temporal environmental variability when assessing fish population dynamics and managing fisheries under changing climatic conditions.

Management implications of climate-induced changes in reference points for commercially-important North Sea stocks

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A set of targets and limits - the so-called reference points - form the basis of sustainable fisheries management by which the current stock status can be compared. Often, they are determined through management strategy evaluation (MSE) simulations projecting the current stock perception under a series of fishing pressures up to equilibrium conditions. But what if a stock's productivity changes over time? In particular, changing environmental conditions under climate change can alter important life cycle characteristics, such as recruitment, growth or natural mortality. Periodic "benchmark assessments", e.g. conducted every 5–10 years, can account for reference points updates, but may lag behind if strong trends, variability changes or regime shifts are involved. They also imply strong assumptions and difficult decisions like truncation of recruitment time series to better reflect current and future productivity. Alternatively, dynamic reference points, e.g. via the explicit integration of environmental covariates in fitting stock-recruitment relationships to historic data, can be used in the projection of stock dynamics. We explored how climate change might act on recruitment dynamics for various commercially-important stocks within the North Sea utilising representative climate projections RCP4.5 and RPC8.5 of a regionally-downscaled climate model in an MSE-framework. The work estimates reference point changes under projected climate change conditions in the 2030s, 2040s and 2050s in order to identify potential directions of developments and implications for management, but also to highlight uncertainty involved in identifying suitable drivers as well as projections for the future. To facilitate further usability within the fisheries science community and ICES, we built on functionality within the established fisheries-libraries for R (FLR) framework ready to be used for future reference point determination.

Winners and losers under changing oceans

Marie Savina-Rolland, IFREMER, (Marie.Savina.Rolland@ifremer.fr)

An ecosystem approach to fisheries management involves considering fished species as integral components of their ecosystems and understanding the links between their productivity and the surrounding environment. In the HEUR project SEAwise, we investigated how environmental drivers impact key aspects of fish productivity, including reproduction, growth, body condition, and maturity. Our study focused on populations of fished species across Europe, ranging from the Baltic Sea to the central Mediterranean Sea. Our initial assessment was based on a comprehensive systematic literature review, which we then supplemented with targeted statistical analyses. These analyses aimed to detect the environmental effects on the productivity of 60 populations of 25 species across our case studies (Baltic Sea, North Sea, Western Waters and central Mediterranean Sea), and to explore whether incorporating these environmental effects enhances the predictive power of our population recruitment and growth models. This presentation will examine how the findings from the SEAwise project validate and build upon the existing body of knowledge. We will also explore how changes in the environment impact the productivity of fished species, depending on regions, biological processes, and the ecology and distribution of the species.

Session 4: Sustainable management of ecological effects of fisheries

Keynote: Caterina Fortuna, ISPRA: TBC

Variation in the ecological status of European marine ecosystems under different fisheries management strategies: Will all our wishes come through?

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Knowledge based decision making in fisheries management requires clear information on the effects of fisheries on marine ecosystems. The effects must be evaluated separately for regions and fisheries to allow managers to make informed, tailored and effective decisions. Here, we present an integrated evaluation of the impact of small and large scale fisheries using active or passive gears relative to agreed thresholds for sustainability. We evaluate the likely change in status or risk under different management and climate scenarios for retained species, non-retained bycatch species, seafloor habitats and foodwebs and speculate on the development in fisheries related litter in the Mediterranean, Bay of Biscay, Celtic Seas and the North Sea. The management scenarios investigated included fishing scenarios with different effort levels, closed areas and changes in relative effort of passive and active gears. We investigated whether scenarios with a higher proportion of landed stocks in good status also had a higher proportion of other ecological indicators in good status and the degree to which more restrictive, risk adverse management scenarios provided lower yields under current or future climate scenarios. In the North Sea and Celtic Seas, more landed stocks in good status coincided with a higher proportion of other ecological aspects in good status, whereas in other areas, the two were unrelated. Under the likely climate warming scenarios, landings declined on average in all alternative fishing scenarios compared to landings under climate warming and current management. This suggests that attaining a greater proportion of ecological indicators in good status under climate change will come at the cost of lower landings and that this cost will be greater under future warming than had the current climate conditions persisted.

Saving our seafloor habitats: what will it take?

Gert Van Hoey, ILVO, (gert.vanhoey@ilvo.vlaanderen.be)

Many benthic habitats in the Northeast Atlantic and the Mediterranean Sea have been exposed to physical disturbances over a long period and are not in a good environmental state (OSPAR QSR 2023). Mobile bottom trawling is one of the primary causes of anthropogenic physical disturbance to the seafloor ecosystem. Therefore, sustainable management of this fishery is urgently needed to help restore and improve habitat conditions. Through this contribution, we invite you to follow our SEAWISE journey and share some of the key lessons we've learned along the way. Large-scale assessments are essential to evaluate the extent of adverse effects caused by different types of mobile bottom trawling on the habitats. One method suitable for such large-scale evaluations is the Relative Benthic State (RBS) approach. This method estimates the risk of habitat degradation by analyzing fisheries depletion and the recovery potential of the habitats. This approach has been further applied across several regions (including the Bay of Biscay, Celtic Seas, Adriatic and Ionian Sea) within the SEAWISE project. In our work, we aimed to provide insights into fisheries management measures using these benthic habitat assessments. To this end, we examined scenarios of spatial restrictions (e.g., Marine Protected Areas), sometimes combined with effort reduction, and tested across various scales (e.g., habitats, member state EEZ). Spatial restrictions generally showed minimal effects on mean RBS values, particularly at large scales, with habitat-specific responses and effort displacement sometimes causing a strong dichotomy in effort distribution and impact. To save our seafloor habitats, a decrease in overall fishing effort may gradually improve seafloor health, but the required effort reduction or area protection for specific improvements remains uncertain and context-dependent.

Seafloor Disturbance and Benthic Status under Fishing Pressure in the Adriatic and Western Ionian Seas: Management-Oriented Analysis

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Bottom-trawl fisheries using mobile gears can significantly alter seabed integrity, compromising benthic ecosystems and threatening marine biodiversity. The extent of such impacts depends on the natural vulnerability of benthic habitats, the characteristics of the fishing gear employed, and the temporal and spatial intensity of fishing pressure. This research investigates the condition of benthic communities in the Adriatic and Western Ionian Seas (GSAs 17, 18, and 19 in the Mediterranean) by applying the Relative Benthic State (RBS) indicator, which integrates spatial data on fishing disturbance with habitat-specific sensitivity. The study, conducted within the SEAwise project and building on the ICES WGFBIT framework, aims to inform ecosystem-based fisheries management by identifying areas where conservation and sustainable fishing must be carefully balanced. Results show clear spatial contrasts: the Adriatic Sea, with its high density of trawl activities targeting muddy shelf environments, exhibits widespread benthic negative impact. Conversely, the Western Ionian Sea has higher benthic status, likely due to its deeper waters and lower trawling intensity. To evaluate options for mitigation, two alternative management strategies were simulated. The first involved spatial closures in ecologically vulnerable zones, redirecting fishing activity toward less sensitive habitats. The second scenario simulated a progressive reduction in overall fishing effort over a five-year period, consistent with the regional management framework. While the first scenario produced localized ecological improvements, the second yielded broader positive outcomes at the regional scale. The study highlights the necessity of spatially explicit and adaptive management approaches to reduce fishing impacts, preserve habitat quality, and maintain the resilience and functionality of marine ecosystems over time.

Distribution and change in seafloor macro-litter in European seas and the pressure induced on key species groups

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Marine litter on the seafloor is a primary societal concern for marine ecosystems. Litter can impact marine animals after ingestion or entanglement, resulting in adverse effects, including death or injury. Further, litter is eventually broken into smaller pieces that may introduce contaminants in the food chain through consumption by filter- or deposit-feeders. Changes in the macro-litter amount on the European seafloor are monitored in several ways, including the trawl surveys that are the basis of this study. The analyses used a common modelling approach from the Baltic Sea to the Mediterranean and demonstrated a comparable density of fishing related (FR) litter in all the studied areas. In contrast, Single Use Plastic reached higher density in the Bay of Biscay and Mediterranean than in the NE Atlantic, Irish Waters and the Baltic Sea (from around 150 to 15 items/km2). The distribution of hotspots of FR litter and key fish species showed a high overlap in the South Adriatic. In 2012, around 10 items/km2 of FR litter were detected in the NE Atlantic, whereas in the last sampling year this category had increased to around 22 items/km2 , more than doubling in 10 years. A similar rate of increase was seen in litter posing entanglement risk and ingestible litter. The combined analysis of fishing effort and FR litter demonstrated some degree of overlap, but low correlations. The reason is presumably that, similarly to other litter types, FR litter accumulates on the seafloor and the density will be the result of long-time processes. Ongoing initiatives in Europe (e.g. trend assessments from trawling data, thresholds from image-based seabed litter analysis) and a threshold of 38 items/km2 (all litter categories), adopted by UNEP/MAP in the Mediterranean Sea, require a significant reduction of litter density estimated from long-term trend analysis of surveys.

Using Management Strategy Evaluation (MSE) to examine impacts of changing gear selectivity on bycatch and escape mortality

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Bycatch of undersized fish (e.g. below the Minimum Landing Size) threatens sustainable fisheries management by increasing the risk of growth overfishing. Growth overfishing can also be driven by additional mortality of escaping individuals, a process that remains mostly unknown. Bycatch and escape mortality of undersized fish are, at least partially, attributed to gear-specific characteristics used by individual fleets within a fishery. We developed and conducted a desktop Management Strategy Evaluation (MSE) that examines impacts to both stock and fishing fleets of changes in gear-specific selectivity characteristics. The demersal seine fleet in the Northeast Arctic haddock (Melanogrammus aeglefinus) fishery is used as a case study, where retention and escape mortality estimates for alternative gears are available from extensive field experiments. Size-selectivity may have disproportionate effects on haddock productivity, which is characterized by spasmodic recruitment and density-dependent mass and both are projected in MSE simulations. A stochastic length-at-age relationship is used to translate the effect of length-based selectivity on age-based stock and catch dynamics. Results from MSE simulations suggest even incremental shifts in gear-specific selectivity characteristics can shift overall catch composition toward larger fish. The results also quantify tradeoffs in performance of different fleets within a fishery between alternative modifications to gear-specific selectivity. This study highlights the use of MSE to provide usable information for both managers and fishers on the impacts of changes in fishing practices, not just quotas.

How bycatch rates of ETP species vary spatiotemporally and with covariates

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Since 2010, in Denmark, electronic monitoring (EM) has been routinely done in gillnet fisheries to collect data on bycatch of endangered, threatened and protected (ETP) species. The EM data is collected at a fine spatial and temporal scale, including time, position, and effort of each fishing operation, whether or not there was a bycatch event. Effort is in the form of net-length and soak-time. The EM data allowed us to model bycatch per unit effort and how it changed with location, time, and different aspects of the fishery. Separately, standard national logbook data gives us an overall approximation of the total effort in the Danish gillnet fisheries. These data were then used to extrapolate estimates of annual total bycatch of ETP species. Annual total bycatch is a nonlinear function of the model parameters including a spatio-temporal random effect. Recent statistical developments have shown that, in this case, estimates can be improved using a bias correction method that was recently implemented in glmmTMB. Here, we present these statistical models and the resulting estimates of annual bycatch of porpoises, seals, cormorants, common eiders, and alcides in Danish gillnet fisheries.

Evaluating ecosystem model (EwE) derived indicators to track climate change impacts in the Aegean and Eastern Ionian Seas

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The European Union's Marine Framework Directive (MSFD) has acknowledged the importance of maintaining marine food webs in a Good Environmental Status (GES) for the long-term provision of essential ecosystem goods and services. Consequently, it has established a requirement to monitor the state of European marine ecosystems and their responses to variable environmental and anthropogenic pressures. A significant challenge exists, however, in identifying the indicators that most effectively track perturbation-induced shifts in food webs. According to the current criteria and methodological standards of MSFD, a relatively simple breakdown of the ecosystem into trophic guilds is a sufficient approach to improve GES monitoring and management. In this study we projected the future responses of two Ecopath with Ecosim (EwE) models developed for the Aegean Sea (AS) and the Eastern Ionian Sea (EIS) to three climate simulations (baseline, RCP4.5 and RCP8.5) for the period 2021-2050. We then assessed the response of five ecological indicators (Biomass, Mean Maximum Length, LSI, Mean Trophic Level and Shannon's Index) estimated for five trophic guilds (apex predators, sub-apex pelagic predators, sub-apex demersal predators, planktivorous fish and invertebrates, benthic feeding invertebrates) by estimating the relative change (%RC) in relation to the baseline scenario in three time-periods (2026-30, 2036-40, 2046-50). Although ecological indicators highlighted significant structural differences between the two systems, the effects of climate change were intensified in both systems in the long-term under the RCP8.5 scenario. Climate warming seemed to induce cascading effects linked to top-down processes stemming from increased indicator values for apex predators (Bi, MML, MTL) under all scenarios and time periods in the AS and only in the long-term in the EIS. Our findings emphasize the necessity for fisheries management to incorporate climate-adaptive measures in order to prevent future declines of marine resources from the potentially devastating impacts of climate change on Mediterranean marine ecosystems.

Towards robust operationalisation of an ecosystem approach to fisheries under climate change and increasing use of the sea

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Sustainable development relies on environmental, social and economic sustainability. Within the sector of fisheries, science based advice is vital to secure environmental sustainability. The advice should reflect relevant harvest control rules developed in cooperation with fisheries managers, be transparent and based on best available scientific knowledge and methods. The ecosystem approach to fisheries (EAF) has now been around as a concept for fisheries management for more than two decades. Over this period, many different conceptual approaches have been developed, with different ambition levels in terms of operational application of the framework. Here we discuss operationalisation of EAF in Norway in a setting of ongoing climate change and increased use of the sea. This will be stock specific, where management objectives, data availability and acceptable risk levels determines management action. Firstly, we discuss the operationalisation of EAF in a Norwegian context. Thereafter, we suggest how climate change can be handled by giving advice on appropriate harvest levels that take into account the effect of climate changes on stock productivity, in line with optimal exploitation of stocks. We demonstrate how keeping exploitation levels below or at FMSY strengthen stock robustness towards climate changes by supporting stock abundances and age and size distribution ranges, and conclude that more effort should be given to surveillance of stock productivity and respond to changes with frequent MSEs, as well as scenario analysis, developed in cooperation between science and management. Finally, we present examples and discuss options for reducing effects of fisheries on habitats and bycatch of juvenile fish and vulnerable species, and how explicit multispecies considerations and trade-offs as well as indirect foodweb effects are included in the Norwegian approach to EAF.

Session 5: Spatial management for Ecosystem Based Fisheries Management

Keynote: Spatial Ecosystem-Based Fisheries Management: From Scientific Advances to Implementation Realities

Howard Townsend, Fisheries specialist, acting independently [redacted]

The science to support spatial Ecosystem-Based Fisheries Management (EBFM) is advancing, driven by the need to move beyond single-species approaches that are unable to capture the important spatial dynamics of marine ecosystems. This presentation examines how spatial EBFM represents a shift towards managing fisheries as a whole system, and recognising that fish populations are distributed dynamically and non-uniformly. In addition, different areas within ecosystems hold varying ecological importance for species interactions, habitat functions, and ecosystem resilience.

Current progress centers on understanding spatial dynamics, through habitat mapping and characterisation of critical areas, such as: spawning grounds, nursery habitats, and feeding areas. Recent work in spatially explicit ecosystem modeling simulates complex ecosystem dynamics and predicts management impacts across different spatial scales. Key advances include the integration of fisheries-dependent and independent spatial data analysis, enabling improved assessments of population status and management effectiveness.

New technologies, e.g., remote sensing, telemetry/GPS tracking, and real-time monitoring systems are improving our ability to understand fish movements and habitat use patterns. Spatially explicit management strategies are being developed and tested. While progress is being made, challenges to implementation persist, including data limitations, the inherent complexity of predicting ecosystem responses, and the need for meaningful stakeholder engagement. Climate change impacts are also increasingly being incorporated into spatial management frameworks, alongside ongoing efforts to improve data sharing and accessibility across jurisdictions. Governance flexibility to balance scientific rigor with practical implementation is needed – in particular coordinated governance approaches that can effectively integrate human dimensions, while maintaining ecosystem health and fishing community resilience in an era of rapid environmental change.

Projecting Ecosystem Impacts of Spatial Developments and Climate Pressures in the North Sea Using OSMOSE

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The North Sea is one of the most intensively used marine ecosystems in the world, supporting a wide array of human activities including shipping, energy production, and commercial fisheries. As pressures from these sectors continue to grow in response to rising global demand, so does the need for integrated management strategies that can safeguard ecosystem integrity. Among the most prominent spatial drivers of change are the establishment of Marine Protected Areas (MPAs) and the rapid expansion of Offshore Wind Farms (OWFs), both of which are reshaping the spatial footprint of human activity across the seascape. At the same time, climate change is driving shifts in species distributions and ecosystem structure, introducing additional complexity to marine spatial management. This study uses the North Sea OSMOSE (Object-oriented Simulator of Marine ecOSystEms) model to examine how combined pressures from climate change and spatial management influence the structure and function of the North Sea ecosystem. The model simulates trophic interactions and population dynamics for 14 ecologically and commercially important fish species, enabling scenario-based assessments under an Ecosystem-Based Fisheries Management (EBFM) framework. Climate effects are incorporated as bottom-up changes in productivity, while spatial closures are represented through top-down shifts in the distribution of fishing effort. Results indicate that climate-induced changes are likely to be the dominant driver of biomass trends across most species groups. However, specific benefits may emerge from spatial management: for example, species such as sandeel, which strongly overlap with the Dogger Bank MPA, or demersal benthivores sensitive to localised fishing pressure, could experience relative gains despite overall declines in productivity. This work underscores the importance of adaptive, ecosystem-informed planning in ensuring resilient marine ecosystems under future environmental and socio-economic conditions.

Evaluating Fisheries Management Scenarios for the Eastern Ionian Sea: Spatiotemporal Prohibitions, Effort Controls, Climate Change Adaptation, and Greece's Political Commitments

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This study examines the effects of spatial management measures on fish and fisheries in the eastern Ionian Sea using DISPLACE, a dynamic, spatially explicit bio-economic model. The model simulates individual vessel behavior while integrating ecological, economic, fisheries, and climate-related parameters. Approximately 3,600 vessels across five fishing fleet segments were modeled and provided outcomes on a 10-years horizon (on an hourly basis), by incorporating fine-scale spatiotemporal distributions of fishing effort for trawlers, purse seiners and small-scale fisheries (SSF). Due to the lack of Vessel Monitoring System data for SSF vessels (<12 meters, 95% of the Greek fleet), an extended Multi-Criteria Decision Analysis approach was refined to predict SSF effort, and outcomes were incorporated into the model. Fine-scale abundance data for nine key commercial and vulnerable bycatch species were included, along with biological, fisheries-related parameters and climate change projections to assess potential effects on species distributions and productivity. Management scenarios were then explored, including trawl restrictions in Marine Protected Areas (MPAs), spatiotemporal closures on hake nurseries and sensitive benthic habitats, overall effort reductions, while considering future climate conditions. The most ecologically effective scenario combining the closure of hake nursery grounds with an overall fishing effort reduction, contributed to objectives related to increasing hake’s spawning stock biomass (+13%) and reducing bycatches (-25%), while economic impacts varied by fleet segment. In contrast, MPA closures led to effort displacement yielding limited ecological benefits, while economic losses reached -25%. This, along with findings that important benthic habitats were beyond the borders of protected areas in Greek waters, highlights the need for further action and questions the effectiveness of political commitments to ban trawling in all MPAs. Our study highlights that achieving sustainable socio-economic and environmental goals requires targeted research efforts to support operational Ecosystem-Based Management, while considering spatial dynamics, climate change and effort displacement effects.

Bio-economic spatial modelling: evaluation of viable management measures in Central Mediterranean Sea

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Spatial management can play a key role on the improvement of the exploitation pattern of target stocks through the implementation of closure areas in Essential Fish Habitats (EFH) (i.e. nursery and spawning grounds of commercial species) or in hotspots of by-catch species. In recent years, new Fishery Restricted Areas (FRA) have been established in the Adriatic Sea (GSAs 17-18), that is becoming one of the Mediterranean sub-regions with the highest percentage of FRA. Assessing the effects of area closure is essential for informed, knowledge-driven decision making and for implementing an Ecosystem-Based Fisheries Management (EBFM). In SEAwise project, management scenarios based on new closure areas were simulated in the Adriatic (GSAs 17 and 18, GFCM sensu) and western Ionian Sea (GSA19) and a novel spatial sub-model (Spatial-BEMTOOL), communicating with BEMTOOL bio-economic model, was developed to evaluate social and ecological impacts of fisheries management measures. Spatial-BEMTOOL is implemented to integrate alteration of stock distribution and to predict the consequent effort reallocation based on the fishers' adaptation to management measures. Spatial BEMTOOL includes a component modelling the stock distribution along the time according to climate change, life-history traits and spatial fishing pressure, the latter integrating two behavioural sub-models: 1) the specialists' one, minimizing fuel costs and fishing nearby the home port, 2) the switcher one, maximizing revenues by targeting distant, high-profit fishing grounds. The optimization algorithm driving the effort reallocation are defined depending by the identified local fishing communities. The integration in Spatial- BEMTOOL of the fishers' behaviour sub-model enables spatial quantification of changes in exploitation patterns and economic performance, accounting for shifts in fuel consumption and revenues due to effort reallocation. This component supports identifying management trade-offs by incorporating fishers' responses to spatial restrictions, while also assessing the impacts of climate change on various fleet segments and fishing communities.

A spatiotemporal decision tool for fishers, starting with bycatch mitigation

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A novel spatiotemporal decision tool for fishers at métier level is being developed to support ecosystem based fisheries management (EBFM). The tool combines habitat information for targeted, unwanted (e.g., choke), and protected species to provide a multi-species evaluation of spatial distribution in near real-time. This approach allows for the assignment of weighting factors to each species, representing the desired balance between catching targeted species, avoiding unwanted bycatch, and protecting vulnerable species, while considering their conservation status. Two case studies are being developed: a pelagic longline fishery for bluefin tuna with the most vulnerable stages of blue shark as bycatch, and a demersal bottom trawl fishery for deep-water rose shrimp and Norway lobster with juvenile European hake as main unwanted bycatch. The tool generates ensemble habitat maps that identify areas with optimal trade-offs among management objectives, categorized into high, medium, and low priority areas for bycatch mitigation. This spatiotemporal approach can be used to estimate the potential effectiveness of bycatch mitigation measures. Similarly, for a given bottom fishing fleet and adding the recent cumulative effort, the spatial overlap can be used to evaluate the socio-economic impact of selecting sustainable fishing grounds. This decision tool offers a concrete basis for future smarter fisheries, balancing conservation and fishery sustainability objectives while strengthening governance of high and coastal seas. Future developments will incorporate additional layers, such as distance to port, regional fish prices, fuel costs, sea state, biodiversity hotspots and other spatial restrictions (energy, MPAs, human infrastructures), to improve the tool's usefulness and effectiveness within a compatible Maritime Spatial Planning framework. This research contributes to the evaluation of spatial management measures for EBFM, aiming to reduce bycatch, protect sensitive species and habitats, and increase socio-economic benefits for fishers in agreement with the principle of fishing less but better.

Scenarios of spatial fishing closures indicate lower but more concentrated fishing effort for southern the North Sea

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The North Sea is a global hotspot for anthropogenic activities such as fishing, shipping, and fossil and green energies. Especially offshore wind farms (OWF) have been increasing in the last years and ambitious targets for green energy promise a strong expansion in the next two decades. Concurrently, nature conservation measures, i.e. no-take zones (NTZ), have been implemented and conservation plans ask for larger marine protecting areas. Both OWFs and NTZs reduce the space available for fishing and potentially displaces fishing effort. These changes pose challenges for North Sea fishers and introduce large uncertainties for their future existence, as well as for fisheries management. Here, we apply FISHCODE, an agent-based model (ABM) for German fisheries in the southern North Sea, to test scenarios of these pressures. FISHCODE simulates the most relevant German fisheries in the southern North Sea and has emphasis on flexible fisher behavior beyond profit maximization making it suitable to simulate adaption to new situations. Results revealed a displacement and reduction of fishing effort and profits for all scenarios, i.e. more OWFs (state 2030 and 2040) and NTZs. OWF scenarios affected mostly flatfish and Nephrops fisheries, while brown shrimp fishing effort was heavily affected by the closing of all currently designed MPAs to fishery. In all scenarios, fishing effort intensified in the remaining open areas, which could have negative effects for ecosystems. Overall, we provide insights that are helpful to anticipate fishery’s responses to change and therefore can support future-oriented marine spatial management, a cornerstone for ecosystem-based fishery management.

A win-win-win for fish and fisheries? restoration of habitats key to improving stocks, catches and marine ecosystems

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For a large proportion of fish species, coastal nurseries are critical habitats that support the key juvenile phase of the life cycle, as fish depend on them for their growth and survival to adulthood. These habitats face numerous anthropogenic pressures, whose local impacts on juvenile fish habitats are documented. Yet, these impacts are poorly quantified at population and fisheries level, at a dramatically wider scale. We developed and a generic modelling approach to investigate how loss and degradation of essential habitats affects the productivity of commercial fish stocks. The model integrates the dependence of recruitment on juvenile habitats with a parameterization that rely on juvenile habitat quality and surface area. This model was applied to assess the potential impact of restoring estuarine nursery grounds for exploited fish species of main fisheries interest, from scenarios using previous estimates of both local nursery area loss and decrease in juvenile density. Habitat restoration would lead to substantial increases in reproductively mature stocks (e.g., up to 52% in the stock of reproductively mature seabass), meaning more fish in the sea, with beneficial consequences for the sustainability of fish populations and the wider ecosystem, and more quotas for fishermen in the long run. Indeed, habitat restoration, and measures to tackle the effects of pollution and proliferating coastal development, may be just as important to ensuring healthy fish stocks as regulating fishing pressure; and could mean thousands of more tons of fish for fishermen.

Anticipating how spatial fishing restrictions in EU waters perform to protect marine species, habitats, and dependent fisheries

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This study investigates the implications of spatial management strategies on fish populations and fisheries across EU waters, particularly focusing on establishing potential areas for fishing closures to protect nurseries, benthic communities, and biodiversity hotspots in the Northeast Atlantic and Mediterranean. The research addresses the effectiveness of prohibiting certain fishing practices in the context of the EU Common Fisheries Policy (CFP). Based on spatial ecosystem modelling which provides insights into species interactions and distribution shifts, and bioeconomic fisheries models which incorporate finely defined fishing fleets and economic dynamics, we investigate spatial- and effort-based fisheries management strategies. Our findings emphasize that redistributing fishing effort without reducing overall effort and catches may not negate intended decreases in mortality rates of sensitive marine species or restoration of vulnerable marine habitats to the status targeted by the European marine legislation (EU MSFD). We highlight the complex interplay of social, economic, ecological, and institutional factors influencing fishers' decision-making in effort displacement. As the proportion of closed regions increases, potential effects on marine ecosystems can even be damaging to some species and habitats in the short term, emphasizing the importance of the placement of closed areas and of combining area-based management with other fishery management measures. Findings from case studies in the North Sea, Mediterranean, and Bay of Biscay indicate that prohibiting certain fishing practices in designated areas will likely induce short-term economic losses on the fisheries economy of specific fleets. Where the prohibitions contribute to improved selectivity or productivity of the fish stocks, these losses may be regained in the long term. Finally, the long-term benefits for marine life that are expected through the spatial protection of vulnerable life stages and habitats will rely on the extent to which climate change affects ocean productivity and distribution of species and habitats.

Marine Protected Areas as tools in European ecosystem-based fisheries management: Existing compatibility, objective misalignment, and potential for future fisheries objectives

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Fisheries management in Europe requires ecosystem considerations in the regulation of fisheries activities (European Commission, 2023/103). Europe also has other conservation objectives, focussed on protecting marine habitats and vulnerable species (Directive 2008/56/EC). Furthermore, a desire to prevent biodiversity loss has been expressed in pledges to protect and restore marine habitats (Regulation 2024/1991). In the context of these many objectives and legislative mechanisms, how are MPAs around Europe currently interacting with fisheries, how do the various fisheries regulations they impose align with their stated conservation objectives, and in what contexts might future MPAs be designed to incorporate fisheries objectives? These three questions are addressed using empirical data from an augmented, European wide database of MPAs, a comprehensive data call on fishing activities in MPAs, the application of a SEAwise systematic literature review, and a novel systematic review of spillover from MPAs. We conclude that currently, European MPAs are focussed on specific conservation goals, but the evidence that these objectives are ever achieved or improved upon is lacking. These MPAs are not established as fisheries management tools, but often impose regulations on fishing activities. Even where these regulations are in place, they often lead to no change in fishing behaviour, because of their implementation where there is low or no conflict with fisheries. Furthermore, while empirical studies of spillover from MPAs is sparse, we find that there are conditions under which spillover from MPAs could be a feasible objective. Such conditions include the MPA's age, position relative to the coast, and relationship to an MPA network; as well as the life-histories and traits of the organisms of interest (e.g. broadcast spawning vs brooding, walking vs swimming). The integration of conservation and EBFM objectives in the planning and design of MPAs will both improve their efficacy and their acceptance as a management tool.

Session 6: Management advice integrating predicted effects on social and ecological systems

Keynote: From simulations to successful operationalisation of management advice that achieves Ecosystem Based Fisheries Management

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Accounting for trophic interactions in tactical management models and decision-making frameworks remains rare and is further complicated by climate change as well as the need to also consider social and economic processes when advancing towards ecosystem-based fisheries management (EBFM). Although a range of methods exist, the fitness for tactical management depends inter alia on technical specifications, urgency of need, trust and buy-in from scientists, managers and stakeholders, as well as demonstrated reliability of advice used to underpin management decisions. Promising approaches include use of MICE (Models of Intermediate Complexity for Ecosystem assessments) and MSE (Management Strategy Evaluation). MSE involves evaluating and modifying harvest control rules (HCRs) to adjust management responses in such a way as to meet pre-specified objectives (which may include ecological, economic, social and/or broader ecosystem objectives). Given the overwhelming complexity of operationalising EBFM, this talk also outlines how use of more formal multispecies harvest strategies can help guide structured specification of objectives, reference levels, methods, and HCRs, as well as testing the robustness of management rules to climate change. To illustrate these concepts, I draw on examples of the methods and management strategies tested and applied to the Torres Strait tropical fisheries as well as Australia's multispecies northern prawn fishery. The Torres Strait example highlights the utility of MSE in evaluating complex trade-offs between economic, biological and social factors. The multispecies prawn example extends beyond considering technical interactions to also account for ecological interactions and habitat dependencies, compound climate change drivers as well as need to mitigate negative impacts on fish habitats and recruitment due to competition with non-fishery sectors. Finally, I summarise progress made and remaining gaps in our ability to collectively develop management advice that more holistically integrates key social and ecological considerations.

Climate-Resilient Management Strategies: Impacts on Ecosystems and Fisheries Economics in Mediterranean Sea

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Ecosystem-Based Fisheries Management (EBFM) seeks to conserve biodiversity and ensure the long-term viability of the fisheries sector by managing scientific uncertainty through a precautionary approach and integrating ecological, economic, and social dimensions into decision-making processes. Over the past two decades, significant declines in demersal stocks in the Adriatic and Western Ionian Seas have prompted the implementation of targeted fishery management measures. However, the Adriatic Sea—one of the most productive yet heavily overfished regions in the Mediterranean—remains particularly exposed to environmental impacts, underscoring the urgent need to assess the robustness of existing and alternative management measures under climate change scenarios, by multi-fleet and multi-stock models. This research builds upon the SEAwise project work, integrating an enhanced version of the BEMTOOL bio-economic model and an Ecopath with Ecosim (EwE) ecosystem model for the Adriatic and Western Ionian Seas. The two models were developed with consistent stock and fleet resolution to maximize comparability and facilitate interaction. Biomass-at-age outputs from BEMTOOL have been used to inform EwE, and fishing mortality estimates from BEMTOOL have been integrated in EwE as external drivers. The BEMTOOL results demonstrate the effectiveness of effort reductions measures to achieve target fishing mortalities for the most vulnerable stocks under a strict Maximum Sustainable Yield (MSY) approach promoted by the GFCM Multi-Annual Management Plans. These reductions are expected to have a negative impact on employment, while increasing the food production (i.e. number of adult meals served) due to stock recovery. The ecosystem model predicted that climate change would reduce biomass across most functional groups; these adverse effects could be partially mitigated under MSY and PGY management scenarios. Consistently between models, the Pretty Good Yield approach has been identified as a trade-off scenario, producing similar biological benefits with smaller economic losses outcomes.

Optimizing effort of mixed demersal fisheries to maximize sustainable yield and protect seafloor integrity in the Celtic Seas

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Ecosystem-based fisheries management (EBFM) in Europe is guided by the Common Fisheries Policy, which aims to sustainably manage exploited species and contribute to the protection of the marine environment. Sustainable use of fish stocks is implemented through Total Allowable Catches (TACs) based on Maximum Sustainable Yield (MSY) for single-species stocks. Many demersal fisheries catches are mixed as species cannot be selectively harvested. Quota exhaustion of the most limiting species leads to discarding or chokes fishing effort under a landing obligation policy. To protect the marine environment, the EU Marine Strategy Framework Directive (MSFD) and UK Marine Strategy set qualitative descriptors to achieve Good Environmental Status (GES). This study focused on seafloor integrity as one key descriptor impacted by fishing and considered GES achieved when 75% of each MSFD-defined habitat type met a threshold for the risk-based indicator 'Relative Benthic State'. Our study aims to tackle both (1) the mixed fisheries challenge and (2) the development of MSFD measures to protect seafloor integrity. Métier-specific effort management was simulated as a common solution to both objectives. Using optimization algorithms and scenario development we explored whether TACs of multiple fish stocks could be matched with the catch profiles of mobile fishing métiers by balancing their effort levels. Similarly, we balanced their effort to ensure that benthic depletion levels did not exceed GES thresholds for habitat-specific benthic community biomass. Effort changes of static gears were kept minimal to prevent increasing the risk of bycatch of seabirds and marine mammals. Finally, we integrated both policy objectives and examined how changes in métier-specific effort could help align fish catches with multiple TAC levels and habitat-specific depletion thresholds. Our study investigated how constraining Total Allowable Effort of fishing métiers could integrate multiple objectives and support the operationalization of EBFM in the mixed demersal fisheries of the Celtic Seas.

From Single Stocks to Ecosystems: Advancing Fisheries Management with Mixed Fisheries Models

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Ecosystem-Based Fisheries Management (EBFM) addresses the limitations of traditional single species fisheries management, aiming for a more comprehensive and holistic approach to ocean governance. Although significant progress has been made over the last decades in EBFM, advice on fishing opportunities still relies predominantly on single-stock assessments. Ecosystem models of varying complexity emerged, striving to capture the dynamics of entire ecosystems. While these models have garnered considerable academic recognition, their application in real-world management decisions remains limited. Meanwhile, stakeholders are increasingly demanding the incorporation of global change, inter-stock interactions and broader ecosystem considerations in single-stock assessments. Mixed fisheries models represent a vital pathway for advancing EBFM, as they encompass key stocks caught by fleets in specific regions and describe fishing activities, enabling the assessment of socio-economic impacts of management strategies. In the Seawise project, mixed fisheries approaches across European regions were further developed to align with EBFM principles. The developments were approached from two sides, by incorporating dynamic processes to model the elements that were already part of these models, such as recruitment and prices, and by defining new indicators associated with exogenous components related to the endogenous variables of the mixed fisheries models. A key advantage of mixed fisheries models is their consistency with single-stock assessments, allowing existing frameworks to be adapted for mixed fisheries management. Based on their implementation in six European regions, we identified the strengths and weaknesses of these models, offering recommendations for future development and practical implementation to inform fisheries management.

A multi-criteria approach to support decision making in ecosystem-based fisheries management

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Fisheries management requires decision-makers to balance multiple, often conflicting, objectives such as maximising fishing yields and profits while minimising ecological and social impacts. Multi-criteria analysis offers a conceptual framework to support the decision process by explicitly highlighting trade-offs between competing viewpoints and by addressing objectives that cannot be reduced to a single dimension, such as monetary value. Within the H2020 SEAwise project, we developed a decision support framework based on Multi-Attribute Utility Theory to compare alternative management strategies. The framework involves 1) identifying a set of indicators that measure performance across multiple dimensions reflecting different management objectives; 2) developing utility functions to represent the satisfaction associated with different indicator values; 3) assigning weights to indicators to reflect their relative importance in the decision; and 4) aggregating weighted utilities into a composite score representing the overall performance of each strategy. We applied this framework to three case studies (the mixed fisheries of the Bay of Biscay, the North Sea, and the Adriatic and western Ionian Seas) to evaluate the overall performance of alternative management strategies under different climate scenarios (current climate, RCP4.5 and RCP8.5), time horizons (from present to 2060) and weighting schemes (equal weighting, environment first, economy first). In the Bay of Biscay, the status quo strategy generally performed best, particularly when economic priorities were emphasized, with minimal sensitivity to climate change. In the North Sea, the status quo strategy consistently produced the lowest utilities, while alternative strategies were more resilient to climate impacts, which notably reduced biodiversity and revenues. In the Adriatic and western Ionian Seas, FMSYbased strategies consistently outperformed others, although climate change lowered overall utilities. Across all regions, the optimal management strategy was highly dependent on the climate trajectory, the decision-making timeframe, and the relative importance assigned to the management objectives.

Operationalising EBFM: Insights and Reflections from the BoB case study

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Moving forward from the traditional fisheries management towards the ecosystem-based fisheries management (EBFM) requires adapting and further developing the tools that are used currently for providing scientific advice. Mixed fisheries models that account for technical interactions between species caught together provide a suitable tool to advance towards the EBFM as they link the biological component and socio-economic components of the fisheries socio-ecological system.

In this work we focus on the Bay of Biscay region to illustrate how a mixed fisheries model can be shaped to tackle some of the key challenges posed by EBFM such as the coverage of the different parts of the ecosystem, the inclusion of environmental drivers affecting stocks' productivity, the evaluation of the impact of fishing on the ecosystem and the simulation of alternative management strategies that go beyond mono-specific catch limits. First, we describe how the different elements were included and showcase the type of results that can be obtained. Then, we conduct a critical review of what has worked well and what has not, identifying potential areas for improvement. Finally, we define a roadmap to develop the approach further in the future to operationalise its use for EBFM in the region.

Time varying reference points as a pathway to include ecosystem processes in fisheries management

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A cornerstone in marine fisheries management is the application of fisheries reference points, to ensure that stocks are caught at sustainable levels. Reference points determine the amount of fishing pressure a stock can sustain by either keeping the biomass above a level that does not impair recruitment (e.g., Blim), or by regulating the fishing mortality to match the productivity of the exploited stock (e.g., Fmsy). Historically, reference points have been assumed static by assuming a fixed recruitment regime, natural mortality, and growth. However, in a changing ocean this assumption may risk sustainable fisheries. To this end, we run a management strategy evaluation (MSE) with stock assessments that can account for environmental changes in both the operating model (OM) and estimation model (EM). We test the application of time varying reference points and compare it to simulations that assume static reference points. We compare the performance metrics in terms of yield, risk of overfishing, and interannual catch variability. We evaluate the uncertainty and contextualize the results in relation to current fisheries management to provide an avenue for improving the sustainability of fisheries in the future.

Prototype management strategy evaluation for ecosystem-based fisheries management in the Northeast USA

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Successful EBFM requires understanding and acceptance by decision-makers of the benefits of approaches, and how ecosystem advice can be translated to management action. As part of efforts toward EBFM by the New England Fishery Management Council, we conducted a prototype Management Strategy Evaluation, including a small-scale stakeholder engagement process and a closed loop simulation framework. We tested alternatives for providing catch advice using aggregated stock complexes, as well as status quo single species management, for mixed fisheries on Georges Bank. Proposed stock complex management included assessments and control rules at the aggregate stock level with ceilings on whole-of-system catch and indicator-based adjustments to catch advice based on individual species status relative to thresholds, to direct catch quotas and prevent species-specific depletion. A multispecies operating model accounted for trophic dynamics between ten stocks of interest and modeled fishing dynamics included mixed species fleets, with effort resulting in harvest of multiple species. Stock complex approaches were able to meet management goals like increased yield and less underutilized quota without stocks falling below thresholds compared to single species approaches. This pattern held, whether using trophic or gear stock complexes, if fleet dynamics were based on availability or price, or if reference points were static or dynamic. Stock complex alternatives were more able to take advantage of abundant species within complexes because catch advice was aggregated over species, rather than fishing being constrained by catch of each stock within a complex. In ongoing work, we are comparing performance of a range of risk policies and ecosystem control rules with more realistic fleet dynamics and when multispecies operating model dynamics are subject to environmental impacts on productivity and availability to fishing fleets. These analyses will provide further guidance on how prospective EBFM options may perform for management objectives and their robustness to expected regional changes.

Incompatible objectives and the limits of scientific information

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Fisheries modellers have been successful in including a large amount of ecosystem realism in current stock assessment models, and work is ongoing to improve this. In addition, there are tools (ecosystem models, multispecies models, Management Strategy Evaluations) which can estimate the expected outcomes of different management actions in an ecosystem context. Together, these two strands provide the “best available science” to support increased ecosystem considerations in fisheries management. However, there are two key limitations of the science. The first is that predicting novel ecosystem behaviour is intrinsically uncertain, with the complex interactions involved meaning that not only is the outcome of any management action uncertain but also that the degree of uncertainty is not readily quantifiable. The second issue is that in many cases, ecosystem management requires choices on how to select between different management priorities. And scientific analysis cannot reconcile these different priorities. These may involve conflicts between conservation and fisheries objectives, between different fisheries and fish species, or between fisheries and other marine uses. This talk will highlight a range of different examples where scientific information can be, and has been, used to give to provide an (uncertain) background to decision making in fisheries, but cannot provide a single “best” choice between different priorities. Improving our scientific knowledge base is a key part of progressing EBFM, but it is critical to acknowledge that such improvements will not remove the increasing need for clear political decisions about how to weight different priorities.

Data and models to support the implementation of ecosystem based fisheries management in the North Sea - Yes we Can!

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The theoretical foundation of Ecosystem Based Fisheries Management (EBFM) is well-established, emphasizing the need to balance ecological, economic, and social objectives. In contrast, the implementation of EBFM has been challenging due to diverse and often conflicting objectives, as well as the complexity of marine ecosystems. Management strategy evaluation (MSE) offers a promising framework to help identify win-win and trade-off situations as a basis for advice on suitable management measures. In this study, we demonstrate how a set of data and models available for the North Sea area may be combined to provide a comprehensive comparison of management strategies in an EBFM context. For this task, we used the bio-economic mixed fisheries model FLBEIA, the stochastic multi species model SMS and the end-to-end ecosystem model StrathE2E. The models were expanded by explicitly taking into account climate change effects on stocks and the food web. Additionally, model predictions were linked to analyses on e.g., relative benthic state or landings by harbour as proxy for the contributions of fishing to coastal communities. We extended the traditional set of indicators used for MSE simulations to deal with a wide range of objectives related to the European Common Fisheries Policy, the Marine Strategy Framework Directive as well as global objectives such as reducing CO2 footprints. Results highlight win-win situations achieving objectives simultaneously by implementing different interpretations of the MSY concept next to the landing obligation. Negative effects of climate change were encountered, but also the ability of management strategies to partly mitigate these effects. Remaining trade-offs were mainly identified between ecological and social objectives. Despite larger parameter and structural uncertainties, we provide a worked example to illustrate how data and models can be combined to support a target-oriented discussion on management options under EBFM.

Session 7: Operational scope of Ecosystem Based Fisheries Management

Barriers to advice on operationalising Ecosystem Based Fisheries Management

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Ecosystem Based Fisheries Management (EBFM) aims to balance ecological, social, and economic objectives towards restoring fisheries sustainability, while ensuring both food security and healthy marine ecosystems. Implementing EBFM is inherently complex, as it requires accounting for a wide range of interconnected factors, such as multi-species trophic interactions, environmental and climate variability, habitat status, anthropogenic forcing, socio-economic trade-offs, stakeholder engagement and governance frameworks. Although the European Union is formally moving towards managing fisheries via ecosystem-based approaches, significant scientific, social, and institutional barriers remain. Current scientific approaches frequently fail to fully integrate interdisciplinary perspectives, particularly from the social sciences. Moreover, ecosystem models, while insightful, are not always aligned with policy needs and frequently lack the precision required for effective decision-making. Data gaps and uncertainties—regarding inputs, environmental drivers, and the models themselves—further reduce confidence in outcomes. Institutional obstacles include the fragmented policy landscape between environmental and fisheries regulations, inconsistent legal mandates, and conflicting management objectives. These tensions, especially between ecological and socio-economic goals, can hinder consensus among stakeholders. In addition, limited understanding of EBFM among non-scientific stakeholders, and ineffective communication of scientific results (mainly due to scientific jargon and poor visualisation) further obstruct implementation. Local governance bodies frequently lack the capacity to keep pace with scientific developments. Advancing EBFM requires improved data collection, stronger interdisciplinary research and governance, better communication of scientific findings, and enforcement of science-based measures. These efforts are essential to mitigate overfishing and enhance the long-term resilience of marine ecosystems across European seas.

Sustainable management of social impacts of fisheries

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Sustainable management of social systems requires recognising the plurality and diversity of human values. Conventional approaches to Ecosystem Based Fisheries Management (EBFM) focus on a shared set of objectives to be pursued and balanced, often lacking guidance to inform choices on the social and economic dimensions. Global experiences with EBFM implementation highlight the need to rethink both the processes and desired outcomes. Rather than focusing on compromise and trade-offs among ecosystem-level objectives, we need to explore how communities with differing values can share the same ecosystem, assessing the risks to generate safe operating spaces in fisheries management. As part of this transformation, we introduce quantitative, qualitative, and mixed-method approaches to better operationalize the human dimension—encompassing social, economic, institutional, and cultural aspects. These approaches offer standardised methodologies for assessing the societal role of fisheries, and evaluating the effects of environmental changes (e.g., climate change) and shifts in governance (e.g., management system reforms). Session 2 explores how evidence from the social sciences can enhance participatory processes, strengthen the science-policy interface, and accelerate the uptake of findings presented at the Symposium. In particular, the session highlights tools for real-time monitoring and forecasting of the socio-economic impacts of management measures, enabling more adaptive and responsive decision-making. Key barriers identified during the session will be shared and addressed in the concluding discussion.

Sustainable management when productivity of fished stocks changes

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An ecosystem-based approach to fisheries management recognises that fished species are integral parts of their ecosystems, and needs to assess the link between their productivity and the surrounding environment. Focusing on fish populations across Europe, from the Baltic Sea to the central Mediterranean, we began with a comprehensive systematic literature review, complemented by targeted data analyses across key case study regions: the Baltic Sea, North Sea, Western Waters, and central Mediterranean Sea. Temperature emerged as the most frequently identified environmental driver influencing recruitment and individual growth. Studies on mortality primarily addressed impacts from natural predators, including fish, marine mammals, and seabirds. To ensure fisheries forecasts and management advice remain relevant under future climate change, it is essential to develop methods and protocols that integrate environmental effects into modelling tools. These models must be capable of predicting stock dynamics and catches under various management strategies for both single-stock and mixed fisheries. This presentation includes agreed-upon protocols from an ICES workshop focused on developing environmentally informed productivity forecasts. When applied to climate change scenarios, these enhanced models projected declines in biomass and catch for 10 out of 19 European stocks, while 5 stocks showed increases, compared to a baseline scenario without climate change. These projections rely on the assumption that historical relationships between environmental factors and productivity will remain stable. To provide context to support assessment and interpretation of results, we also examined alternative forecasts generated by global change scenarios using ecosystem models. The talk concludes with a synthesis of insights shared by symposium participants, highlighting key barriers to delivering operational advice for the sustainable management of stocks undergoing productivity shifts—and offering suggestions for overcoming these challenges.

Sustainable management of ecological effects of Fisheries

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Fisheries are considered by IPBES to exert the biggest human impact on marine Ecosystems. The effects that fisheries exert can be grouped into effects on the target species, bycatch and habitats. In addition to direct effects, fisheries also have indirect effects through the foodweb, and through behaviourally mediated effects. Target species experience increased mortality, reduced biomass and declines in the abundance of older fish. However, fisheries may also make stocks more productive by reducing competition for food and removing predatory fish. Fishing gear often catches both target species and unwanted species including vulnerable species such as sharks and rays, undersized fish, seabirds and marine mammals, the majority of which do not survive the encounter.Habitat effects occur where gear is in contact with the bottom such as demersal trawling and pots being dragged along the bottom. Additional effects are increased turbidity in the water column due to spreading of sediments and particles during demersal trawling. Finally, lost fishing gear causes ghost fishing and plastic pollution. While increased fishing effort generally increases the impact, the level of impact that is sustainable is difficult to define from this relationship. Further, the impact differs between gear types, target species and when and where the fishery takes place: some species and habitats are particularly vulnerable to some gear types in specific areas and seasons. Because of this, the ability of different measures to make fisheries more sustainable depends on what we aim to protect, the landings we aim to attain and the balance we seek to strike between these. To complete this talk, the discussions during the symposium on the trade-offs between different ecosystem objectives for target species, habitats, vulnerable species, litter, and foodwebs, fishery objectives and other marine considerations such as MPAs and Offshore energy are summarised.

Spatial advice for Ecosystem based fisheries management

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Spatial management is a fundamental tool in Ecosystem Based Fisheries Management (EBFM), with fishery closures serving as a key mechanism to protect biodiversity, rebuild stocks, and sustain ecosystem services. Their success depends not only on implementation but also on scale, location, and adaptability—especially in the context of climate change.
This presentation examines the purpose and performance of fishery closures through case studies from the Mediterranean, Atlantic, and beyond. We highlight effective examples where strong governance, stakeholder engagement, and scientific support delivered ecological and socioeconomic benefits. As a contrast, we also discuss cases where limited enforcement, poor design, or lack of

community involvement hindered outcomes. Closures may also create opportunities for ecosystem restoration. By reducing pressures in targeted areas, closures enable passive recovery of habitats and species, particularly when aligned with connectivity networks that support recolonization. In such contexts, closures serve as a foundation for both passive and active restoration, especially when integrated with monitoring and adaptive management. These examples underscore the importance of knowledge-based decision-making, where adaptive spatial management is informed, on one hand, by the collection of robust ecological, biological and socio-economic data and, on the other, by the use of models that simulate the potential of closures to enhance habitat quality and species distribution under a changing climate, estimate recovery timelines, and address the effects of and on socioeconomic drivers. When based on sound information, models enable the evaluation of closures not only in terms of ecological outcomes—such as reducing juvenile catch, protecting or restoring habitats and identifying so-called climate refugia—but also in terms of social and economic trade-offs, ultimately enabling effective management. In conclusion, barriers to operationalising ecosystem-based advice for spatial management are summarised, as identified during the symposium, and practical ways forward are suggested to trigger a discussion as to how these barriers can be overcome.

Combining fisheries management advice for social and ecological priorities

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Increasing fisheries benefits while reducing ecosystem impacts, in an era of environmental change and increased competition for marine space, presents a key challenge to European Ecosystem Based Fisheries Management (EBFM). This presentation outlines examples of modelled impacts of management measures and climate change on target species, wider ecologies, and fishing fleets, alongside broader society. Across the examples, the management we apply to mixed species fisheries today performed poorly on ecological aims. Restrictive management such as that based on F_{MSY} with strict implementation of a landing obligation enhanced ecological performance but led to substantial declines in long-term catches and a subsequent deterioration in social indicators, including number of meals produced from the catches. The declines in productivity of some stocks under future climate change led to fewer fish meals produced, and lower performance on other social aspects as well. Models indicated that the effect of closed area management depended on whether the areas closed contained the species or habitats of interest and how effort was redistributed. The closures generally decreased performance on social aspects, as catch rates declined, and operating costs and carbon emissions increased. The same effects occurred when increasing mesh size. The impacts of management scenarios and climate change differed between small- and large-scale fisheries, but neither of these fleet segments consistently performed better on ecological or social objectives. In conclusion, the measures required to attain the aims of fisheries management are often in conflict, and require decisions on how to weigh different considerations. The barriers to providing operational advice for both ecological and social priorities are discussed together with the need for information to support management decisions, and ways for those who request advice to facilitate the process explored.

Poster Abstracts

The fishing fleet as platform for data collection enabling the EBFM

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The Belgian fishing fleet is a living lab where technological and social innovation go hand in hand. This combination has led to a close cooperation between scientists, fishers, managers and NGO's leading to full openness in data collection from fishing vessels. This concept proposes to use the existing fishing fleet as a dynamic and geographically distributed platform for real-time marine data collection. Equipped with cameras, vessels capture data on both commercial and non-commercial fish, as well as invertebrates. Automated environmental DNA (eDNA) samplers and exploratory tools for automated fish larvae detection enhance biodiversity monitoring. These high-resolution, near real-time datasets can be combined with Emodnet and Copernicus sourced data and can feed into dynamic models for stock assessment, food web analysis, and ecosystem quality evaluation. Applications include operational catch prediction (already prototyped), real-time discard assessment, and fish hotspot detection. This approach has the potential to operationalize the Ecosystem Approach to Fisheries Management (EAFM), transitioning it from a theoretical ideal to a practical and data-driven reality.

Identifying environmental factors influencing Downs herring larval survival using a Lagrangian individual-based larval transport model

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Downs herring, which collapsed in the late 1970s, have recovered to account for 25 % of the North Sea herring spawning biomass by 2020, but recruitment is low. Downs herring, the main component of the North Sea herring stock, spawn during winter in the eastern English Channel and southern North Sea, where suboptimal trophic conditions result in high larval mortality. This study aims to identify the environmental and trophic factors that influence the variability in survival of Downs herring larvae during transport to the nursery.We combined the Lagrangian modelling tool ICHTHYOP with multiannual fisheries survey data (IBTS IHLS) on larval distribution in the eastern English Channel and southern North Sea, and laboratory experiments on herring larval growth, mortality and vertical migration. The model simulates larval transport by integrating both passive current-driven movement and biological behaviors, including growth, optimal temperature ranges, specific gravity and vertical migration. It was driven by hourly 3D fields of current, salinity and temperature from an operational forecast model available through the MARC project. Larval dispersal was simulated over a decade (2013-2022) using growth and mortality functions derived from laboratory data. Spawning areas were identified based on optimal abiotic conditions, such as hard substrates (gravel and rock) combined with suitable temperature and salinity ranges. Even when only general abiotic criteria were used to define spawning areas, the model accurately identified key spawning areas documented in ICES reports. The model results were validated against fishery survey data, specifically by comparing predicted larval sizes. The results suggest that a retention period followed by delayed transport to the North Sea correlates with the presence of larger larvae in the fishery survey data. This approach improves our understanding of recruitment variability and provides knowledge for sustainable management of the herring stock.

Sustainable management under changes in productivity of fished stocks

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Sustainable management of fished stocks is increasingly challenged by changes in productivity due to climate change and environmental factors. Effective strategies must incorporate adaptive management practices that account for fluctuating stock levels, ensure the resilience of marine ecosystems, and promote recovery of overfished populations. Integrating scientific assessments with stakeholder engagement is essential for developing robust policies that maintain fishery sustainability while addressing the impacts of changing ocean conditions.

Disentangling climate and parental effects on recruitment of southern stock of European hake (Merluccius merluccius)

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The southern stock of European hake (Merluccius merluccius) is one of the most important commercial fish species in Europe, whose recruitment has shown marked fluctuations over recent decades. Since recruitment levels are key indicators of stock health, productivity and resilience, understanding the mechanisms that regulate them is essential for effective stock assessment and catch management. These regulatory mechanisms may be external (e.g., environmental variability and fishing pressure) or internal (e.g., parental effects and density-dependent processes). In this study we examine the influence of environmental variables—sea surface temperature (SST), the North Atlantic Oscillation (NAO), and the Atlantic Multidecadal Oscillation (AMO)—alongside with spawning stock biomass (as a proxy for density dependence) and parental effects (size at first maturity by sex and the length structure of the spawning stock) on recruitment dynamics of the southern hake stock in Iberian Atlantic waters over the last few decades. The annual variability in recruitment (R) was modelled using a Generalized Additive Model (GAM), with environmental and biological variables included as explanatory predictors. Additionally, we investigate the potential of the Shannon diversity index (H') as an indicator of the state of the southern hake population. The findings of this research will provide valuable insights into the drivers of recruitment variability in the southern hake stock, which are crucial for sustainable management under changing conditions and for evaluating the utility of tools to assess the stock's state.

Cumulative and interactive effects of climate warming and multi-gear fishing on the Eastern Ionian Sea ecosystem using EwE

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One of the greatest challenges when predicting ecological change, is understanding how multiple stressors interact and determining the potential for complex synergistic, antagonistic, or non-additive interactions among them. In this study we developed an Ecopath ecosystem model for the Eastern Ionian Sea (Central Mediterranean) in 1998-2000, parameterized and fitted the temporal dynamic module Ecosim to biomass and catch data from 2000 to 2020, and projected the ecosystems' future responses (2021-2080) under 21 simulations examining single and multiple stressor scenarios consisting of various levels of climate change (RCP 4.5 and RCP 8.5) and total and gear-specific fishing effort reductions. Special emphasis is placed on the interaction between stressors in the multi-stressor scenarios in an attempt to determine whether they interact synergistically or antagonistically. The interactive effect of temperature increases and fishing effort reductions in the combined scenarios was quantified by the interaction effect index (IEI) which compares the cumulative mean size effect of the two stressors with the sum of their individual effects. Our results highlighted that antagonistic interactions consistently prevailed throughout the projection period, under all combined RCP 4.5 scenarios, while in the combined RCP 8.5 simulations we recorded a clear shift from antagonistic interactions in the mid-term (2050), to synergistic in the latter half of the century (2080). This transition highlights a concerning trajectory under the most severe warming scenario, where climate-driven changes are likely to intensify due to synergistic stressor interactions. Results from the present study will provide insights on specific responses of fishing stocks to climate change and fishing effort scenarios and may inform the development of management strategies integrating environmental considerations, thereby facilitating the move towards ecosystem-based fisheries management.

Bottom trawling and hypoxia impacts on macrofaunal communities in the North Sea and Baltic Sea transition area

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Seabed habitats are widely impacted by demersal fishery and eutrophication in European coastal waters. This is particularly true of the coastal transitional waters between the high saline Greater North Sea and the low saline Baltic Sea. We applied longevity distribution and hypoxia sensitivity of benthic macrofauna to estimate indicators of environmental state of seabed habitats under anthropogenic pressures in this area. Spatio-temporal high-resolution data of the fisheries footprint and hypoxia were combined with longevity biomass composition of benthic macrofauna to estimate the Relative Benthic State (RBS) of seabed habitats. Spatial-temporal oxygen condition was estimated based on the North Sea Copernicus and Baltic Sea Ice Ocean models. Categories for no, low, medium and high hypoxia were defined based on oxygen depletion intensity to correspond with a mortality risk of 50% of the crustaceans or 20% of the total benthic invertebrates. The RBS indicator describes the relative change of invertebrate communities due to bottom trawling based on estimated faunal depletion rates of different bottom trawling métiers and their spatial footprint, and faunal recovery rates from an empirically derived longevity-biomass distribution of the community. Good Environmental Status (GES) was assessed by application of an overall extent-threshold of ≤25% adversely effected area combined with a quality-thresholds of RBS ≥0.8 and the hypoxia index. In the Greater North Sea area, 3 to 5 of the 15 benthic Broad Habitat Types exceeded the GES-threshold of adverse effects due to fishing while none exceeded the threshold due to hypoxia. In the Baltic Sea area, 7 to 10 of the 15 habitats exceeded the GES-threshold of adverse effects due to hypoxia but none exceeded the threshold due to fishing. These results supported recent national assessments of seabed habitat GES, associated perturbation impact trade-offs, and the identification and prioritisation of sensitive areas for marine protection in Danish seas.

Between sustainable sea urchin fisheries and marine forest conservation: advancing the multi-threshold management framework

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Through their grazing activity, sea urchins can cause regime shifts from rich algal beds to deserts by removing macroalgae until bare rock. Locally, sea urchins are also intensely harvested, leading to population decline and collapse. The collapse of marcoalgal forests and the depletion of sea urchin populations due to overfishing are thus two extremes of the same continuum. To permit a viable sea urchin fishery while simultaneously conserving marine forests, and given the hysteresis-prone nature of these systems, sea urchin populations should be kept within two thresholds, i.e., avoiding too high or too low abundance. A conceptual framework to identify the safe operating space between sustainable fisheries and marine forest conservation has been proposed, embedding in addition to an upper and a lower biomass thresholds, a socioeconomic threshold. However, quantification of these thresholds is scarce, highly case-specific, and rarely applied to manage the ecosystem in a holistic manner, remaining, so far, a theoretical exercise. Here, we attempt to move forward the conceptual identification of the safe-space area toward practical implementation by framing it in the context of fisheries management reference points. An empirically estimated "ecosystem thresholds" informs the higher limit of sea urchin biomass, while MSY-based reference points can be used for the "population threshold". A modified Kobe plot is proposed to visualize the envisioned management framework.

Beyond this exercise, identifying these thresholds for individual stocks and systematizing the proposed framework is essential to enable an adaptive management that can tackle abrupt fluctuations between extremes caused by natural and/or anthropogenic factors which may lead to irreversible regime shifts. The proposed approach aligns with the principles of ecosystem approach to fisheries and adaptive management, making it highly relevant and applicable across coastal systems worldwide. Future steps will evaluate implementation in real-case scenarios to assess applicability for management advice.

Climate Change Adaptions of Demersal Fisheries in the Adriatic and Ionian Sea

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Climate changes may alter the productivity and spatial distribution of marine species particularly in exposed areas as in the Mediterranean Sea, where high climate vulnerability necessitates adaptive management approaches. Marine species populations are expected to shift their spatial distribution in response to changing environmental conditions, while fishing fleets may adjust their spatial strategies to maintain operational efficiency. This study, conducted within the SEAwise project and building on the ICES WKFISHDISH2 methodology, aims to project future spatial distributions of key demersal species (European hake, deep-water rose shrimp, Norway lobster, giant red shrimp and blue and red shrimp) targeted by mixed and deep-water demersal fisheries in the Adriatic and Ionian Seas (GSAs 17, 18, 19, and 20). Projections are based on climate change scenarios representing a high-emissions pathway. The resulting species distribution forecasts were used as inputs for models simulating potential spatial adjustments of fishing activity in response to climate-induced ecological changes. Findings indicate that under RCP 8.5 scenario, more pronounced spatial redistributions of species are expected in the long-term (2080-2099) compared to previous periods (2010-2020, 2040-2060), with variations across GSAs and species-specific shifts in key hotspots. The spatial footprint of bottom trawl fisheries is predicted to adjust moderately at a local scale, in line with the expected redistribution of target species. By integrating climate projections into species and fishery distribution models, this work supports the development of climate-aware, ecosystem-based fisheries management strategies tailored to the central Mediterranean sub-regions.

The impact of offshore wind farms on fishing effort in the North Sea

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Spatial fishing closures have varying effects on fisheries, ranging from the displacement to the attraction of fishing effort. Offshore wind farms (OWF) can be viewed as fishing closures because either legislation or the risk of damaging infrastructure often limits fishing within their borders. OWFs also introduce artificial hard structures that serve as artificial reefs, potentially attracting species of interest to fisheries. Although many studies have focused on the ecological impacts of OWFs, their effect on fishing activities in the North Sea has not been researched beyond passive-gear fisheries. We combined a spatio-temporal data set of international fishing effort with polygons of OWFs that were constructed before or during the study period (2009-2021). By employing general additive models (GAMs) and spatial hotspot analysis, we identified 33 metiers (out of 42) that were affected by OWF implementations. However, the direction of the effects vary by OWF and is therefore challenging to classify per metier. We applied before, after, control, and impact (BACI) comparisons to isolate the effects of individual OWFs on metier fishing effort. Our results show that there is no or weak effects around the majority of OWFs, while 5% of OWF-metier combinations were classified as attracting and 14% as repulsing. Our classification of effects per metier and OWF provide important indications for potential effects of future OWFs in the North Sea.

Effects of existing and proposed spatial fisheries management measures on the deep-water ecosystem of the Adriatic and Western Ionian seas

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The Adriatic and western Ionian Seas (central Mediterranean sub-region), constitute an ecologically and oceanographically complex area, where important fisheries and key habitat and species of conservation interest can be found. The conflicts emerging from the spatial overlap between distribution of demersal fishing fleets and habitats of conservation interest, especially along the slope of south Adriatic and western Ionian sea, are increasingly addressed through spatial management measures. However, these measures can convey unexpected outcomes as the displacement of fishing effort risks increasing negative fishing impacts in areas previously less heavily impacted, potentially causing impacts to the ecosystem as a whole. Moreover, fishers may experience reduced profit, despite rebuilding of commercial stocks, as sailing costs may increase and landing decrease or change with displacement from their traditional fishing grounds. Spatially explicit ecosystem models can support the evaluation of effects of alternative management measures by investigating both positive and negative responses of species, ecosystem indicators, and fishing fleets to fishing closures. This work presents an Ecospace model, the spatial component of Ecopath with Ecosim (EwE), parameterized for the South Adriatic and West Ionian Sea. The model includes 83 groups, including 14 assessed stocks, and 36 fishing fleets and is fitted to time-series of catch and biomass and forced with fishing effort time series from 2008 to 2020. It simulates spatial distribution of the species biomass and fleets' effort. The model evaluates the effects of recently proposed spatial management measures, through ecosystem and community indicators. Indicators of biodiversity (Shannon Index) and of community (mean trophic level of the community and of the catch) are calculated at fine spatial scale, showing effects on fish biomass and on biodiversity inside and in the vicinity of investigated spatial closures. This work aspires to contribute to the ecosystem-based spatial management for fisheries at sub-regional level.

Sandeel in Space: Spatial management of fish stock dynamics and displacement in transboundary fisheries

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Effective spatial management of transboundary fisheries requires frameworks capable of assessing ecological risks and fisheries displacement under shifting political and environmental regimes. Traditional stock assessment models, which often lack spatial resolution, are seldom equipped to capture local population dynamics or the ecological impacts of spatial shifts in fishing pressure across jurisdictional boundaries. To address this challenge using Brexit as a case study, we formulate a model that explicitly accounts for spatial dynamics through migration/drift, recruitment, and catches. We condition an assessment model to historical research survey and catch data, and use fleet information to test future spatial catch scenarios. To condition the model we use center of gravity analysis of historical catches and drift patterns of sandeel larvae to show how the fishery has shifted from the predominant fishing grounds in UK waters to the North Eastern grounds in EU waters. We use the conditioned model to examine the immediate and long-term implications of fisheries displacement on future stock dynamics and catch opportunities. Scenario analysis projects a significant reduction in catch per fishing day and decreased recruitment and spawning stock biomass in certain areas in scenarios with high fishing pressure. We present this investigation as a comprehensive tool for the spatial management of fish stocks and displacement in transboundary fisheries.

Identification of key environmental variables to predict future distribution of European hake populations

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Climate change has generated changes in the spatial distribution of many species. In the case of commercial fish populations, these changes generate challenges in their management to ensure the biological sustainability of the populations and socio-economic sustainability of fishing communities. Species Distribution Modelling (SDM) aims to describe the distribution of species based on environmental variables. European hake Merluccius merluccius is one of the most relevant commercial fish species and is present in a large extent of the North-East Atlantic ranging from Mauritania to Norway. Previous works have shown that the species has a marked bathymetric preference, but other environmental variables that condition its presence and abundance remain unknown. The purpose of this study is to identify key environmental variables that condition hake distribution. This would allow us to make future predictions of the spatial extent of the species due to climate change driven variations. We carried out a large spatio-temporal analysis of 10 different trawl surveys in the North-East Atlantic from 1993 to 2023, available in DATRAS database. Environmental data characterizing physical and biochemical ocean conditions were obtained from the Copernicus Marine Service. SDMs were fitted separately for juveniles (42 cm) using shape-constrained generalized additive models. Two different types of models were fitted, presence and abundance conditioned on the species being present. The results indicated that bottom water potential temperature, oxygen concentration, bottom seawater salinity, bottom phytoplankton concentration and seawater pH at total scale were significant explanatory variables for both the presence and abundance of hake. Our findings demonstrate that environmental factors can forecast the distribution of hake, offering crucial information for managing fisheries conservation initiatives.

Simulating Fleet Dynamics and Ecosystem Responses in the Eastern Ionian Demersal Fishery

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The eastern Ionian Sea demersal fishery is a typical Mediterranean mixed-fishery. A large scale fleet (LSF) consisting of 26 trawl vessels and a small scale coastal fleet (SSF) utilizing longlines and nets (~ 3000 vessels) exploit a large number of stocks (~80) with the bulk of the catch referring to European hake, red mullet and deep water rose shrimp. Currently, only the LSF is managed through effort control, while the SSF is mostly un-managed. The mixed-fishery bioeconomic model FLBEIA was applied to simulate the dynamics of a two-fleet, multi-species fishery under a range of alternative effort allocation scenarios. In parallel, the same fishing effort scenarios were implemented within an ecosystem model developed using Ecopath with Ecosim (EwE), allowing for direct comparability between bio-economic and ecological outcomes. The scenarios were designed to explore effort levels capable of achieving both single stocks MSY objectives and good ecosystem status. In particular, ecosystem status was assessed through sensitive species bycatch and the Ryther index, serving as a proxy for ecosystem productivity and a benchmark for achieving Good Environmental Status (GES) under the Marine Strategy Framework Directive (MSFD). The integration of bioeconomic and ecosystem modeling frameworks constitutes an initial step toward operationalizing an ecosystem-based approach to fisheries management. A suite of biological, economic, and ecosystem-level indicators was estimated to assess the trade-offs and potential conflicts among competing management objectives, including fleet profitability, stock conservation, and ecosystem integrity. In a subsequent phase, recruitment dynamics for hake (Merluccius merluccius) and red mullet (Mullus barbatus), mediated by environmental variability, were incorporated to evaluate potential implications under projected climate change conditions, thereby enhancing the model's capacity to inform adaptive management strategies.

Dynamic and durability of exploited ecosystems

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The Celtic Sea is an area of high biodiversity providing significant catches to European fisheries. Faced with the need to anticipate climate change impacts and minimize long-term fishing impacts in the area and within the frame of EBFM, this work is built on two axes: 1) a theoretical one exploring the long-term cumulative impacts of fishing and climate change on the ecosystem health and resilience 2) a practical one testing if a juvenile protection for 7 commercial species simultaneously is an efficient EBFM strategy. To this aim, an ecosystem model is used to forecast the long-term effects of climate change and fisheries management through scenario combinations: two climate scenarios (RCP4.5, RCP8.5) and fisheries management scenarios including effort reduction and juvenile protection strategies. In axis 1, individual and cumulative effects of climate and fishing are assessed using 45 ecosystem's health indicators. Our results reveal climate change impacts on Boreal, pelagic species and ecosystem stability. Fishing preferentially removes top-predators and is predicted to increase the likelihood of a regime shift by decreasing ecosystems' capacity to recover. Predicted cumulative effects are mainly additive and antagonistic but synergies are observed for high fishing effort levels. Finally, climate change had minor impacts on ecosystem recovery to fishing. Fishing is shown to be the main driver of cumulative impacts and of ecosystem resilience over the next decades. Results suggest that slight reduction in fishing effort is enough to mitigate the impact of climate change. In axis 2, the efficiency of the juvenile protection is assessed through biomass and catches of protected stocks. Protecting juveniles overall rebuilds stocks and induce more catches for fisheries while inducing winners and losers due to trophic interactions. Combined with effort reduction, the juvenile protection is identified to minimize the effect of fishing and mitigate climate change effects.

Ecosystem Modelling as a Key Driver for Adaptive and Ecosystem Based Marine Management in Iberian Waters - The EWE4GES Network

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The EWE4GES working group was established in the context of the Marine Strategy Framework Directive (MSFD) to operationalize ecosystem modeling tools -particularly Ecopath with Ecosim (EwE) - for assessing the status and dynamics of food webs across Iberian marine regions. Standardized protocols were applied for the selection of relevant Ecological Network Analysis (ENA) indicators capable of capturing trophic interactions and quantify key ecological processes across all trophic levels. Analyses of three case studies - the Bay of Biscay, Southern Catalan Sea, and Gulf of Alicante - revealed signals of fishing pressure, biodiversity loss, and climate-driven ecological shifts. These results underscore the importance of considering species interactions to support ecosystem-based management (EBM) and ensure the effective implementation of the MSFD. Looking ahead, future work will focus on consolidating and expanding the network's capacity to provide useful advice for policy-makers. Key priorities include: enhancing interoperability among existing EwE models; co-developing and testing management scenarios with decision-makers to test management options, especially considering cumulative human impacts and climate change; promoting cross-institutional collaboration through workshops, shared resources, and joint projects; and improving data integration and refining uncertainty analysis methods to enhance more reliable and transparent models. Ultimately, EWE4GES promotes a strong link between science and policy based on EBM principles. By embracing ecosystem models that explicitly account for species interactions, the group promotes a more comprehensive, anticipatory, and effective approach to marine ecosystem management. This not only benefits the Iberian Peninsula but also offers a framework for broader regional application facing global environmental change.

A Modular Framework to Couple Essential Fish Habitat, Ecosystem Services and Cumulative Risk for Spatial Fisheries Advice

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Essential Fish Habitat (EFH), ecosystem-service (ES) provision and anthropogenic pressures are usually analysed in isolation, limiting their integration in spatial fisheries management. Nursery habitats are at the base of fisheries sustainability because they supply the recruits that will enter future catches. Although their biological importance is widely acknowledged, the economic value they generate is seldom expressed in spatially-explicit terms. This omission hampers the dialogue between ecologists, economists and managers and often leads to nursery closures being perceived as a cost rather than an investment. We propose a modular framework that bridges this gap by coupling EFH mapping, ES valuation and cumulative-risk analysis. Specifically, juvenile density maps are converted into a Habitat-based Fisheries Productivity layer (HFP € km^{-2} yr^{-1}) assigning to each cell on the seabed a monetary value that reflects the expected biomass of adults that will emerge from the juveniles observed there. A composite HFP can be calculated considering multiple species. The resulting layer is then coupled with a cumulative-risk layer that merges fishing pressure by multiple fleets through habitat-specific sensitivity scores. The ratio between the two layers, called the Nursery Benefit Index (NBI), highlights locations where the long-term economic returns from nurseries outweigh the current footprint of fisheries. These NBI hotspots generate useful advice for ecosystem-based fisheries management and can be fed directly into spatial-optimisation routines to design closures that protect nursery value while reducing socio-economic impact. In sum, the framework provides a map-based indicator that integrates ecological function (nursery productivity) with socio-economic value and current fishery pressure and provide transparent, evidence-based guidance for Ecosystem Based Fisheries Management.

Indicators of ecosystem overfishing in European waters

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Fisheries are vital to food security, livelihoods, and economic resilience, particularly in European waters such as the Mediterranean Sea and northeast Atlantic Ocean. Yet, sustainability across these regions remains uneven. The Mediterranean and Black Seas continue to face intense overfishing, while the northeast Atlantic benefits from stronger governance and healthier stocks. These differences are largely driven by variations in fisheries management, data availability, enforcement, and adherence to scientific advice. This work applied three novel ecosystem overfishing (EOF) indicators —the Ryther index, the Fogarty ratio, and the Friedland ratio— based on fisheries catch data and system productivity. The indicators were applied across eight case studies in European and adjacent waters. Results indicated that persistent EOF was not consistently detected by all indicators in any region. However, some ecosystems exhibited signs of ecosystem-level overexploitation when assessed with one or two of the indicators. Notably, the Adriatic and Greater North Seas displayed long-term EOF trends based on the Ryther and Friedland indices. Milder declines in ecosystem health were observed in the Bay of Biscay & Iberian Coast, Baltic Sea, and Balearic Sea. In contrast, the Levantine and Black Seas showed limited evidence of EOF, and the Aegean Sea presented no indication of ecosystem overexploitation. Nonetheless, these eastern Mediterranean Sea systems continue to face pressures from overfishing and invasive species. Some results differed from earlier catch-based and ecotrophic studies, emphasizing the importance of applying multiple complementary metrics to assess ecosystem health. Ultimately, addressing the identified pressures calls for adaptive, ecosystem-based fisheries management that considers environmental variability, exploitation, and long-term sustainability goals. Strengthening governance, improving data collection, and enforcing science-driven measures are essential steps towards mitigating overfishing risks and ensuring long-term marine ecosystem resilient across European waters.

Evaluating EC Action Plan measures for the Aegean Sea using spatiotemporal modelling

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The European Commission's 2023 Action Plan, "Protecting and Restoring Marine Ecosystems for Sustainable and Resilient Fisheries", sets a roadmap to reverse biodiversity loss by designating at least 30% of EU marine waters as protected areas, with 10% under strict protection. A central aim of the Action Plan is to reduce the environmental impact of fishing, particularly by limiting bottom trawling in sensitive coastal and offshore marine habitats. In line with these objectives, this study applied the ECOSPACE module of the ECOPATH with ECOSIM (EwE) modelling framework to assess two Action Plan-related scenarios in the Aegean Sea ecosystem. In the first scenario, depth-based spatial restrictions were introduced, banning bottom trawling shallower than 50 meters and purse seining shallower than 70 meters, resulting in a 10% increase of the total protected area. The second scenario extended bottom trawling bans within 3 nautical miles across the study area, increasing the total area under trawling restrictions to nearly 30%. Results revealed that the first scenario yielded the highest biomass gains among key demersal groups such as rays and skates (+6.2%) and shrimps (+2.3%), though it was accompanied by a 4.5% reduction in total catch, mostly affecting pelagic species. In contrast, the second scenario produced more moderate biomass increases but almost negligible catch declines (0.1%), making it potentially more acceptable to fisheries stakeholders. Biomass gains were spatially concentrated within newly restricted zones, highlighting the localized effectiveness of targeted fisheries closures. Overall, these findings suggested that strategic, gear-specific spatial restrictions can reconcile conservation and fisheries management goals. This study demonstrated the value of ECOSPACE as a decision-support tool for evaluating marine spatial planning options under the European Green Deal framework, contributing to ecosystem resilience, sustainable fisheries, and informed policy development in the Mediterranean Sea.

Applying ecological models to design MPAs under climate change and influx of alien species

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The Eastern Mediterranean is characterised by warmer and drier climatic conditions. This ultra-oligotrophic region is characterised by rapidly warming temperatures, relatively low biological productivity, and limited biodiversity. In addition, the Eastern Mediterranean serves as a major entry point for non-native species, particularly following the opening of the Suez Canal in 1869. This phenomenon, known as Lessepsian migration, has resulted in the influx of hundreds of alien species, many of which are well-adapted to the region’s warm, high salinity, and nutrient-poor waters. As a result of the increasing temperatures and influx of the invasive species, native species have been displaced and local fisheries and ecosystems have been impacted.

Marine Protected Areas (MPAs) are essential tools for preserving biodiversity and restoring marine ecosystems that have been degraded by overfishing and environmental change. By restricting or prohibiting fishing activities within these zones, MPAs enable native species to recover, contributing to spillover effects that replenish fish populations in surrounding areas. An example is the Achziv Marine Reserve in northern Israel. Recent surveys conducted by the Israel Nature and Parks Authority show a rise in the biomass of large predatory fish such as groupers within the reserve, compared to adjacent unprotected areas.

Recently, attempts were made to define MPAs within the Israeli EEZ that will abide by the EU 30x30 guidelines and support spatial planning to minimise damage by fossil fuel explorations and production on the marine ecosystem. We applied Ecopath with Ecosim and Ecospace suite of models to evaluate potential locations for MPAs. By accounting for projected future conditions, the models identified potential climate refugia for native species and regions that will maximise protection for native species. In this study we demonstrate the application of the models and how their outcomes can be translated into actionable policy tools for spatial EBM.

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