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Theme session Report

Theme Session H - Future Integrated Ecosystem Assessments

Conveners: Benjamin Planque (Norway), Carolyn Faithfull (Sweden), Paulina Ramirez (Denmark)

Integrated Ecosystem Assessments (IEAs) synthesise knowledge on ecosystems state and dynamics and provide fact-based support to management. The aim of the session was to cover a broad range of IEA-related topics to facilitate knowledge exchange based on best practices and lessons learned, as well as to inspire future progress by identifying challenges, opportunities, and recent innovations. This session addressed several IEA topics including objectives, methods and tools, translation of IEAs into advice, and consideration of future ecosystem states in IEAs.

The session included a review of current practices in IEA groups within ICES, six presentations of regional case studies, two presentations with a more methodological focus and two presentations looking into the current and future context surrounding IEA work. It was complemented by 12 posters encompassing multispecies modelling contributions to IEAs, methodological developments, regional case studies and conceptual links between IEAs and Ecosystem Based Fisheries Management. Interactive polls were conducted at the beginning and end of the presentations and a 30-minute discussion took place before closing.

Overall, the inclusion of “future” as an element of IEAs is still in its infancy, and many IEA groups today focus primarily on assessing the past and present states of ecosystems. Climate change is often considered implicitly rather than explicitly by IEA groups. Expertise in natural sciences remain dominant but social science are gradually being included in IEA work. The dialogue with stakeholders is progressing but often remains at a low level. This limits the translation of IEA results into management and policy. In many IEA groups participants are few and work on a voluntary basis, with digital collaborative platforms that have limited efficiency. The resulting limited capacity is a major hurdle for expert groups to adequately address broad IEA questions. In recent years, risk assessment using the ODEMM framework has developed as a standardised practice across many ICES IEA groups.

Several issues emerged from the session presentations, posters, and discussions, including:

- To enhance the integration of Climate Change (CC) into the work of IEA, we should focus on developing CC-related indicators, look at both short-term (less than 5 years) and long-term (more than 5 years) futures, develop regionally relevant CC attribution science, scenarios, and numerical models.
- To improve how IEA outputs are utilized by management and policymakers, we need better communication and collaboration between end-users and IEA experts. This can be achieved through more scoping, training of end-users and by end-users, stronger focus on trade-offs, development of IEA product options, and emphasis on actionable solutions.
- IEAs are expanding their scope from natural sciences to encompass economic and social sciences. This expansion can go further by including assessments of governance systems and how they can incorporate IEAs. IEAs will benefit from improved communication to a wider audience and, when resources are limited, from adopting simple(r) approaches.

Contents

CM 32: Future steps to move fisheries management towards an ecosystem-based approach

Cousido-Rocha, M.[1], Andonegi, E., Bartolino, V., Bentley, J., Castro, M.D., Cerviño, S., Coll, M., Corrales, X., Dickey-Collas, M., García, D., Guijarro, B., Howell, D., Ibaibarriaga, L., Macías, D., Rehren, J., Rincón, M., Rindorf, A., Romagnoni, G., Szalaj, D., Steenbeek, J., Tengvall, J., Torres, M., Pennino, M.G.

It has been increasingly recognized internationally that there is a need to move fisheries management towards an ecosystem-based approach. Yet, current fisheries management in most countries is still mainly based on advice from single-species stock assessments, and ecosystem models are still only used to provide strategic information to decision makers and not tactical advice (i.e., TAC). A crucial step towards effective fisheries management imply the development of hybrid approaches that bridges the gap between traditional single-species stock assessment and ecosystem models. With this aim we held the Workshop " *Advances in Fisheries Science: Using Ecological Models to Inform Current Fisheries Advice*", founded by Euromarine, to bring together experts in both approaches and discuss the benefit and limits of each approach. In addition, during the meeting we identified the most important challenges to combine these models, as for example the “institutional” one, as there is a structural inertia of the management system to change. Experts also recognized that there is a lack of a conceptual framework to coupling these approaches as well as is not easy to find people skilled in both types of modelling and thus more collaborations are needed. More importantly, during the meeting we defined feasible future lines of work to achieve an ecosystem-based fisheries management strategy, establishing a roadmap to follow coupling both approaches. Future lines of work include, among other ideas, the inclusion of ecosystem components in stock assessment models or the use of a Management Strategy Evaluation based on an operational ecosystem model.

Keywords: fisheries management, single-species stock assessments, ecosystem models

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CM 75: Using food web indicators to assess the impact of fisheries on marine ecosystems

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Fishing pressure is one of the main drivers of change in marine ecosystems. Fishing impacts reverberate throughout the food web affecting marine ecosystem structure and functioning. These impacts have been studied through ecosystem models that were developed to capture the complexity of the marine systems. Ecosystem models enable simulations of different fishing strategies scenarios that are useful to explore potential effects of fishing at ecosystem level and support managers in their decisions. Comparison among different scenarios can be achieved through ecological indicators that represent the status of the ecosystems. Besides the relevance for ecological studies, advancing these methods improves communication between scientists and stakeholders. Therefore, the motivations of this study were to investigate (a) how fishing changes the functioning of food webs, (b) whether network indicators are able to detect these impacts and (c) how the indicators respond to fishing pressure. We used two ecosystem models (Osmose and Atlantis models) in order to handle the structural uncertainty in our analysis. Several levels of fishing pressure were simulated using a set of FMSY (Fishing mortality at the Maximum Sustainable Yield) multipliers for target species. Model outputs were applied to carry out ecological network analysis allowing the computation of network-derived indicators. These indicators are able to reveal the onset of the ecosystem resilience collapse whenever a system is exposed to disturbances. Our results showed that the indicators responded to fishing pressure. The trends of the indicators demonstrated that overfishing decreased the amount of energy flow on the food webs and simplified their structure by lowering quantitatively and qualitatively the connections between the species. Our findings suggest that (I) fishing pressure decreases the resilience of food webs and (II) network indicators have potential to reveal fishing impacts on marine food webs. The network-derived indicators represented the whole ecosystem indicating the status of the ecosystem health, which makes them suitable for fishery monitoring and possibly support management strategies.

Keywords: food web, ecological indicators, multi-model approach, ecosystem resilience

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CM 102: Effects of seasonality on the structure and functioning of a Mediterranean Sea ecosystem

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The Mediterranean Sea is characterized by strong seasonality impacting species distribution and marine productivity, with effects on community dynamics that may have implications for the structure and functioning of the marine ecosystem. However, there is a lack of seasonal data for marine organisms and communities, which results in ecosystem assessments being based on estimates from specific times of the year, not accounting for seasonality. Here, we investigated the effect of the seasonal dynamics on the ecosystem structure and functioning of the Northwestern Mediterranean Sea by comparing results from ecosystem models parameterized with seasonal input data *vs* annual averages. We used data from two experimental oceanographic surveys conducted in two contrasting seasons, winter and summer, along the southern Catalan Sea (Spain). We developed three ecosystem models that represented the two contrasting seasons and an annual average, using the Ecopath with Ecosim (EwE) approach. We used several ecological indicators to compare changes derived from these three ecosystems representations and found significant variations between them. We discuss the implications that the use of data from a specific time of the year in quantitative models may have on our understanding of marine ecosystem ecology. Our results highlight the need to conduct seasonal surveys to capture seasonality dynamics at the ecosystem scale.

Keywords: ecosystem model, Ecopath with Ecosim, Mediterranean Sea, seasonality, ecological indicators

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CM 130: Integrated Assessment of the Canary Current large marine ecosystem with a focus on the Canary Islands and Senegal-Gambia-Guinea-Bissau subregions

Juncal Cabrera-Busto[1], Eduardo Ramírez-Romero[2], Raul Jumpe[3], Alfredo García-de-Vinuesa[1], Eva García-Isarch[1], Babacar Diop[4], Marcos Llope[1]*

The Canary Current Large Marine Ecosystem (or CCLME) is one of the most productive upwelling systems on the globe. It extends from the Straits of Gibraltar in the north to Bijagós Islands off Guinea-Bissau in the south, embracing the coasts and Exclusive Economic Zones of Morocco and Western Sahara, Mauritania, Senegal, the Gambia and Guinea-Bissau as well as the Canary (Spain) and Cabo Verde archipelagos. Due to its high productivity, the CCLME is key in providing food and resources to its bordering countries and much of West Africa. It comprises a diverse array of marine and coastal ecosystems, which includes dunes and long beaches, estuaries and saltmarshes, mangroves and seagrass beds, as well as open sea areas. An Integrated Ecosystem Assessment (IEA) was carried out for the whole CCLME, with particular focus on the Canary Islands and the Senegal-Gambia-Guinea-Bissau (SGGB) subregions as these are most different in terms of human activities and pressures, ecological characteristics and social, economic and institutional objectives. The CCLME IEA included various methodologies: (i) a structured risk assessment following the ODEMM methodology, (ii) a number of informal (interviews) and formal (workshops) scoping and validation exercises with stakeholders and (iii) the co-creation of a conceptual model with actors from very diverse backgrounds: NGOs, fishers, managers, natural and social scientists. The three top sectors impacting the CCLME as a whole were fishing, shipping and agriculture. These were the same and in the same order for the southern stretch of the CCLME. For the Canaries, tourism/recreation displaced agriculture in the third position. In terms of pressures litter, contaminants and species extraction dominated across subregions. The most impacted ecosystem components were reptiles, seabirds, marine mammals and demersal fish. A conceptual model was crafted for the SGGB subregion and captured issues not accounted for by the risk assessment, such as the current dramatic impacts of climate change with knock-on effects on livelihoods and migration patterns or the upcoming gas extraction project. While the Canaries future is perceived to revolve around blue growth and energy transition (i.e., renewables), the SGGB has great hopes on the prospects that the exploitation of fossil fuels can bring in terms of development. The scarcity of data, natural and cultural diversity, including languages, policy landscapes and development levels, posed great challenges to this IEA endeavour but gave us a number of practices and lessons learned that we believe are worth sharing across the community of IEA practitioners.

Keywords: Integrated Ecosystem Assessment (IEA), Socio-Ecological Systems (SES), ODEMM; conceptual modelling, inclusion of local knowledge, stakeholder engagement, climate change

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CM 131: How and why do marine ecosystem indicators change with scale and what does it mean

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Ecosystem indicators are quantitative and/or qualitative measures of key components of the ecosystem and are used to track the status and trends in ecosystems. Marine and Great Lakes ecosystems provide food, jobs, security, well-being, and other services to millions of people across the United States. Yet, marine and Great Lakes ecosystems and the people that rely on them are facing increasingly complex challenges. Tracking the status and trends of ocean, Great Lakes and coastal ecosystems is critically important to understand how these ecosystems are changing and identify potential issues.

Ecosystem indicators need to be consistent and need to accurately convey the status of the system. Indicator suites should be developed and applied to tracking progress toward conservation and management goals. When developed correctly, these suites provide insight into the general status of an ecosystem, keeping in mind that all of the indicators are interconnected as an ecosystem-based approach. A full suite of indicators assesses holistic ecosystem status, and it is essential to include human dimensions.

Prior studies have shown that the same indicator can have different results based upon the scale and boundaries of analysis from regional to localized studies (Heim et al. 2021). However, the actual indicator being evaluated is not always consistent across scales, especially when considering global to national to regional to local scales.

In this study, we investigate both the indicator suites selected as well as individual indicators at various scales to examine how the scale affects the indicators and the results of ecosystem assessments. The goals of this study are to examine the following questions: 1) How do indicators/ indicator suites change with scale, 2) How do indicators at the same scale vary across geographies, and 3) How does the spatial scale of indicators make a difference in how we interpret them?

Keywords: ecosystem based management, ecosystem indicators, resource management, ecosystem assessment, indicator scale

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CM 176: A systematic review of Management Strategy Evaluations in fisheries: In search of future challenges in a context of global change

Cristina Pallero[1], Silvia Fernández-Reguero, José L. Oviedo

An uncertainty exists concerning the effects of climate change on the management of fisheries and the ecosystems they rely on. Management Strategy Evaluation (MSE) assesses the efficiency of one or several fisheries management strategies according to pre-defined objectives. However, the variety of approaches, depending on the focus considered, makes it difficult for the practitioner to choose the most appropriate methodologies. This study aims to understand the designs and approaches followed by the most widely implemented fishery management strategies. We made systematic review on MSE in publications in order to obtain an overview of the main advances and conclusions on the subject. We intended to answer: Is the problem adequately defined to advance in its resolution? What are the factors that allow/difficult the best decision making for sustainability objectives in fisheries?

The literature on MSE emphasizes the need to include exploratory tools that consider alternative management scenarios integrating the multiple characteristics of fisheries (biological-social), allowing us to offer more robust management advice to the uncertainties. However, the results obtained show that the actual weight of the contributions differs according to the approach and can be grouped into: (i) biological models; (ii) bioeconomic models; (iii) Bayesian models; (iv) discrete choice models; and (v) qualitative methods. We also obtained that the operational tools have advanced rapidly and that their the success and applicability in an MSE context depends on their conceptualization, but also on the ability to carry out simulations quickly and efficiently. The FLR stands out as a modelling system to validate and evaluate strategies with specialized packages that fit specific objectives and scopes, being few operational tools that perform a complete MSE due to its complexity.

Our main conclusion is that the MSE is the most appropriate approach to evaluate management strategies considering uncertainties, but it also shows inconsistencies. Despite the indispensability of social and biological considerations in the actual performance of the sector and its regulation, these are not adequately considered. There is a gap between the recommendations and advances in scientific knowledge and the operational management of the sector (sectoral approaches predominate). This becomes evident in the case of global climate change. The current tendency of the main legislating institutions and fisheries managers is to consolidate and adapt to new fisheries management scenarios, incorporating adaptations and uncertainties. Therefore, modelling should not be seen as a priority, but instead as a tool to form the basis for decision making.

Keywords: mse, general approach, fisheries, socio-ecological system, ecosystem management

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CM 177: Strategic Environmental Assessment (SEA) for seas: towards a more strategic and environmentally-oriented marine spatial planning processes

Juul E.H. Kusters[1], Ferry M.G. van Kann, C. Zuidema, Jos Arts

The presently fast-growing intensity and variety of ocean activities requires methods and tools for performing more integrated ecosystem assessments. Strategic Environmental Assessments (SEA) can be such valuable tools for more strategic and environmentally-oriented Marine Spatial Planning (MSP) practice, enabling decision-makers to take into account potential environmental consequences of ocean activities on the marine environment and develop more sustainable marine spatial plans. SEA and MSP theoretically resonate: (1) both have similar points of departure in aiming to strengthen the environmental component in decision-making processes and (2) both aim to facilitate strategic and proactive decision-making processes by providing a framework to guide future decision-making on project- as well as plan-levels. However, empirical evidence on SEAs for MSP processes is sparse and more work is needed to identify best practices and share lessons learned. Hence, this study examines how SEA can contribute to a more strategic and environmentally-oriented MSP process. Thereby, we acknowledge the influence of institutional factors for their influence on the set-up of SEAs and integration with MSP processes. Four SEA processes for Belgian, English, German and Dutch marine spatial plans are evaluated through an analysis of SEA documents and interviews.

The results identify two types of assessment: an exploratory approach for policy design and SEA as an appraisal instrument. The first provides comparatively greater opportunities for more strategic and environmentally-oriented MSP processes, including a timely consideration of alternatives which enables environmental factors to be included in policy formulation from the start. However, the institutional context of MSP including its cyclical and multi-actor nature provides space for prior policy and political pressures to hinder SEAs in providing an integrated overview of a plan's consequences. As such, exploratory SEAs are only feasible if sufficient resources are present and require close collaborations between policymakers and SEA executors. Regardless of SEA type, the results indicate that most barriers emerge through ambiguities in (governance of) monitoring and evaluation. However, given that data unavailability is a large challenge for the marine environment, monitoring and evaluation should in fact be a critical step for any SEA of a marine spatial plan. At minimum, SEAs may improve plans' environmental performance and enable cross-sectoral learning by identifying and bringing together information on environmental consequences of ocean activities across policy domains.

Keywords: Strategic Environmental Assessment (SEA), Marine Spatial Planning, SEA effectiveness, North Sea

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CM 299: ICES IEA groups: what they are doing, why, how and for whom

Benjamin Planque, et al.

ICES has established 10 regional groups for integrated ecosystem assessments since 2012. The setting up of these groups has been part of an overall strategy of ICES to promote the science that supports ecosystem-based management. While all IEA groups contribute to the same overarching goal, and while the groups terms-of-reference are ultimately approved by ICES committees, defining the aims, agenda and way-of-working of individual groups is left to the groups themselves.

In this contribution, we review the priorities that the different IEA groups have identified, the approach they have developed to address these priorities, the nature of the scientific outputs they provide and their target group. We consider the target groups in a broad sense, that includes stakeholders with whom a two-way dialogue can be established.

We use the results of this analysis to identify areas where IEA groups could learn from each other, for the development of common practices and for potential harmonization of scientific outputs.

Keywords: Integrated Ecosystem Assessment, review, Levin Cycle, stakeholder engagement, monitoring, forecasts

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CM 331: Bayesian meta-analysis model for assessing bioeconomic impacts of oil spills on fisheries

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My aim is to build a Bayesian meta-analysis model of oil impacts on early life stages of fish that can be used in modelling of oil spill impacts on stocks and fisheries. Using the methodology of meta-analysis allows me to synthesize oil impact data from existing research papers which is more cost effective than conducting new exposure studies. The meta-analysis model will be built using a hierarchical structure that allows the borrowing of information from data-rich species and oils to data-poor ones. The combination of a meta-analysis and a model structure that allows information borrowing can be especially useful in situations where estimates are needed fast and there is a limited amount of available data. Furthermore, using Bayesian methods to build the meta-analysis model creates the opportunity for accumulation of information in a continuum. The model produces posterior probability distributions of the estimated oil impacts per species and per different oil type from prior knowledge and data. These posteriors can then be used as prior information in a subsequent analysis conducted with the model, whenever there is a need to update the impact estimates with new data. The meta-analysis model and its results can be used together with a population dynamics model to predict population level impacts of oil spill scenarios. The combination of the models will be extended to predict economic impacts of an oil spill on fisheries.

Keywords: Bayesian methods, Bayesian inference, Bayes, prediction, model, fish, oil spill, meta-analysis, probability, uncertainty

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CM 338: A climate vulnerability assessment of the fish community in the Western Baltic Sea

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The negative impacts of climate change on fisheries threaten not only fish species and their habitats but also local communities that depend on fisheries. As a consequence, adaptation to the already existing but especially expected future effects of climate change is crucially required to prevent fisheries systems to end in an unintended or undesired state. To assess the potential climate change impact on fish communities and their adaptive capabilities, we realized a climate vulnerability assessment (CVA), an assessment applied in many areas of the world but still lacking in the western Baltic Sea. Our CVA analysis used two future (middle and end of the century) RCP scenarios (4.5 and 8.5) to assess a sensitivity score, based on the fish species sensitivity represented by traits of the species (including adaptive capacity), and an exposure score based on their susceptibility to changes in the climate. We also assessed an overall climate vulnerability score, based on both previous scores, and a future direction of change, assessing the expected positive or negative consequences from future climatic change. A CVA for the Western Baltic Sea is interesting since such assessments are underrepresented for highly dynamic estuarine ecosystems, although these ecosystems are known to be vulnerable and affected by climate change in the future. This may be especially the case for the Baltic Sea, where climate impacts are already severe, but the future anticipation of changes is complicated by the dynamic nature of its oceanography. Our results revealed that the fish species' sensitivity to climate change are generally determined by traits related to the life cycle of the fish species. Also, the exposure of the species to future temperature changes tends to be low by the middle of the century, increasing until the end of the century depending of the type of emission scenario assumed. The overall vulnerability of the species increased accordingly until the end of the century with some of the commercially important species such as cod, herring and salmon having the highest scorings. Our results underpin the urgent need of adaptation plans for developing the future of fisheries in the western Baltic Sea grounded on ecosystem-based management to ensure sustainable use of the fish resources under the impact of climate change.

Keywords: vulnerability assessment, fisheries, western Baltic Sea, climate change

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CM 354: Towards end-to-end (E2E) models in Spanish fisheries: Phys2Fish and Demon projects

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End-to-end (E2E) models include the explicit dynamics of the physical environment, the primary and secondary production, as well as the exploited fish populations. This communication aims to show the roadmap and the methodology that will be developed for the configuration of E2E models for 4 commercial species in the context of the Phys2Fish and Demon projects. Phys2Fish is focused on three key commercial species: the European sardine (*Sardina pilchardus*), the European hake (*Merluccius merluccius*) and the common octopus (*Octopus vulgaris*). The application of E2E models will integrate bio-physical models, higher trophic level models, and socio-economic models. The structure is based on the Regional Ocean Modeling System (ROMs) on which a biogeochemical NP2ZD2 model will be run. Taking this model as a basis, a Lagrangian Individual Based Model (IBM) will be parameterised for each of the species. Although these species are well known and have been studied in depth, in many cases this knowledge is not parameterised, and this is one of the most important tasks in the development of each of the parts that make up the final model. The knowledge gaps in the parameterization of the processes will play a dual role: first, to validate the established knowledge and second, to estimate unknown parameters. A major challenge is to find the best way to couple the outputs of this type of model with the higher trophic level models used for the stock assessments and provide a management advice. Furthermore, Demon project will study the populations of European sardine and anchovy in two oceanographically distinct regions: the Mediterranean and the North and North-West Iberian Peninsula. In this case, we will work on improving the physical and Lagrangian models. It is known that slight variations in the outputs of these models are amplified and lead to large changes in the survival and connectivity of species. In order to improve the current knowledge in this type of process, we will work using the same tools and models to allow greater efficiency and better comparability of the results. The ultimate goal of both Projects is the simulation of scenarios *what if*? to assess the impacts of changes at climate scales, including socio-economic impacts, and facilitate the implementation of fisheries management strategies.

Keywords: end-to-end model, Spanish fisheries, sardine, hake, octopus, anchovy, Mediterranean Sea, Galicia waters

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CM 363: The Central Arctic Ocean Integrated Ecosystem Assessment: Why, How and for Whom?

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WGICA is the ICES-PICES-PAME working group for the remote and data limited Central Arctic Ocean (CAO), consisting of members from both the Atlantic and the Pacific part of the Arctic in a collaboration that also includes the Arctic Council. The WGICA Integrated Ecosystem Assessment (IEA) is based on best available published data. A risk assessment approach is used, building upon an understanding of how climate warming and advection from global pollution sources, are adding to the impact of this High Arctic ecosystem. The analyses will synthesize and evaluate information on physical, chemical, ecological, human and environmental processes affecting this ecosystem.

The results of the assessment will be presented to and discussed with different stakeholders including indigenous peoples. We would like to understand if the measured "state" is within the expectation of the indigenous people living in and of the high Arctic. How does the current "state" meet ecological, social, economic and cultural objectives of the Indigenous peoples.

The goal of IEA is also to raise early warning signals to managers of upcoming changes that will influence the ecosystems and the human activities and ecosystem services that depend on them. The High Seas of the CAO does not have a well-defined operative management unit in place; the nations surrounding the CAO with interest in the area, will therefore act as stewards in the management of the marine resources and human activities. WGICA will present the results of the IEA assessment in forums where these nations participate (meetings and conferences), promoting an open and inclusive discussion on the use of the IEA as a tool to achieve nationally and international relevant ecological, social, economic, and institutional objectives. The translation of the IEA knowledge into operational advice must be in such a way that nations can negotiate for common agreements that Protects and preserves the delicate CAO Ecosystem from current and future increased stress induced by Human activities.

Keywords: central arctic ocean, integrated ecosystem assessment, climate change, ship traffic, stakeholders, operational advice

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CM 370: Integrated ecosystem assessments (IEA) are hard; challenges of scale, focus, integration, interaction and managing complexity in the Celtic Sea/s

Debbi Pedreschi[1], Dave Reid[1]

Integrated ecosystem assessments (IEA) are hard. IEA's have the noble intention of integrating all components of an ecosystem, including anthropogenic and ecological pressures, society, and the economy. However, all of these components also interact with each other. And our societal preferences, economic conditions, political circumstances, and technological capabilities keep changing and evolving. Unsurprisingly, this throws up all kinds of issues and complexity, including, what even is an IEA?

Here we detail the experiences, trials, tribulations, and lessons learned from working on IEA in the Celtic Sea/s. We highlight issues of scale (national regional to ecoregional level), the difficulties in integrating different types of scientific knowledge, data streams, and skill-sets with limited budgets and very small teams, the challenges of incorporating interactions between pressures (e.g. cumulative effects), what happens when your stakeholders have different priorities than your project, and how we are working to wrestle all of this information into something understandable, interpretable, and most importantly, useful.

Keywords: integrated ecosystem assessment, stakeholder engagement, ecosystem, human dimensions

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CM 450: Organizing Integrated Ecosystem Assessment in the Field of Ocean Governance

Kurt Rachlitz[(1)], Jennifer L. Bailey[(1)], Michael Grothe-Hammer[(1)], Patricia M. Clay[(2)], Matthew Cutler[(2)], Dorothy J. Dankel[(3)], Jessica L. Fuller[(3)]

Integrated Ecosystem Assessments (IEAs) are tools meant to assess very complex interrelationships in order to make scientifically sound recommendations to policymakers. The recommendations they generate should integrate the state of knowledge of different – often even mutually contradictory – knowledge communities (Link & Browman, 2014).

Both the design and the implementation of IEAs present challenges. The call for abstracts recognizes many of these: Which perspectives are integrated into assessments, and which are not? To what extent do both their underlying approaches and their practical implementations differ? What are the reasons for these differences? To what extent is it possible to integrate these different perspectives in a meaningful way? To what extent are these assessments successfully communicated to policymakers? And how do you ensure that policymakers do not limit complexity, whether inadvertently or due to conflicting goals (Clay et al., 2023)?

Instead of answering these questions, we add yet another dimension to this discourse. Our working hypothesis is that the success of IEA is not only a matter of smart IEA design and finding ways of integrating the best knowledge sources, but also of creating the right organizational circumstances. So, we pose another question, namely:

What organizational circumstances must be in place for IEAs to succeed?

Our objective is to both introduce the organizational dimension into the IEA discussion and to provide the first steps toward addressing its implications, with ICES as a case study. Building on existing work on ICES (Burns & Stöhr, 2011; Cvitanovic, Mackay, et al., 2021; Cvitanovic, Shellock, et al., 2021; Dankel et al., 2016; Karcher et al., 2022; Stange et al., 2012; Wenzel, 2016; Wilson, 2009), as well as to our own empirical research, we seek to understand both how ICES functions as an organization (i.e., a specific type of social system) and the socio-political environment in which it operates. The first question focuses on goals, programs, communication structures, and staffing decisions. The second question centers around the field of ocean governance, i.e., other actors and their interactions that significantly shape ICES – especially the engaged scientists, the member countries, the organizations to which ICES provides advice, and the national fisheries ministries and national marine institutions, stakeholder based advisory bodies, ENGOs and other interest groups such as fishers and fishing communities.

We draw on two sociological approaches: basic concepts from Niklas Luhmann's modern systems theory (Luhmann, 2018, 2020; Grothe-Hammer, 2022) and the so called "field-as-social system perspective" (Windeler & Jungmann, 2022).

Keywords: IEA, organization, ocean governance, modern systems theory, field-as-social system

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CM 490: Predator-prey interactions: modelling the multi-species functional response of grey and harbour seals in the North Sea

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Resource uptake is the fundamental process that links trophic levels through predator-prey interactions. The critical component that describes how consumption rate of a predator varies in relation to prey density is the functional response and is crucial to understand trophic interactions, predation pressure, prey preference and population dynamics.

This study modelled the multi-species functional response (MSFR) of grey (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) in the North Sea to describe how consumption will vary dynamically depending on the availability of multiple prey species. Bayesian methodology was employed to estimate MSFR parameters and to incorporate uncertainties in diet and prey availability estimates. Diet composition was based on information from seal faecal samples. Prey availability estimation was based on combining prey distributions, estimated from fish survey data, with predictions of the geographical area that was accessible to the predator, given food passage time, from telemetry data.

Results indicated that both seal species have a type III functional response. Sandeels are important but more strongly preferred by grey seals. While harbour and grey seals are sympatric and consume similar prey species, results also suggested that they might be functionally distinct predators, with harbour seals having a more diverse diet and exhibiting a more sigmoidal response that may indicate a greater tendency to switch prey. Depending on what kind of prey is available and their associated profitability (i.e., obtained energy divided by costs of acquiring that prey) could lead to circumstances that are unfavourable for harbour seal populations.

Keywords: multi-species functional response, North Sea, grey seal, harbour seal, predator–prey interactions, prey switching, sandeels

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CM 498: Risks from cumulative human impacts on Ecologically and Biologically Significant Areas in Norwegian waters

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Recent work defines 60% of Norwegian marine waters as Ecologically and biologically Significant Areas and hence of particular interest for biodiversity conservation. We used the ODEMM (Options for Delivering Ecosystem based marine management) approach to assess the cumulative risk from human activities in each of these areas (19 in total) distributed across the North, Norwegian and Barents Seas. The assessment was based on vulnerabilities and exposure of the relevant ecosystem components to pressures from diverse economic sectors. Cumulative risks from the sectors varied greatly between the areas. Coastal areas were in general associated with higher impact risk than more offshore and remote areas, and impact risks were higher in southern compared to northern areas. Overall, four main sectors were associated with the highest risk of impact: shipping, fisheries, oil and gas and tourism. However, in coastal areas also land based sectors and nearshore activities added to the cumulative impact risk. Here we discuss how climate change have been and could have been included the assessment, how the risk assessment has been co-developed with managers and feed into the cross-sector management plans for these regions, and how these assessments link to integrated ecosystem assessments of the same regions.

Keywords: ecosystem risk assessment, Integrated ecosystem assessment, co-production

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CM 505: Exploring future trajectories of human activities, climate change, marine conservation and their interactions to inform cumulative effects assessments

Vanessa Stelzenmüller, Jennifer Rehren, Serra Örey[1], Rabea Diekmann

The global industrializations of seascapes and climate change are increasing the risk of severe impacts on ecosystem functioning and viability of coastal and offshore areas. While large-scale spatio-temporal assessments of human pressures on marine ecosystems have increased in recent years, future trajectories of human activities at regional and local scales often remain speculative. In the course of the MuSSel project, which aims to assess the cumulative adverse effects of human pressures and climate change on the seabed of the southern North Sea (SNS), we developed a transdisciplinary framework to determine future trajectories and future (2030, 2060) scenarios of key human activities. Hence, building on a sustainability narrative we identified key development components and defined a template for optimistic, realistic, and pessimistic future scenarios of the activity/stressor in terms of its spatial footprint, intensity, and technological advances. An essential step in our framework was to hold a workshop (March 2022), with recognized experts in fisheries, offshore wind energy production, nutrient discharge, and sand and gravel extraction. Sub-groups were formed for each activity to review and prioritize components influencing development, considering long-term impacts of climate change, the growing need for marine conservation, and technological innovation or nature-based solutions. Using network analysis, we analyzed and categorized the interactions between the current and future trajectories of the activities. Further we mapped a case study near future scenario for fisheries for comparison with the current state. Our study highlights the importance of expert and knowledge-based scenarios for direct use in cumulative effects assessments and provides for the first time robust future change pathways and scenarios for four human activities in the German North Sea.

Keywords: human pressures, climate change, the southern North Sea, foresight workshop, multiple stressors, cumulative effects assessments

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CM 533: Spatiotemporal models improve Integrated Ecosystem Assessment indicators

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Integrated ecosystem assessments incorporate information across a wide range of processes (e.g., ecological, human, and physical) that are taken together can support holistic management objectives. Typically, these ecosystem processes are distilled into indicators to inform decision making. Indicators often contain some inherent artifacts from the underlying survey design and data collection, such as spatial coverage and temporal resolution, which could influence the interpretation of indicators relative to management objectives. For example, some fish species exhibit spatial variation in size, weight, and diet according to their seasonal distribution, and indicators developed for a particular area or season could misrepresent broad patterns occurring for that species. Here, we explore spatial and temporally explicit ecological indicators developed using multivariate spatiotemporal models using survey data from the Northeast United States Shelf Ecosystem. We evaluate several case studies to explore how these models can help assess ecosystem performance relative to management objectives, such as to: (1) identify dominant modes of variation in seasonal zooplankton communities, (2) quantify ecosystem portfolios, and (3) assess density-dependent fish condition over time. Disentangling the spatial components of these ecological indicators highlights that ecosystem processes are highly variable over both space and time, and we should consider the best ways to communicate these spatio-temporal patterns so that managers can effectively evaluate trade-offs between management objectives.

Keywords: integrated ecosystem assessment, ecological indicators, vector autoregressive spatio-temporal (VAST) modeling, northwest Atlantic

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CM 554: Parasite hazards in ICES fish stocks: a neglected source in Integrated Ecosystem Assessments

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Fish are an important part of a healthy, well-balanced diet. They provide a good source of protein and vitamins and are a primary dietary source of heart-healthy omega-3 fatty acids. While eating fish has nutritional benefits, it also has potential risks. Fish can take in harmful biohazards from naturally exploited ecosystems and the food they eat.

Regarding parasite hazards, there is plenty of scientific evidence related to the raised natural impact of marine parasites on the 3S stands for Fisheries: Security, Safety, and Sustainability. Many parasites, which occur in exploited ecosystems, could potentially overcome a hierarchical series of barriers to cause spillover effects on wild fish productivity and sustainability, and/or seafood consumer´s health. The conclusion behind an intensive decade of fish parasite monitoring at ICES fishing areas tell us about quality product rejection with significant economic losses along the fish-production value chain, serious parasite risk exposure for fish-eating consumers, unsustainable fishing practices on heavily-parasitized stocks still being considered, and an increased confused concern at the fish industry on how managing these challenges. The idea that parasite biodiversity may constitutes a threat to efficient ICES fish production value chains provokes a very real sound perspective of parasites being integrated within the fish holobiont paradigm, and as a part of the socioecological management system in any particular fishery. We provide data to argue that a parasite hazard warning system based on the 3S model (from net to plate), integrated in an adaptive co-management of fisheries, could be the best choice highlighted by the cost-effectiveness to prevent such socioecological potentially damaging impact of parasites to ICES fisheries. Overall, we propose a design for major parasite threats integrated in the One Health approach needed in ecosystem management practices.

Keywords: parasite hazards, 3S model, holobiont, socioecological system

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CM 607: Ecosystem modelling and integrated ecosystem assessment in the Gulf of Alaska

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The Gulf of Alaska (GOA) is one of the most important large marine ecosystems (LMEs) in the United States, hosting numerous federally protected species and valuable fisheries. It is also one of several US LMEs with an integrated ecosystem assessment (IEA) program operated by NOAA Fisheries. These IEA programs produce annual reports for regional fisheries management councils on trends in ecosystem indicators, from physical oceanographic variables to top predator populations, with the goal of assisting ecosystem-based fisheries management (EBFM). Many of the LMEs with IEAs are also represented by ecosystem models designed to aid EBFM. This paper reports on GOA ecosystem models developed at the US NOAA Alaska Fisheries Science Center as part of the GOA IEA and GOA Climate Integrated Modeling (GOA-CLIM) projects. These models, built using the Ecopath with Ecosim (EwE) and Atlantis frameworks, can generate projections of trends in ecosystem indicators (e.g., motile epifauna and apex predator biomass) under various fisheries and climate scenarios. Models are initialized using data for 1990-1993 (when most reliable time series began) and informed by fisheries-independent surveys (primarily bottom trawl and longline), fisheries catches, and oceanographic (ROMS-NPZ) models. The model area includes US waters overlying the continental shelf and upper slope (0-1000 m deep). Models represent the GOA ecosystem as a set of functional groups (i.e., species or groups thereof sharing fundamental ecological traits) spanning all trophic levels and size classes from phytoplankton to whales and linked by biomass fluxes representing trophic interactions. Important commercial fish species are represented with explicit age structure. Models also include fishing fleets defined primarily by gear and target species. Functional group and fleet structure focuses on protected species and commercial fisheries. Models are tuned (Atlantis) or fitted to time series (EwE) to provide hindcasts of ecosystem dynamics. Model outputs reveal the directions and strengths of trophic interactions in the GOA ecosystem. These models are expected to support IEA and EBFM by projecting ecosystem indicator trends under combined climate and fisheries management scenarios.

Keywords: Gulf of Alaska, Northeast Pacific Ocean, United States, integrated ecosystem assessment, IEA, ecosystem indicators, ecosystem dynamics, ecosystem modeling, Ecopath with Ecosim, EwE, Atlantis

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CM 614: What is the status of food webs in the Baltic Sea? – development of biodiversity indicators within HELCOM

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Food webs are vital for marine biodiversity and productive ecosystems. The need to improve food web assessment is urgent in many sea regions, as well as the need to develop relevant management actions to ensure their healthy state. For the Baltic Sea, major human-induced changes in the abundance and biomass of important species have been associated with corresponding alterations in food webs, and several examples of whole-system disruptions and putative tipping points give cause for concern. Unfortunately, presently available data do not support systematic, quantitative assessments of food web status. Current HELCOM indicators to some extent indicate the status of key food web components but do not facilitate studies of interlinkages or address changes in food web functionality. Addressing policy relevance, e.g., for the Marine Strategy Framework Directive (MSFD), and catalysing management action is therefore difficult.

The HELCOM Expert Group on Food Webs (EG Foodweb) provided qualitative assessment of food web status for the HELCOM HOLAS 3 (Holistic Assessment on the State of the Baltic Sea), and is tasked with the further development of quantitative, indicator-based assessment of food web status in the Baltic Sea. The work is supported by inter alia the ICES/HELCOM group for integrated assessments of the Baltic Sea (WGIAB) and aligns with requirements of the EU MSFD.

Quantitative analyses for different sub-basins illustrate the potential for further indicator development. Specifically, integrated trend analyses of offshore food web dynamics in the Bothnian Sea over the last 30 years revealed shifts in the relative abundance of trophic guilds with breaking points in 2005 and 2016, coupled with decreases in herring biomass and changes in seal abundance. The shifts were associated with changes in fishing mortality, nutrient availability and benthic species composition. Further, an ecosystem model of the Western Baltic Sea showed how the collapse and lack of recovery of both western Baltic cod and western Baltic spring-spawning herring is linked to negative consequences for overall biodiversity and food web resilience to ocean warming. Small sizes of these commercial stocks threaten the persistence of small-scale fisheries and have the potential of altering carbon biogeochemistry. Efforts to date also highlight that upscaling quantitative approaches to the entire Baltic and further indicator development may depend on the initiation of new databases, for example to support integrated analyses or provide information on diets. To succeed and to develop better indicators, new data may be required at the regional level, which may have implications for monitoring and data collection in the future.

Current knowledge highlights that maintaining the resilience and regulatory capacities of food webs requires management that accounts for multiple pressures and is conservative. Examples include measures to adapt fish extraction quotas to environmental conditions, and enhanced protection of biodiversity and habitats. Vice versa, considering the role of food webs in mediating prevalent disturbances in the Baltic Sea, an improved understanding of food webs has strong potential to inform and strengthen the management of pressures and biodiversity components.

Keywords: food web, HELCOM, Baltic Sea, Ecopath with Ecosim, indicators, Integrated trend analysis

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CM 643: An index-based multi-criteria approach for assessing the coastal risk to litter pollution

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The rapid increase in the amount and prevalence of litter along coasts and in the oceans is one of the most significant examples of negative human activities. Along with global warming, loss of biodiversity, ocean acidification, and overpopulation, litter has been named as one of the top 5 environmental problems facing humans and one of the global Sustainable Development Goals. Identification of the most vulnerable sites is an important challenge for coastal zone planning and management. The main aim of this work was to develop an index-based methodology for the assessment of coastal zones under potential pollution risk by litter in the South-Eastern Baltic Sea, Lithuanian coastal zone. Developed potential coastal pollution risk (CPR) methodology consists of the coastal use (CU), the coastal anthropogenic pressure (CAP) and the coastal exposure to marine litter pollution (CEMPL) indices. Twelve environmental and socio-economic criteria were identified, collected and analysed using ArcGIS 10.3 software package. The components of the criteria were rated on a 5-level risk scale, ranging from very low (1) to very high risk (5). Expert judgment was used to determine the relative weights of the criteria using the Analytic Hierarchy Process (AHP). CU, CAP and CEMPL indices and the final CPR index were calculated for each 1 km stretch of shoreline and output maps were produced. Anselin Moran, I clustering was used to identify statistically significant high-risk coastal areas, which distinguished hot/cold spots and statistically insignificant areas. The assessment of CPR showed that 48% of the seacoast is at low and very low risk, 30% at medium risk, and 8% and 14% at high and very high risk respectively. The spatial statistical analysis showed areas of increased risk ('hot spots') (12.6% of the total coastline), which coincided with the very high-risk sections identified by the CPR. These results were highly consistent with the spatial pattern of CPR values. The highest risk areas were identified by at least 6 criteria with a "very high" risk rating. Although 'high' risk zones were underestimated and did not fall into a statistically significant cluster of hotspots, as a result, about 22% of the surveyed coastline is at high persistent risk and requires extra attention in coastal zone management decisions. These are the areas of intensive coastal use and anthropogenic pressure, close to the settlements and zones of intensive tourism.

Keywords: marine litter, pollution risk, coastal management, Multi-criteria evaluation, AHP, GIS

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CM 651: Integrated Ecosystem Assessment in a remote archipelago context

Inês Gomes[1], Diana Serrano, Christopher Pham, Pedro Afonso

Identifying the diversity, dynamics and implication of anthropogenic pressures affecting marine ecosystems sets the basis for Integrated Ecosystem Assessments (IEA). Operationalizing such concept allows for the identification and quantification of pressure pathways, as a flexible tool to measure both impact risk and vulnerability of marine systems, based on best available knowledge.

Building upon this concept and based on the ODEMM approach (Options for Delivering Ecosystem-based Marine management), we propose a cross-sectorial IEA analysis adjusted to the Azorean socio-ecological setting. A semi-quantitative risk assessment was performed across sectors, pressures and ecosystems, at multiple ecological scales, using a broad literature review, expert judgment, and stakeholder engagement. Our results identified 12 economic activities (sectors) triggering 16 pressures, with a potential impact on 28 ecological components (671 impact chains) within the full extent of the Azores EEZ.

Fishing, tourism, and shipping accounted for over 86% of the summed impact risk across sectors, due to their impact concerning species extraction, bycatch, contaminants, invasive species and litter. Importantly, out of 15 pressures analysed, these 5 were responsible for 95% of the total impact risk in the Azores marine ecosystem. Even though coastal ecosystems make up only about 1% of the total area assessed, it experienced more than 50% of all impact risk, affecting mostly demersal fishes, shallow and littoral rock and reef and coastal pelagic fishes.

The vulnerability assessment complemented the impact risk score by accounting for the ability of the system to resist change, underlining the presence of important vulnerable ecosystem components such as long-lived open-ocean highly mobile species (reptiles, pelagic elasmobranchs, and marine mammals) and deep-sea habitats (such as deep-sea reefs and large seamounts).

Overall, this IEA methodology allowed a) a systematic overview of the human imprint (impact risk) and vulnerability of different ecosystem components at a regional scale b) the recognition of knowledge gaps associated to such linkages and c) the integration of results in the face of MSFD requirements and the establishment of MSP plans.

Keywords: Risk Assessment, impact chain, oceanic islands, ecosystem-based-management, MSFD

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