WORKSHOP ON FOURTH GENERATION ECOSYSTEM OVERVIEWS (WKEO4; outputs from 2025 meeting)

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Contents

i Executive summary

Ecosystem Overviews (EOs) are central products in the ICES approach to support Ecosystem Based Management, through providing the ecoregion context, identifying main pressures, associated human activities and impacts on ecosystem state. The Workshop on fourth generation ecosystem overviews (WKEO4) reviewed and updated priority topic lists for the EOs, discussed and advanced climate change impacts, and social and economic context sections in the EOs, and developed recommendations on how to improve the utility of EOs to meet advisory and decision-making needs.

The workshop proposed the following five priority topics to be included/advanced in EOs: effects of climate change, foresight (with a focus on spatial analyses), cumulative effects, biodiversity and functional diversity, and trade-offs between ecological, social and economic sustainability.

These priorities reflect a consensus to update EOs from static, descriptive summaries into dynamic, integrated, and operational tools that explicitly link ecosystem information and advice to options for management responses. Workshop discussions also highlighted the need for stronger connections between ecological and social information, improved visual and spatial presentation of results, and greater alignment with international and regional policy frameworks such as the EU Marine Strategy Framework Directive, OSPAR, and the Kunming-Montreal Global Biodiversity Framework. Participants also discussed the need to more systematically adopt available workflow resources (e.g. Transparent Assessment Framework), interactive delivery platforms (e.g. ICES Xplorer suite), and novel methodologies applied within ICES (e.g. Spatial Cumulative Assessment of Impact Risk for Management). Doing so would help transition EOs towards a more modular structure, where sections can be updated more readily with self-contained methods, code, and analyses. With this, we aim to streamline EO updates and enable EOs to transition into an online application.

Further work should include workshops on: i) societal/management objectives to support EOs, ii) developing guidance on social and economic data collection, use and documentation, iii) revised risk assessment methodology and a follow-up benchmark (Workshop on methods and guidelines to link human activities, pressures and state of the ecosystem in Ecosystem Overviews 2 (WKTRANSPARENT2)), and iv) Fifth Generation EOs (WKEO5).

ii Expert group information

Expert group name	Workshop on Fourth Generation Ecosystem Overviews (WKEO4)
Expert group cycle	Annual
Year cycle started	2025
Reporting year in cycle	1/1
Chairs	Henn Ojaveer, Estonia
	Jacob Bentley, UK
	Nathalie Steins, Netherlands
Meeting venue and dates	16–20 June 2025, Copenhagen, Denmark (55 participants)

1 Introduction

The ICES science and advisory plans highlight the importance of providing ecosystem-based advice to management. The Ecosystem Overviews (EO) are one of the main products to deliver our science for Ecosystem Based Management (EBM). The EOs have been developed through consultations with the advice requesters, and a series of scoping and framing workshops.

The EOs are part of the recurrent advice in the Administrative Agreement signed between the EU and ICES, included Memorandum of Understanding (MoUs) with other requesters and are a key mechanism for ICES to deliver its ecosystem-informed advice incorporating climate change impacts. This workshop (WK; Figure 1.1) is strategic for the development of ICES Ecosystem Approaches and Methods Steering Group (EAMSG) and Human Dimension Steering Group (HUDISG), advancing the implementation of the ICES Framework for Ecosystem-Informed Science and Advice (FEISA) and following up on the work of the Workshop on the design and scope of the 3rd generation of ICES Ecosystem Overviews (WKEO3), ICES Workshop on Challenges, Opportunities, Needs and Successes for including human dimensions in IEAs (WKCONSERVE) and Workshop on pathways to climate-related advice (WKCLIMAD). The outcomes of the workshop will be relevant to any future iterations and formats of the ICES overviews taking account of the discussion of the ICES Advisory Committee (ACOM) on improving integration.

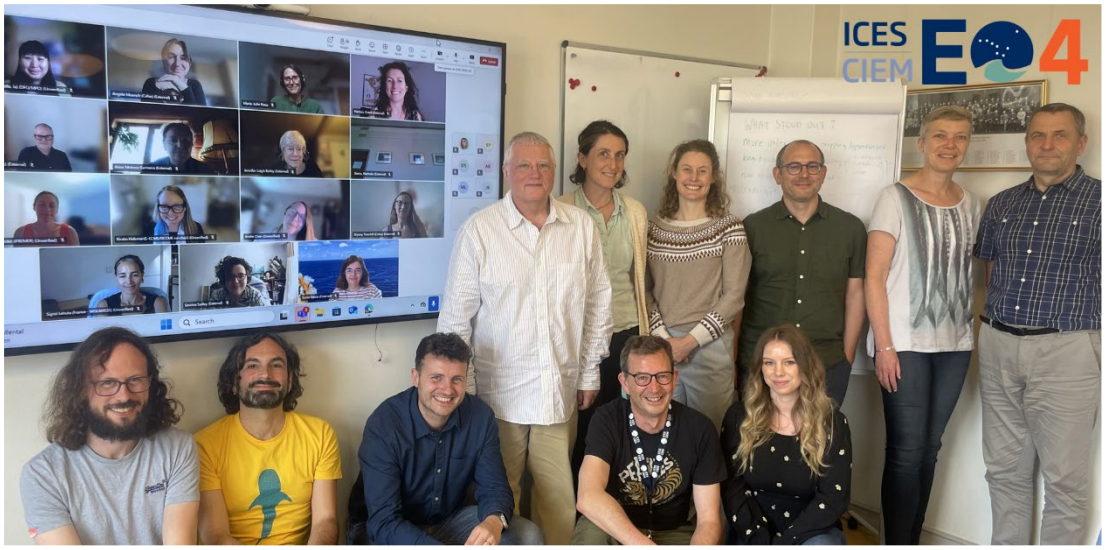

Figure 1.1 Participants of WKEO4, ICES HQ, Copenhagen.

The Terms of Reference of WKEO4 were to:

a) Review and update priority topic lists for the Ecosystem Overviews (EOs). Identify and document progress to date, existing gaps and emerging topics, and prioritize based on available knowledge and advice users' needs. Produce updated medium (3–5 years), and long-term (5–10 years) priority lists, taking into account the ICES Framework for Ecosystem-informed Science and Advice (FEISA).

b) Considering FEISA, advance specific sections in the EOs to meet end-user needs and by developing/proposing:

   i. A common template structure for the climate change section (flexible to regional needs and available data), to be piloted in the Central Arctic Ocean and Oceanic Northeast Atlantic ecoregions.

ii. A common template structure for the social and economic context section, flexible to regional needs and available data, and flagging future needs/directions
iii. A general schematic summary for communicating the main key signals of the EO.

c) Develop recommendations on how to improve the utility of EOs to meet advisory and decision-making needs, improve communication and accessibility, and address capacity challenges by:
   i. Reviewing Integrated Ecosystem Assessment (IEA) and EO production processes to identify opportunities for streamlining and improving information flow and integration across groups and products, including data and evidence management.
   ii. Investigate how to improve alignment and integrate indicators, data, and information from other state of the environment reporting (e.g. OSPAR, HELCOM, Norway, EU MSFD, NAFO) into the EOs to reduce redundancy and address capacity challenges.
   iii. Critically review current EO format to assess how to improve accessibility, such as via interactive outputs from IEA and EOs (e.g. Shiny apps, ArcGIS Story maps, Web Services, etc.).

2 ToR a: priorities

2.1 Background

ToR a: Review and update priority topic lists for the Ecosystem Overviews

ToR a description: Review and update priority topic lists for the Ecosystem Overviews. Identify and document progress to date, existing gaps and emerging topics, and prioritize based on available knowledge and advice users' needs. Produce updated medium (3–5 years), and long-term (5–10 years) priority lists, taking into account the ICES Framework for Ecosystem-informed Science and Advice (FEISA).

To address ToR A, a mixed methods approach was used. Prior to WKEO4, the chairs developed a stakeholder questionnaire. Results of this survey were used to inform discussions in focused breakout groups, followed by a plenary discussion to draw joint conclusions. Results of each stage are presented below.

2.2 Stakeholder questionnaire

Findings

Prior to WKEO4, a questionnaire about Ecosystem Overviews (EOs) was sent to the requesters of advice (through the meeting with ICES and the requesters of ICES advice, MIRIA), individuals and organizations with stakeholders (through the meeting between ICES, Advisory Councils and other Observers, MIACO), the through the coordination meeting between ICES and the European Advisory Councils (MIAC), and participants in WKEO4. The questionnaire aimed to evaluate the current usage of EOs by stakeholders and their needs.

The questionnaire received 39 responses from various stakeholders, including policy and regulatory bodies, academia, applied research, fisheries associations, and NGOs, from across at least 13 ICES Member Countries. Over a quarter of respondents were involved in representing stakeholder interests, followed by conducting research, providing scientific advice, policy development, management decisions, or other activities. As such, the questionnaire results provide a diverse range of perspectives. However, the results (Annex 3) must be interpreted with caution, as they do not meet criteria for quantitative or qualitative representativeness for the ICES science network or single stakeholder groups (policy, interest groups, etc). The results can therefore only serve as an indication to guide or inspire discussion.

Key future topics for EBM identified included, in order of highest score (≥10 times selected): (1) inclusion of ecosystem-based considerations for fisheries in ICES advice on fishing opportunities; (2) effects of climate change; (3), biodiversity/functional diversity; and (4) spatial management.

From the 39 respondents, most were moderately familiar (n=16) or very familiar (n=12) with the ICES EOs. Ten were slightly familiar and one was not familiar at all with them. ICES observers constituted the group with the highest familiarity, followed by chairs or members of ICES expert

groups. Requesters of ICES advice were stakeholders least familiar with the EOs, with none of them indicating they were very familiar with them. This can be explained by the organizational background of the advice requesters, again showing that the results are not representative but indicative only.

Eighteen out of the 39 respondents used the EOs in their work. The ICES observers used the EOs the most (9 out of 13), followed by ICES expert group chairs or members (3 out of 12), 'others' (3 out of 4), and requesters of advice (1 out of 7). Of those respondents who chose not to disclose their role (3), two had used the EOs. Respondents use the EO for the following purposes:

- advising or giving recommendations to managers (scientists, ACs, NGOs, others);
- advocacy work (NGO's, fisheries associations);
- comparative analysis between ecoregions (scientists, NGOs);
- draw managers' attention to wider ecosystem considerations as opposed to single species fisheries management (NGOs);
- education (scientists);
- information source (scientists, ACs, NGOs, others); and
- supporting management decisions (policy).

Seven respondents did not use the EOs in their work. These included expert group chairs or members (4 out of 12), requesters of advice (2 out of 7), and observers (1 out of 13). Considerations for not using the EOs included:

- a perceived lack of transparency about applied methods, data used, and scientific basis of their conclusions (scientists);
- EOs being too general and largely inapplicable to stakeholder interests (fisheries associations);
- too many reports to read, too little time (policy);
- not being sure of how EOs can help (policy); and
- not relevant to particular advisory role (scientists).

The questionnaire also asked stakeholders to rank the importance of the current subheadings in EOs (Table 2.1). The results show that the state of the ecosystem section was considered almost as important as Key signals (document summary), more important than the Pressures section, and far more important than the Climate change and the Social and economic context sections. Again, these results are indicative only, and not representative for the ICES stakeholder community (including ICES scientists).

Table 2.1 Stakeholder questionnaire results – ranking of the subheadings in the Ecosystem Overviews, including weighted average scores where rank 1 had the highest weight (6) and rank 6 had the lowest weight (1). N=39.

EO Heading	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Weighted results
Climate change effects	1	6	10	6	9	7	119
Ecoregion description	4	9	2	4	5	15	114
Key signals (document summary)	17	4	5	4	4	5	167
Pressures (of human activities)	6	11	3	14	4	1	154
Social and economic context	1	3	6	6	16	7	102
State of the ecosystem	10	6	13	5	1	4	163
N=	**39**	**39**	**39**	**39**	**39**	**39**	

Finally, the questionnaire asked about the preferred presentation for EOs in future. Respondents expressed preferences for a combination of a traditional pdf document with a supporting infographic or interactive format.

Discussion of questionnaire results

Workshop participants were surprised that the key signals section – the document summary that includes the WIRE-diagram - was considered less important than the State of the ecosystem section. The low ranking of the Social and economic context section was also unexpected. It was suggested that these findings may be biased by the limited range in organizational backgrounds the respondents represented. Analysing responses by organizational backgrounds had not been done formally since the required representativeness criteria such an analysis were not met. However, a post-workshop check suggested no link with respondents' organizational backgrounds.

The finding that a 'lack of transparency about methods and underlying data for EOs' was a reason for respondents not to use the EOs sparked discussion. Workshop participants who had been involved in the development of the EOs explained that each paragraph is backed by relevant science and publications, but these are not linked clearly to the main text through a common referencing approach (although a reference list is provided). It raised the question of whether the ACOM decision to exclude references in the text should be revisited. The workshop participants agreed that it seems contradictory to adopt a "transparent assessment" approach without including the relevant references in the text of the advice. It was decided to request ACOM to review their decision to not include the references in the main body text of the EOs.

A discussion of the findings related to prioritization of topics and to future approaches to the presentation of the advice is discussed in Chapter 2.3.

Following discussion of the questionnaire result, WKEO4 set out to identify key priorities for the development of EOs in relation to the needs of stakeholders. The workshop used the indicative questionnaire results to prioritize topics.

2.3 Prioritization of topics and inventory of stakeholder needs

Approach

To identify priorities for the fourth generation of EOs, a stakeholder interaction meeting was organized. The discussion was prepared using two consecutive sessions of subgroups, each lasting one hour. Table 2.2 gives an overview of the subgroup themes, questions and participant categories. Results of the subgroups were discussed in plenary.

Table 2.2 Organization of subgroups during the stakeholder interaction meeting

Theme	Subgroup	Participants	Questions
Prioritization of topics	1a	Stakeholders incl. members of MIRIA, MIACO, MIAC	Based on findings from stakeholder questionnaire, identify 3 high priority topics ICES should include in EOs in the short term (next 3-5 years) and 5 high priorities for the longer term (5-10 years).
	1b, 1c	Scientists of mixed disciplines (two subgroups)	[*note the same question was asked in each subgroup*]
How to meet stakeholder needs with EOs?	2a	Stakeholders incl. members of MIRIA, MIACO, MIAC	Identify what needs *advice users* have in relation to future integrated ecosystem-based advice.
	2b	Scientists of mixed disciplines	Identify what scientists, considering their expertise or developments in their field, think will be key issues (content-wise) in relation to integrated ecosystem-based management, *managers* will need information about in the near future.
Inclusion of ecosystem-based considerations in Fisheries Overviews	2c	Scientists and stakeholders (including advice requesters, eNGOs and members of MIRIA, MIACO)	When we think of Ecosystem-Based Fisheries Management, what is the priority form it takes and for what objective? To help inform reflections, it may be useful to think about: Limits of current fishing opportunity advice Missed opportunities in the Ecosystem Overviews Wider ecosystem policy objectives Specific objectives of your institution or legal framework Any specific examples which might exist

Topics for future advice

All three subgroups (i.e. one subgroup of stakeholders and two subgroups of scientists) listed 'effects of climate change', 'spatial management' and 'cumulative effects' as top 5 priorities for the next generation of EOs (Table 2.3). 'Biodiversity/functional diversity' was in the top 5 for subgroups of scientists only. In contrast, 'Trade-offs between ecological, social and economic sustainability' was prioritized by the stakeholder subgroup and one of the subgroups of scientists.

In the plenary discussion it was emphasized that many of the topics listed depend on each other, which made prioritization difficult. Therefore, clarifying pathways and dependencies within and between different components of the marine social-ecological system is essential. The plenary also discussed that greater emphasis should be placed on the concepts of vulnerability and resilience. Resilience, as a concept, offers the advantage of allowing us to consider systems more holistically rather than examining individual components in isolation. A good example is the current debate on banning bottom trawling that links ecological, economic and social systems.

ICES was considered to have a key role as a communicator of complexity, particularly in terms of cumulative impacts of multiple pressures and trade-offs between sectors and conservation. In this context, the three pillars of sustainability – ecological, social, and economic – should be considered in unison. In the current EOs – as well as in other ICES advisory products – there tends

to be a bias towards ecological concerns, while all three pillars should ideally be progressed simultaneously. The group recognized that the advice is shaped by requests from managers. However, it may be more constructive to consider three separate priority lists — one for each pillar — with clearly identified priorities within each. This would reflect the reality that, while natural resources underpin all aspects of the system, these pillars are also shaped by differing management approaches, policy frameworks, and political dynamics, which can at times have conflicting objectives. This also means that trade-offs between pillars are clarified.

There is currently no heading on trade-offs in the EOs, which was considered an omission. Understanding and anticipating trade-offs between the three pillars of sustainability under potential future management scenarios was seen as critical. Methodologies and guidance should be developed, and improved coordination between different ICES groups working on trade-offs is key to this. The group also agreed that rather than seeking more data, the focus of future EOs should be more on providing insights and synthesis in support of policy decisions.

WKEO4 concluded that that topics such as climate change, trade-offs, and biodiversity, should be prioritized. However, the group also acknowledged that further discussion is needed to finalize the prioritization process. In view of the complexity of the issues, a comprehensive approach to prioritize effectively is needed.

WKEO4 also concluded that, given the known timelines for the update of EOs, there may also be an opportunity to collect targeted stakeholder feedback on region-specific issues. This could enhance the relevance and responsiveness of the advice provided across different ecoregions.

Table 2.3 Overview of questionnaire results for the following question: "In your work, what are the topics in relation to Ecosystem-Based Management for which you would like to require (future) ICES advice? You can select a maximum of three topics from the alphabetically ordered list below. If a topic is missing, please use the 'other' field at the bottom of the list to specify". Topics for future advice are listed by score (#times selected). Top 5 priorities of WKEO4 subgroups (are indicated with 'X'. Note: the option 'Inclusion of ecosystem-based fisheries considerations in ICES fishing opportunities advice', which was most often selected by questionnaire respondents, was excluded from the priorities discussion by the subgroups (see below? text section not numbered? or? section 5).

Questionnaire results		Top 5 priorities WKEO4 subgroups		
Topic future advice (excluding ecosystem-based considerations in fishing opportunities advice)	**#times selected**	**Group 1a Stakeholders**	**Group 1b Scientists**	**Group 1c Scientists**
Effects of climate change	12	X	X	X
Biodiversity, functional diversity	11		X	X
Spatial management (e.g. fisheries, multiple ocean uses, protected areas, etc.)	10	X	X	X
Cumulative effects	9	X	X	X
Economic welfare of coastal communities and resource users	8		X	
Ecosystem conservation/restoration	8			
Trade-offs between ecological, social and economic sustainability	7	X	X	
Sustainable seafood production (fisheries and aquaculture)	7			X
Trophic interactions	7			

Knowledge (experiential) from resource users or stakeholders	6	
Emerging human activities and associated pressures (e.g. from Offshore Renewable Energy, deep-sea mining, etc.)	4	
Social welfare of coastal communities and resource users	4	
Ecosystem Services	2	
Tourism and recreation	2	
Governance and policy integration	0	X
Pollution (contaminants, litter, microplastics, etc.)	0	
Oceanographic conditions	0	
Multi-sectoral, integrative assessment	0	
Stakeholder perceptions	0	
Vulnerability/resilience to environmental change	0	
Knowledge (traditional/experiential) from rightsholders or indigenous communities	0	
Other	0	

How to meet stakeholders' needs with EOs?

Two subgroups discussed the question on how to meet stakeholders' needs with EOs. For the subgroup discussion, the Conversation Café method was used, to ensure inclusive, equal and respective discussion (https://www.liberatingstructures.com/17-conversation-cafe/). Both reported to plenary, which was followed by a plenary discussion.

Subgroup 1

The first subgroup comprised of stakeholders from fisheries, environmental organizations and policy. In this subgroup, climate change and its impacts was most frequently flagged as a topic that needs more elaboration in the EOs. In particular, identifying and reporting on knowledge gaps in relation to climate change was seen as important. In addition, the incorporation of 'fisher (experiential) knowledge in the evidence base for ecosystem-based management was identified as a need. In this context, it was also suggested to explore if fishers could play a role in collecting environmental data – as they do for fisheries data. This could foster ownership and motivation for ecosystem-based management. Stakeholders also pointed to the importance of headings such as '(human) pressures on the ecosystem' including high risk factors, 'state of the ecosystem' including ecosystem health, 'trophic/ foodweb interactions'

The format of the EOs should also be evaluated to make it more understandable to non-scientific stakeholders. The format and the information provided in the EOs should be transparent and accessible. It was also suggested that the EO advice should be presented as more actionable. The EOs currently provide an overview of key knowledge supporting the pressure-state linkages presented in the wire-diagram. EOs would be more helpful to managers and to other

stakeholders, if they were more operational, linking them to specific advice questions and management challenges.

Finally, the subgroup noted that from the discussion it was evident that stakeholders from policy, fisheries and environmental NGOs had more in common than is often perceived, as the importance of topics such as climate change, foodweb interaction, stakeholder knowledge and ecosystem-based management approaches were highlighted by all of them.

Subgroup 2

The second subgroup brought together the scientists participating in WKEO4. They looked into the question of what they considered to be key issues (content-wise) in relation to integrated ecosystem-based management, which *managers* will need information about in the near future.

The subgroup noted that there are substantial interdependencies and interlinkages between the different topics covered by the EOs. Some of the topics are extremely broad, while several others fall under these broad topics. Furthermore, some topics that are closely related could be merged in future. The subgroup highlighted that some topics are already included in the ecosystem advice to a limited degree (e.g. climate change), but several other key topics were not included at all. The group agreed not to identify specific high-priority topics per se, but preferred to propose that the integration of specific topics within the broad topics should be considered the high-priority area to be addressed in future.

The subgroup findings were presented and discussed in plenary. Section 2.4 presents the results.

Inclusion of ecosystem-based fisheries considerations in ICES fishing opportunities advice

A separate subgroup discussion was organized around the topic 'Inclusion of ecosystem-based fisheries considerations in ICES fishing opportunities advice'. This topic received the most votes in the survey question on which topics in relation to Ecosystem-Based Management respondents would (future) ICES advice (Annex 3, question 6). As WKEO4's Terms of Reference are not about what future fishing opportunities advice should look like, the group concluded it was not appropriate to include this topic in the discussion on priority areas for future EOs. However, a discussion on how ecosystem considerations could be better integrated for Ecosystem-Based Fisheries Management (EBFM) was considered relevant in view of ongoing discussions on aligning EOs, fisheries overviews, and fishing opportunities advice. A subgroup comprising scientists, ICES requesters, and ICES observers, took on this task and reported to plenary.

Integration of EOs, fisheries overviews and fishing opportunities advice is a logical step in developing a more comprehensive and holistic understanding of marine ecosystems. Integrated advice would also improve the relevance and effectiveness of the advice provided. The subgroup highlighted the need for a comprehensive understanding of the ecosystem to inform fisheries advice. Integrating ecosystem considerations can lead to more informed and sustainable management decisions. While WKEO4 was not required to provide recommendations for the structure of future fishing opportunities advice, this EBFM subgroup aimed to explore how the fourth generation of EOs could communicate ecosystem-informed science and advice which may either support or be useful in the context of fisheries management decisions. There was broad agreement within the group that previous EO have not sufficiently complimented ICES fisheries advice, with better integration needed to identify management decisions and make more applied use of EOs. The subgroup recommended that EOs should include actionable advice to steer fisheries management regarding broader ecosystem objectives, such as the potential risks and trade-offs associated with management strategies for single species and their dependent predators. The subgroup also discussed the relationship between ICES and its requesters and how current

dynamics limit the provision of explicit EBFM advice, with both potentially waiting for the other to initiate ecosystem-informed advice or advice requests.

Overall, the subgroup discussion highlighted agreement between participants that ICES have an opportunity to consciously design EOs to compliment fishing opportunity advice, providing space to draw on diverse forms of knowledge, including qualitative information and fishers' knowledge, and explicitly ecosystem objectives, risk, trade-offs, climate, and cumulative effects. Participants emphasized the potential for collaboration with ICES advice requesters to clarify shared ecosystem objectives and to strengthen the connection between ecosystem information and management needs, e.g. by identify operational objectives. The current description of EOs, provided by ICES online, defines them as "using risk-based methods to identify the main human pressures and explain how these affect key ecosystem components in each ICES ecoregion". This aligns with the 'informational' content they currently include. However, discussions with stakeholders identified demand for a more actionable, less 'just informational' advisory product which can support greater integration of ecosystem information into other areas of ICES advice. While divergent from the existing EO description, this aligns with the ICES science and advisory plans which call for EBM (and EBFM) as well as the development of pathways for using ecosystem information in advice.

2.4 Discussion

Results from the subgroups on stakeholder needs were discussed in the plenary discussion. Strong emphasis was placed on the importance of engaging stakeholders throughout the science and decision-making processes, particularly when considering trade-offs and exploring management scenarios. Stakeholders play a vital role in shaping more informed, inclusive, and widely accepted research questions and management decisions.

A key theme was the value stakeholders bring to discussions around trade-offs and scenario planning. WKEO4 acknowledged that by involving those affected by or with an interest in management outcomes, a broader range of insights and perspectives can be drawn upon, ultimately leading to more balanced and robust options. As part of this process, clear communication and transparency were highlighted as essential elements. Information should be conveyed in a manner that is both transparent and easily understood, allowing stakeholders to participate meaningfully. Ensuring clarity in messaging not only improves understanding but also empowers stakeholders to contribute effectively. Transparent processes were seen as essential to build lasting relationships and securing stakeholder confidence in management outcomes. Openness in sharing data, assumptions, and rationale behind decisions fosters trust and enhances collaboration. The work of ICES Working Group on Stakeholder Engagement (WGENGAGE) was acknowledged as a key development in this context.

The plenary discussion on stakeholder needs again picked up the need for social, economic and ecological trade-offs analysis and organising future EOs around the three pillars of sustainability. There was discussion on whether or not the three pillars are equal. One way of looking at this, is that humans cannot live without nature, so the ecosystem should be the foundation and not an equal pillar. Another way of looking at it, is that taking into account social and economic considerations next to ecosystem considerations, contributes to increasing support for management measures aimed at keeping the ecosystem healthy. Showing different ecological, economic and social (trade-off) scenarios in EOs can inform decision-making, the territory of the managers and not of ICES. The discussion reiterated that trade-off analysis and methodology development, including coordination between expert groups, should be an important priority. In this context, developing a definition of what trade-offs in the context of the EOs means, was deemed necessary. Trade-off analysis is usually understood as an optimization process. The group also agreed

that as part of making potential trade-offs or trade-off scenarios visible in the EOs, information on management objectives is required. Currently, management objectives for the ecoregions are not included in the EOs, as these have not been systematically mapped. The Working Group on Balancing Economic, Social, Ecological Objectives in Integrated Assessments (WGBESEO) is developing a framework for doing this and has a key role to play here. WKEO4 also noted that, in 2019, trade-off analysis was not included in the priorities for the development of third generation of EOs and including it in the work for developing the fourth generation of EOs marks progress in our way of thinking about providing integrated ecosystem-based management advice.

The plenary discussion on EBFM emphasized again the opportunity to align EOs, Fisheries Overviews (FOs), and fishing opportunities advice more deliberately, recognizing that these products should function as connected components of a coherent advisory system rather than as separate streams. This aligns with the overviews integration process initiated by ACOM in 2024 as well as the FEISA implementation goals as reflected in both the ICES Science Plan and Advisory Plan. Participants reflected in plenary that consciously designing EOs with fisheries advice in mind could make them more useful, actionable, and policy-relevant, by drawing on diverse forms of knowledge while embedding climate and cumulative effects as core contextual information. Enhanced collaboration with ICES advice requesters was discussed as essential to clarify and operationalize ecosystem objectives, ensuring that advice reflects both ecological and management priorities. The discussion also acknowledged the limitations of the current single-species framework, noting that while incremental improvements such as incorporating environmental drivers into stock assessments are possible, more substantive progress will require space for qualitative information, uncertainty exploration, and scenario development within EOs. Tools such as Management Strategy Evaluation (MSE) and ecological forecasting were identified as key mechanisms for testing and operationalizing these linkages, supported by early and continuous collaboration between ecosystem and assessment groups, including active engagement with ecosystem science during benchmark processes, as demonstrated by the multiyear benchmark for the Irish Sea (ICES Benchmark Workshop on sharing information on the Irish Sea ecosystem, stock assessments, and fisheries issues, and scoping needs for assessment and management advice (WKIRISH)).

3 ToR b

3.1 Background

ToR b: Develop new frameworks for climate change and social and economic sections

ToR description: Considering FEISA, advance specific sections in the EOs to meet end-user needs and by developing/proposing: i. A common template structure for the climate change section (flexible to regional needs and available data), to be piloted in the Central Arctic Ocean and Oceanic Northeast Atlantic ecoregions. ii. A common template structure for the social and economic context section, flexible to regional needs and available data, and flagging future needs/directions iii. A general schematic summary for communicating the main key signals of the EO.

WKEO4 organized two separate breakout sessions to work on common template structures for the climate change section (Tor B, i) and the social and economic section (ToR B, ii). For ToR b iii, a general schematic summary, the group discussed opportunities for enhancing the presentation and communication of key EO signals and recommendations. The findings for each sub-ToR are reported below.

3.2 Climate section

Breakout group discussion

The climate subgroup discussed several key topics, which are briefly summarized below.

EOs should provide both observed and anticipated effects on different ecosystem components. To make the information more useful and accessible, schematic and concise narratives (to inform trends and climate vulnerability assessments) should be used.

The importance of identifying key parameters for climate-informed models, such as bottom temperature, oxygen, and pH was discussed. The need for a team to assemble information from the CMIP website and other sources to support climate-informed models was also considered with:

Priority action 1: Coordination among ICES EGs directly and/or indirectly contributing research on climate variables, trends and forecasting,

Priority action 2: Develop and apply regional climate vulnerability assessments for both human activity sectors and ecosystem components.

The need for structured discussions and strategic foresight around policy and planning was also explored, with consideration given to the importance of connecting climate information to decision-makers to ensure that the information is more relevant to policy and planning.

Applying a risk and vulnerability approach to identify and summarize the impacts of climate change on different sectors and ecosystem components was suggested, with considering the importance of differentiating between gradual changes and shocks to provide a more accurate assessment of climate impacts. This will make climate advice more practical and impactful. Use

existing scenarios from EU projects and other sources to inform the risk and vulnerability assessments will ensure that the approach is grounded in established research.

Needs for climate change impacts section

The proposed template for standardizing climate change section in the ecosystem overviews includes sections on observed past changes in key climate variables, observed and suggested climate change effects on biotic components, projected effects on abiotic and biotic components, and key knowledge gaps:

- The section on observed past changes focuses on past changes in physical variables such as temperature, salinity, pH, and oxygen content, with up to four variables presented in a panel plot.
- The section on biotic effects includes sections on observed and suggested changes in biotic ecosystem components, such as plankton, fish distributions, and trophic interactions, with confidence assessments based on the IPCC confidence language.
- The section on projected effects of climate change on abiotic and biotic variables, as well as human activities should also include sources of information such as the IPCC Atlas and downscaled climate models.
- The knowledge gap section highlights areas with limited evidence or conflicting information, and suggesting research needs to support management decisions.

The proposed new template (see below) was applied to the Greater North Sea, showcasing how to present observed past changes, observed and suggested changes on biotic ecosystem components, projected effects, and knowledge gaps. The observed past changes section included observed past changes in temperature, salinity, pH, and oxygen content, with data sources such as the IROC and regional synthesis reports. The biotic changes section details observed and/or suggested past changes in biotic components, including plankton production, fish distributions, and seabird populations, with confidence assessments based on the IPCC confidence language. The projected effects on abiotic and biotic variables section used sources such as the IPCC Atlas and downscaled climate models, with examples of potential impacts on fish and benthic species. The knowledge gaps section identified gaps related to limited information on medium-term projections and specific biotic components, and suggests research needs to support management decisions.

Climate change impacts template

1. Observed past change in key climate-change variables that are characteristic for a particular ecoregion. Select up to 4 per ecoregion, arranged into a multi-plot figure. Examples to consider could be:
   a) Temperature (sea surface or bottom)
   b) pH
   c) Salinity
   d) Oxygen content
   e) Currents
   f) Heat content
   g) Others if notable for a species ecoregion

2. Observed and/or suggested past change on biotic ecosystem components, features, processes, etc. Using modelled data or observations. Examples to consider could be:
   a) Phytoplankton and/or zooplankton abundance/biomass, seasonality
   b) Spread/distribution of species (include maps where possible)

c) Production
d) Trophic interactions
e) Others if notable for a species ecoregion

This section should also deliver information on the combined effects of climate change with other human pressures, including on direct and indirect effects, and impacts on socio-economic sectors.

3. Projected future effects and risks of climate change
   a) Abiotic variables (e.g. use the same variables as chosen in I)
   b) Ecosystem biotic components/features (e.g. use the same components as in II)

4. Climate change adaptation and mitigation options

5. Key knowledge gaps and research priorities

Describing the key elements, considerations and potential information sources for the template

For the maps for I and III, can use these sources:

- Standardized sources of data (e.g. https://interactive-atlas.ipcc.ch/)
- Standardized presentation of data (e.g. here are some examples we produced previously with R code and the Atlas https://www.ipcc.ch/report/ar6/wg2/figures/chapter-ccp6/figure-ccp6-002)
- Another source is the NOAA portal for figures

For II and IV, can use IPCC reports, published papers or regional reports.

For III and IV, use risk-based language, following the IPCC risk framework where possible.

For IV, coordinate with the Human Pressures group to ensure consistency and prevent repetition.

Discussion

The Climate change section in ecosystem overviews should provide context for decision-making and planning, facilitating information exchange and supporting climate-linked assessments and advice. The content of climate sections in EOs is currently inconsistent, with only a few including observed or anticipated climate change effects, pressures, states, and knowledge gaps. Standardization is needed to ensure all overviews are comprehensive and comparable. Current EO technical guidance suggests including climate change as a distinct driver, describing its ongoing and anticipated effects on various variables, and identifying key knowledge gaps. More detailed guidance is being developed to help authors populate these sections consistently.

Experience from the North Pacific Fisheries Management Council's Climate Change Task Force, including the recommendations for incorporating climate information into management advice and establishing a dedicated review group, is very relevant in the case of ICES EOs and was therefore briefly introduced and discussed. The Task Force emphasized the need to incorporate climate information into ecosystem status reports, stock assessments, and management advice, ensuring that climate interactions are considered in decision-making processes. The Task Force's final report included strategic planning elements, such as expanding inclusive processes,

considering management tools and options, and establishing a dedicated review group for ongoing climate-related work.

The following key topics were highlighted and discussed, which would need to be addressed in finalizing the new template and amending EO technical guidelines:

- whether to standardize physical parameters across all ecosystem overviews or allow authors to choose the most relevant ones for their ecoregions, considering the variability of physical drivers.
- consideration of including trends in extreme events, such as heat waves and storms, in the climate change sections, given their increasing relevance and impact on marine ecosystems.
- which climate scenarios to use, with suggestions to include bounding scenarios (e.g. SSP 2.6 and 8.5) to capture a range of potential impacts, and the importance of consistency in scenario selection.
- whether to include adaptation in the current template or phase it in later, considering both natural and human adaptation responses and their influence on climate risk and impacts.

The importance of incorporating risk and vulnerability work into the template was highlighted. Such integration would provide a comprehensive understanding of these impacts, help in understanding the impacts of climate change on species distributions and developing effective management strategies.

The need to evaluate the relative importance of climate compared to other pressures was raised. It was suggested that understanding the significance of climate in relation to other factors is crucial to developing an effective template. Pilot projects could help in testing and refining the template, ensuring its effectiveness in different contexts.

The importance of capturing both long-term trends and shocks in the template, as well as the need to differentiate between them in vulnerability and risk assessments is essential. Such differentiation would provide a clearer understanding of the potential risks and vulnerabilities associated with climate change.

Relevance of future scenarios was also mentioned. Scenarios can provide valuable insights into potential future conditions and help stakeholders make informed decisions based on different possible outcomes.

The importance of using IPCC confidence language to assess the level of confidence in climate change information was emphasized, which will help readers understand the robustness of the presented data.

The following issues were mentioned as of specific importance while developing climate section in EOs:

- Availability of climate expertise within the expert groups is critical. Their role is to oversee the writing of the climate sections would ensure accuracy and consistency.
- Using standardized graphics to ensure consistency and clarity in the presentation of information.
- Including fisheries catch yields and recruitment in the template. This information is crucial to understanding the impacts of climate change on fisheries and making informed management decisions.
- Using standardized data sources and graphical standards, as well as the potential for using downscaled models and other sources like Copernicus and the Argo floats network.

- Using standardized confidence language and displaying uncertainty in species distribution models and vulnerability matrices. Using bin ranges or categories to convey uncertainty was suggested.
- Identifying climate information needs and knowledge gaps in the template. This could be useful for advice requesters and project applications.

Proposed next steps:

1. Identification and coordination among relevant expert groups/potential contributors (2026-onward);
2. Online/dynamic tools development for communicating directional, climate related trends or changes in variability levels, aiming for data source alignment, standardization and regionalisation (2026–2027 - may require a dedicated workshop);
3. Develop and operationalize regional climate vulnerability assessments for human activity sectors and ecosystem components, and communicate outcomes using standardized confidence language (2026–2027 - may require a dedicated workshop);
4. Incrementally implement and test 2) and 3) in case study ecoregion(s) from 2027 onward
5. Identify relevant mitigation/adaptation options at local and regional scales (2028 onward).

Knowledge gaps and information need to be documented at each action step.

3.3 Social and economic section

Background

Members of several Human Dimension expert groups participated in a dedicated session aimed at developing guidance for the content of the social and economic section of the EOs. While WKEO4 ToRs refer to 'socio-economic template', it was felt that 'template' is too rigid a wording as there is a plurality of different social, economic, institutional and political contexts in different ICES Ecoregions and constituting nation-states. The group also felt that 'social' and 'economic' should not be coined into 'socio-economic', as the latter has a narrower meaning than 'social'.

The subgroup started with an introduction by Katell Hamon on contributions of ICES Working Group on Economics (WGECON) and Working Group on Social Dimensions (WGSOCIAL) to ICES EOs. These current contributions particularly focus on fisheries. This is partly due partly to the expertise of the people doing the analysis and providing the information to the EOs, and partly due to the available data. Social and economic information has been added by WGECON and WGSOCIAL experts in 3 EOs: (1) the Celtic Seas - as a pilot, (2) the Greater North Sea - where the Celtic Seas analysis was expanded, and (3) the Baltic Sea - where a different approach was taken.

For the Celtic Seas and the Greater North Sea, the contribution included (i) maps showing effort, landings, and values linked to ports of landing (used as proxy for fishing communities) and vessel size categories, (ii) ecoregion employment and economic indicators, and (iii) recent social and economic drivers (such as Covid-19, Brexit and/or the Russian invasion of Ukraine). Different data sources have been used: ai) ICES RDB for the maps; (b) STECF AER data for the employment and economic indicators; and expert knowledge (qualitatively described) for the other drivers. In the Baltic Sea EO, the analysis of the fishing sector is less detailed, but more Blue Economy sectors are characterized in addition to fishing (tourism, shipping, eutrophication mitigation costs, offshore wind and aquaculture).

Work in progress includes moving data from RDB to RDBES database of ICES, developing standardized data workflows via shared generic R scripts (GitHub suggested). However, there are still

limitations with the current approach, especially in the coverage of non-EU countries or small-scale fishing fleets.

In addition to deploying the current analysis to more EOs (where data availability allows it), WGECON and WGSOCIAL have also been looking at other (still fisheries focused) analysis. This includes: (a) understanding links across ecoregions – as harbours may be linked to a sea region they are not bordering, e.g. Dutch harbours with the Celtic Seas), (b) understanding the specificities of harbours (which species/gears are they linked to), which can inform on their resilience or vulnerabilities (to be linked to management changes or climate change), and (c) collaborating with ICES Working Group on Spatial Fisheries Data (WGSFD) to get finer scale maps using VMS/AIS data. Some of these analyses would probably fit better in FOs as they are very fisheries focused.

Review of current social and economic context section

Following this introduction, the current Social and economic context sections in the most recent EOs for the Celtic Seas, Greater North Sea, Baltic Sea and Faroese ecoregions (ICES, 2024c, 2024e, 2024a, 2024d) were reviewed. The group also looked into the Aquaculture Overviews (AOs) for the Norwegian Sea, and the Bay of Biscay and the Iberian Coast ecoregions (ICES, 2021, 2024b). The subgroup did not review the contents of the Management heading in the EOs, although this is also an important part of human dimensions related information.

The review showed that the social and economic information provided varies significantly between EOs, as well as between EOs and AOs. A first notable difference is that fisheries-related information dominates the EOs for the Celtic Seas, Greater North Sea and Faroese ecoregions, whereas the Baltic Sea EO includes information on a suite of uses, such as aquaculture, tourism, offshore renewables, tourism, mineral extraction and shipping. Second, the depth of information per sector also differs between these three EOs. For example, the Celtic Seas and Greater North Sea ecoregions EO provide in-depth information on the location of fishing communities, vessels, effort and landing, which is missing in the EOs for the Baltic Sea and Faroese ecoregions. Third, emphasis is placed on economic importance over subsistence uses. Only the Faroese ecoregion EO included some information on subsistence use. Fourth, information on vulnerable (coastal) communities is missing in all four EOs. However, some socio-economic aspects of indigenous peoples/communities are included in the Central Arctic Ocean EO (ICES, 2025a). Finally, only the Baltic Sea EO explicitly mentions the social and economic benefits deriving from the Baltic Sea. This is relevant in relation to the wire diagram that summarizes the assessment in the EOs. All EOs have a wire diagram, but these focus exclusively on human pressures on ecosystem components and do not provide information on how ecosystem changes may impact social and economic benefits for people and their communities.

It was also noted that the social and economic information in the EOs, with the exception of the Baltic Sea, is dominated by fisheries. This is a legacy issue. When WGSOCIAL and WGECON started, many of their experts had a fisheries background. The process and approach to mapping the fishing communities for the Celtic Seas and the Greater North Sea EOs has recently been published in the ICES Journal of Marine Science (Kraan *et al*., 2025).

When comparing the EOs with the AOs, the subgroup found that the social and economic context heading in the AOs provides more in-depth regional data on employment, profitability and value creation than is found in the EOs. Another observation was that the AOs also include social topics such as welfare, well-being and social acceptability of the specific resource use, as well as a dedicated section on interactions between environmental, economic and social drivers (ICES, 2025b).

Needs for the social and economic context section

Following the review, the subgroup used an adapted version of the Conversation Café method (Lipmanowicz and McCandless, 2014) to make an inventory of what social and economic information currently in the EOs are must-haves, and what social and economic information is currently missing from EOs. This discussion set the scene for a focused exercise on future needs using a MIRO board.

Must-haves that are currently (to some extent) included (in some) EOs include: (1) the information on fishing communities (number of vessels, level of effort, and landings per port), (2) information on other blue economy sectors than fishing, and (3) geopolitical and institutional developments. It was noted that there appeared to be inconsistencies in the information presented. For example, one would expect a geopolitical factor like BREXIT to be mentioned in all relevant EOs.

In relation to the extensive information on fishing communities that dominates Blue Economy information in some of the EOs, the subgroup felt that much of this 'must-have information' is much better placed in the FOs.

Content that was perceived to be missing comprises a much longer list, and includes:

- Information on all Blue Economy sectors (fisheries, aquaculture, shipping, sand and mineral extraction, offshore renewable energy, tourism, maritime heritage, …), including basic social and economic indicators;
- Information on coastal and maritime communities (other than fishing communities), including basic social and economic indicators;
- Economic assessment (e.g. gross value, added value)
- Sea-land relations or interactions (e.g. community dependence on ecosystem services provided by marine resources, impacts of changes in fisheries on the seafood supply chain);
- (Changes in) social acceptability of different blue economy sectors (e.g. the current societal discussion on banning bottom trawling);
- Qualitative description of benefits of ecosystem services to humans, including cultural services;
- Sectoral proportion of overall risks to ecosystem services;
- Regional challenges, trends, and opportunities;
- Blue economy sectors' dependence on ecosystem services;
- Forecasting and vulnerability risk assessment: potential social and economic impacts of climate, ecosystem and management changes;
- Status in relation to social and economic objectives.

The content of the social and economic section should ultimately be determined by the objective of the EOs and the needs of end-users. In this context, it was noted that in the stakeholder interaction session of WKEO4 (Chapter 2.3 of this report), trade-off analysis in relation to the three pillars of sustainability was identified as an important priority for future-proofing EOs. This would require prioritizing development of indicators and methodologies and collection of data and information. The subgroup suggests that additional discussions with MIRIA and MIACO on desired content for the Social and economic content section would be helpful in setting priorities.

When considering future needs for the Social and economic section, it is important to look beyond its content. The group identified a number of interrelated considerations in relation to process.

First, scale is important. EOs cover a large spatial scale and resource-dependence and the impact of changes on Blue Economy sectors and communities may differ significantly even between regions within an ecoregion. This should at least be explicitly acknowledged when providing more generic information. In relation to fisheries, presenting information on a fleet scale may be more relevant than presenting information at the country level.

Second, capacity (people, expertise, funding) and coordination between expert groups with different disciplinary backgrounds were seen as challenges to advancing the content of the Social and economic section and the trade-off work. Given capacity issues the subgroup supported a pragmatic approach to developing the Social and economic context section. This would comprise of a guideline with a range of (priority) topics to be included, and provision of related content depending on availability of data and information. Experts working on the Social and economic context section for a given EO would then all use this guidance. The guidance could include a checkbox and as part of writing the section, experts should indicate for which topics data are readily available and which is 'want-to-have' information. Keeping track of this information would benefit development of future resolutions for HUDISG groups and dedicated research proposals. As part of this pragmatic approach, consideration could be given to rank human activity sectors in the current wire diagram for social and economic importance, and to adjust the size and/or shape of each sector "node" in the current wire diagram accordingly. Introducing a 'social component' in the wire diagram' could show which Blue Economy sectors would be (most) affected by climate, ecosystem, and management changes identified in the current pressures WIRE-diagram. For example, decline in fisheries revenues may be linked to climate-change driven changes in growth rates of fish species.

Third, where a pragmatic approach would be an initial starting point, collaborative efforts should be made to improve linkages between the different sections in the EOs and to exchange expert knowledge of approaches used in different EOs with the objective of learning from each other and fostering more standardized processes. In relation to standardization of processes, it would be useful to draw on the experiences of the WGFSD.

Fourth, there is a need for a more transparent planning cycle and improved communication between the expert groups responsible for the EOs and the experts providing the social and economic information, who are typically not members of the EO groups. This ensures that information can be prepared in time. It was also suggested that a clear request for data – as is the case for data calls for other advice products – would help to alleviate capacity issues.

Fifth, current methodologies and processes in relation to social and economic data differ between EOs. A first priority should be that all current data sources and formats, scripts/codes and methodologies are clearly documented for quality assurance and to enable replication of figures and other results. In relation to data documentation, the existing Data Profiling Tool, DPT (ICES, 2025) is readily available, but many expert group chairs and members seem to be unaware of this tool. The DPT includes documentation of data ownership, control, access, and possession in line with FAIR and CARE principles (Carroll *et al*., 2020; Wilkinson *et al*., 2016). In relation to quality of data – for example, the Regional DataBase and Estimation System (RDBES) – collaboration with the ICES secretariat is needed. For codes/scripts and version control GitHub could be used, including recording of the GitHub in the DPT. However, ultimately documentation should be included in the Transparent Assessment Framework (TAF; ICES, n.d.). Where documentation of current methodologies is a first step, in view of standardization across EOs, there is a clear need to develop common methodologies. Given the differences in data available across regions/countries, pilots and regular assessment of methodology will be required. As part of methodology development, all objective-related indicators used – as well as their assessment method - should be clearly described and documented. Considering the importance of quality assurance for the credibility and legitimacy of ICES advice and to ensure compliance with social research ethics, a

separate workshop should be tasked to develop ICES guidance on social and economic data collection, use and documentation.

Proposed template for social and economic section

The text below describes a proposed template for the context *ideally* to be provided in the Social and economic section of the EOs. A dummy text for inspiration – based on this proposal- is provided in Information Box 3.1.

WKEO4 acknowledges that proposed template is ambitious, and completing it will require expertise that is often scarce beyond fisheries and aquaculture or dependent on underfunded social scientists. A clear, well-coordinated roadmap for each ecoregion will be needed to populate it gradually and coherently.

Proposed content of the social and economic section

Information must be concise. Please only provide information that is or can be made available with present (human) resources) and that can be verified by data/literature, and mapped within the DPT.

The section should not exceed 2 A4 of text (Palatino Linotype 10, single spacing).

Scope

- Spatial and temporal scale of information (acknowledge variability within and between regions).
- Relation to other ICES products (e.g. Fisheries Overviews, Aquaculture Overviews).

Overview of Blue Economy Sectors

- Provide concise, consistent coverage across all relevant sectors. These sectors may include, but are not limited to, depending on the EO: Fisheries *(summary only; detailed data in Fisheries Overviews)*; Aquaculture *(summary only; detailed data in Aquaculture Overviews)*; Seafood processing; Shipping and ports; Offshore renewable energy (wind, wave, tidal); Military; Sand, gravel, and mineral extraction; Tourism and recreation; Maritime heritage and cultural uses.
- Please ensure that all sectors are included. If there is no (detailed) information available, please indicate this as follows: no information available. If information is available but human resources / relevant expertise is not available, please indicate this as follows: information exists/may exist, but relevant expertise is not currently available.
- For each sector, where possible, provide information on basic socio-economic indicators (e.g. employment, gross value added).
- Information on specific trends, opportunities and challenges regarding each section to be reported in the other subheadings.

Coastal and Maritime Communities

- Community dependence on marine resources and services, and observed developments.

Economic Assessment

- Sums up the total gross value added (or other economic indicator) of the Blue Economy and the main contributing sectors.

Social Acceptability of Blue Economy sectors

- Public perception and (anticipated) social acceptability of sectoral activities (e.g. bottom trawling debates).

Risks, Trends, and Forecasting

- List the key drivers that are or will be affecting the social system (economic, social, technological, and environmental), and highlight associated key anticipated socio-economic changes.

Information Box 3.1: Dummy example social and economic context section

Adventure Bay Ecosystem Overview: Social and Economic Context

Scope

Adventure Bay is a highly developed and economically diverse marine region with multiple Blue Economy sectors across national boundaries. Detailed fisheries, aquaculture data are provided in the respective Overviews for this Ecoregion; this section focuses on wider sectoral interactions and dependencies on ecosystem services. Spatial variation within the ecoregion affects resource dependence, economic structure, and community vulnerability. Differences in national reporting create challenges for cross-country comparisons.

Overview of Blue Economy Sectors

Fisheries: Adventure Bay hosts some of the most productive fishing grounds in Europe. Commercial mixed demersal, pelagic, and shellfish fisheries yield >3 million tonnes (2021–2024), valued at €3.6 billion, employing ~30 000 FTE (excluding processing). Fleet capacity and employment have declined, but fisheries remain socially and culturally important.

In addition to commercial fisheries, Adventure Bay hosts a catch-and-release recreational fishery for salmon in the Fjords of Damogran. Economic information on this fishery information exists, but relevant expertise is not currently available. Salmon in this area, as well as demersal species and shellfish in the Sea of Santraginus, are also fished for subsistence by indigenous communities in exclusive zones. There is no information available on catches by the indigenous peoples who depend to a large extent on animal protein from seafood between May and October.

Aquaculture: Marine aquaculture is comparatively limited in the ecoregion but locally significant. Production totals 0.5 million tonnes (€1.5 billion), employing ~8 000 FTE. Key activities include mussel and oyster culture in sheltered coastal areas (e.g. the Fjords of Damogran, Sea of Santraginus), with growing interest in offshore seaweed and finfish production constrained by licensing, spatial competition, and fisheries zoning.

Seafood processing: The decline in fishing capacity has resulted in increasing reliance from imported capture and farmed fish from outside the Adventure Bay Ecoregion, most notably the Tatooine Ecoregion. Further information exists, but relevant expertise is currently not available. Shipping and ports: Major hubs (Santraginus, Erp, Krikkit City) contribute €60–65 billion GVA annually and 400 000–500 000 FTE. Growth is driven by transport, logistics, shipbuilding, and decarbonisation requirements.

Offshore Renewable Energy: Installed capacity exceeds 50 GW, providing €43–80 billion GVA and ~35 000 FTE. The sector drives economic diversification but increases spatial competition with other maritime activities.

Military: Some areas in national waters are closed for use by the military. No further information available.

Sand and mineral extraction: Active mainly in southern Adventure Bay for coastal protection and construction (Traal, Magrathea). No further information available.

Tourism and recreation: Major contributor to regional income and employment (Traal, Magrathea, Betelgeuse, Adventure Beach), dependent on environmental quality and landscapes. Whale watching activities are economically important in Magrathea, but have been known to disturb migration patterns. Social and economic information on tourism and recreation may exist, but relevant expertise is not currently available.

Maritime heritage and cultural Uses: Supports heritage tourism, museums, and cultural events, providing non-material ecosystem service benefits. Further information exists, but relevant expertise is not currently available.

Coastal and Maritime Communities

Communities are transitioning from traditional marine sectors to services and renewables. The number of active fishing towns and villages has decreased over the past decade, and many are diversifying into tourism. This shift is leading to gentrification and related social cohesion challenges, particularly in coastal communities such as Traal. Ecosystem condition influences employment, food security, recreation, and cultural identity.

Economic Assessment

Total Blue Economy GVA exceeds €200 billion annually. Shipping, ports, and offshore renewable energy are the largest contributors, followed by tourism. Fisheries and aquaculture remain locally important. Strong trade and employment linkages increase exposure to market and ecosystem changes.

Social Acceptability of Blue Economy sectors

Public concern over bottom trawling impacts and seabed disturbance shapes fisheries management. Offshore wind enjoys general support, but faces local opposition due to landscape and space-use conflicts. Pilot co-location projects of aquaculture within offshore wind farms have begun in Ummagumma and Fjords of Damogran.

Risks, Trends, and Forecasting

Key drivers affecting the social system include climate change (species shifts, storms, erosion), geopolitical changes (e.g. BREXIT), technological developments (energy transition, port automation), and spatial competition between sectors. Renewable energy and tourism are projected to grow, while employment in extractive sectors declines. Vulnerability is highest in communities dependent on one sector, such as fisheries.

4 ToR c

4.1 Background

ToR c: Improve Ecosystem Overviews to meet the needs of requesters

ToR description: Develop recommendations on how to improve the utility of EOs to meet advisory and decision-making needs, improve communication and accessibility, and address capacity challenges by: i) Reviewing Integrated Ecosystem Assessment (IEA) and EO production processes to identify opportunities for streamlining and improving information flow and integration across groups and products, including data and evidence management. ii) Investigate how to improve alignment and integrate indicators, data, and information from other state of the environment reporting (e.g. OSPAR, HELCOM, Norway, EU MSFD, NAFO) into the EOs to reduce redundancy and address capacity challenges. iii) Critically review current EO format to assess how to improve accessibility, such as via interactive outputs from IEA and EOs (e.g. Shiny apps, ArcGIS Story maps, Web Services, etc.).

EOs were developed to inform ICES requesters by summarizing ecosystem state, pressures, and trends in support of advisory and decision-making processes. However, while they are valued for their synthesis and accessibility, their impact and uptake remain limited, with requesters describing them as 'informational' as opposed to actionable or operational. This raises questions about whether they fully serve their intended purpose as ICES advice. Feedback from across the ICES community highlights that current EOs are often too static and descriptive, lack interactive or dynamic content, and show little evidence of use by decision-makers. The ICES community also commented that human pressures, ecosystem function, socio-economic factors, and climate change tend to be treated as stand-alone sections rather than integrated narratives with tangible advice or recommendations for decision-makers. Addressing these issues required WKEO4 to examine both the structure and process behind the EOs to make them more useful, impactful, and applied given their advisory status.

The aim of ToR c was to develop recommendations to improve the utility, accessibility, and alignment of EOs with advisory and management processes. This includes clarifying their purpose, improving information flow across ICES working groups and products, and streamlining links with other reporting frameworks to reduce redundancy and address capacity challenges. It also involves exploring how EOs can become more interactive and engaging, in a similar sense to the ICES FisheriesXplorer app, and how they can better reflect societal goals, policy frameworks, and management levers. In line with the FEISA framework (Framework for Ecosystem-Informed Science and Advice), ToR C aimed to provide recommendations and a workplan to strengthen the connection between ecosystem science and advice by ensuring EOs explicitly reflect societal needs, management objectives, and present operational advice, enabling ecosystem knowledge to more effectively inform decision-making (Figure 4.1).

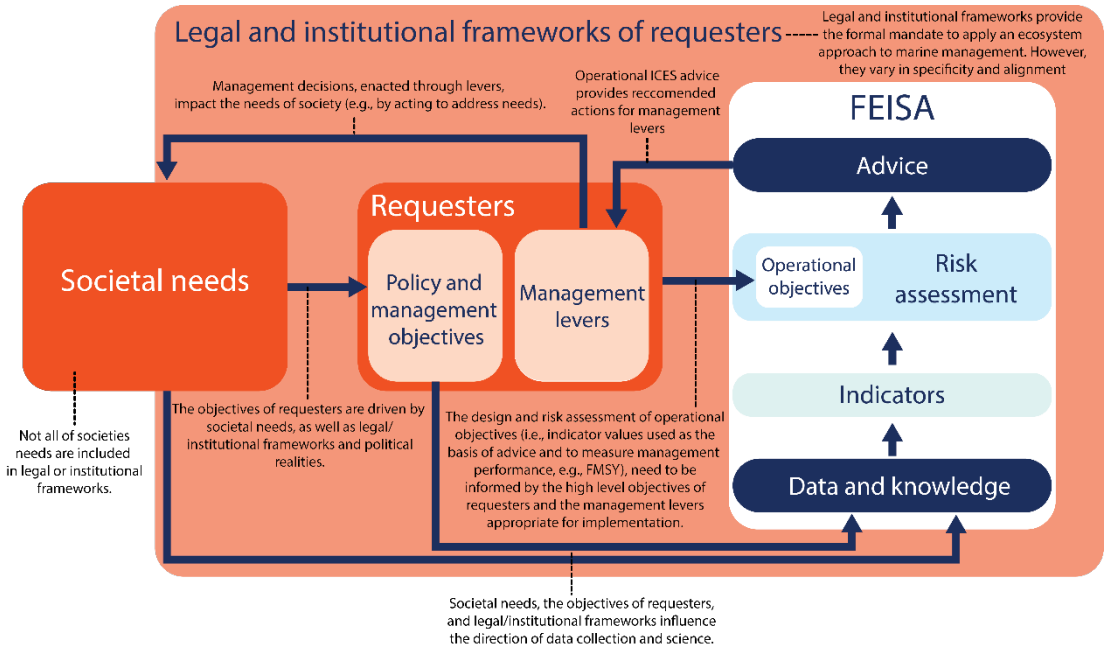

Figure 4.1 Expanding the societal needs and management objectives component of the Framework for Ecosystem Informed Science and Advice (FEISA).

4.2 Break-out sessions

This breakout session was designed to critically assess the pressures and ecosystem state components of the EOs through the lens of their advisory function. For the purpose of this breakout session, we focused on the Greater North Sea EO, as it is one of the more recently updated examples. Each group reviewed a given section and reflected on the current strengths and limitations of the elements as advice. The breakout session aimed to explore how this content serves societal needs, aligns with legal and institutional frameworks, and maps onto existing policy objectives and indicators (e.g. EU Marine Strategy Framework Directive Good Environmental Status (MSFD GES), OSPAR, Kunming-Montreal Global Biodiversity Framework (KM-GBF). Building on these reflections, the groups identified opportunities to move from informative EOs toward more active and explicit advice. Groups considered how this section could evolve to support recommendations and decision-making by exploring operational objectives, identifying management levers, and suggesting mechanisms to bridge scientific assessment with policy implementation.

Breakout group 1

Breakout group 1 focused on oceanographic conditions, species, and foodwebs. The group was provided with sections from the most recent Greater North Sea EO and asked to consider and discuss the questions below.

Breakout group 1, Question 1: Ecosystem Overviews are an ICES advisory product which should also complement other ICES advisory products. What are your general thoughts about the section above as a component of advice? Consider both pros and cons of the current format

All sections, in the current format, are not explicitly relevant to societal needs a

Oceanographic conditions and circulation / foodwebs: this section explains how natural functioning of oceanographic conditions are required to maintain the regulating services, but these are not clearly linked to the section. If linked with the climate change section, it could provide

better understanding of shifts in the state of the ecosystem. The oceanographic section can feed information into the sections below if information about optimum conditions for such species is available.

In the species section, there is a lack of information or no link to societal needs, e.g. the provision of ecosystem services, this section needs to be linked directly to biodiversity, and addressing the current global, regional, biodiversity targets in relation to the current policies.

The foodweb section is relevant to provisional ecosystem service (fish landings) and to cultural ecosystem services (healthy ecosystem), although these are not explicitly stated. Foodwebs are highly relevant for food security (via fishing), biodiversity, non-indigenous species interactions, carbon sequestration and also tourism (the latter via support of marine mammals and seabird populations in particular).

Foodweb information takes an EO from a comprehensive biodiversity overview to an ecosystem overview. The reflection of the interaction between species is what ensures that this ecosystem remains healthy. Thus, if some of these interactions are being affected that would impact the provision of ecosystem services they should be described in this section.

Breakout group 1, Question 3: How is this section relevant to legal and institutional frameworks and objectives? [Either the existing format or the broader subject area, i.e. the potential for this section]

In the current format, the section is not explicitly relevant to legal and institutional frameworks and objectives. And not designed to be relevant.

Oceanographic conditions and circulation / foodwebs could be relevant to EU MSFD and UK Marine Strategy (UKMS), the OSPAR North-East Atlantic Environment Strategy (NEAES) and fundamental to the KM-GBF objectives. The oceanographic subsection, if linked with climate change section, can contribute to prioritization of objectives.

The species section is not very relevant at present for addressing legal and institutional frameworks, as links to information on various policy/management objectives is missing, broader subject area, e.g. biodiversity.

The foodweb section is neither referring to legal and institutional frameworks nor to policy or management objectives. There is a lot of potential in this section. Albeit that all the information about the entire foodweb might not be available, establishing the connections between species clearly sets the stage for EBM because it connects the dots between different pieces of individual species advice.

Breakout group 1, Question 4: What parallels can be drawn between this section and the objectives or indicators included in existing frameworks (e.g. MSFD GES, OSPAR, KM-GBF [links provided above])?

Oceanographic conditions and circulation section could have more relevance if linked through indicators to the EU MSFD Descriptor 7 (Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems) of KM-GBF.

The biota section is meant to describe primarily the dynamics as available in peer-reviewed sources. Major changes in the approach are needed to make it relevant to existing legal frameworks. In this section, there is no explicit link to indicators, especially operational indicators, as well as e.g. link to KM-GBF and the EU Biodiversity Strategy for 2030, EU MSFD, EU Maritime Spatial Planning Directive (EU MSP).

The foodweb section does not refer to any of the indicators for the KM- GBF. It does not refer directly to the 3 foodweb indicators from OSPAR (but maybe could). It is not clear how it is linked to the EU MSFD Descriptor 4 (on foodwebs). The foodwebs section could be linked to

indicators that have been developed to support EU MSFD and UKMS reporting. Indicators such as the Large Fish Index from ICES Working Group on the Ecosystem Effects of Fishing Activities (WGECO), guild biomass from ICES Working Group on Biodiversity Science (WGBIODIV) as used by OSPAR to support countries with biodiversity reporting and zooplankton life-forms (ICES WGBIODIV and Working Group on Zooplankton Ecology (WGZE)).

Breakout group 1, Question 5: How could this section evolve to provide recommendations and formal advice? Consider the following for each suggestion:

- What are the opportunities for explicit advice (based on answers to Qs 2-4)?
- What could the operational objectives be [definition provided above]?
- What are the relevant management levers to consider?
- How appropriate is the current structure?

In the current setup/format, there are not many opportunities for advice. As information is largely based on information available in peer-reviewed publications.

Species sections should be considered to evolve in a biodiversity section to provide explicit advice. The relevant objectives could be the one already agreed under e.g. KM-GBF, EU Directives, and different Multilateral Environmental Agreements (MEAs). The current key challenges, e.g. biodiversity loss and conservation/restoration should be addressed in this section.

Recommendations for the foodweb section are difficult to establish without explicit policy/management goals on foodwebs. A recurrent consideration is the restoration of top predator populations at higher/earlier levels. Recommendations to support restoration could be appropriate in this section. Recommendations that explicitly consider the trade-offs between restoration at higher trophic levels and productivity at lower trophic levels are also relevant. Relevant management measures include fisheries regulations, marine protected areas, bycatch and incidental mortality regulations and "balanced harvesting" considerations.

The objectives used by e.g. OSPAR could be reviewed by ICES to provide operational objectives. Pressure metrics (e.g. fishing effort) could be evaluated to determine if the species/foodwebs are under risk of degradation.

In general, the current structure has a description of static status and then a discussion of dynamics. Inclusion of the information on the static status needs to be reconsidered, including if the information should be related to an advice-relevant baseline or target, or is it general background information, in which case the section could maybe be moved to an annex (or condensed into a short paragraph on historical conditions). For advice purposes, the focus likely needs to be on the dynamics. Where possible, there should be explicit discussion of how the dynamics are linked to each other, to pressures, and to management levers.

Breakout group 2

Breakout group two focused on the wire diagram, selective extraction of species, and benthic habitats sections of the EOs. The group was provided with sections from the most recent Greater North Sea EO and asked to consider and discuss the questions below.

Breakout group 2, Question 1: Ecosystem Overviews are an ICES advisory product which should also complement other ICES advisory products. What are your general thoughts about the section above as a component of advice? Consider both pros and cons of the current format.

For this question, breakout group 2 focused on the wire diagrams included in the Ecosystem Overviews. The points below summarize main topics of discussion:

The pressure wire diagram provides a clear and accessible overview of dominant ecosystem pressures, helping to identify priorities for management and areas requiring further assessment.

Its standardized structure allows for comparison across ecoregions, supporting a more integrated understanding of pressures and drivers at the ICES scale.

Stakeholders have responded positively to the diagram's simplicity and clarity, particularly when compared to more complex visualizations such as Sankey diagrams.

The concise format suits time-limited audiences and could be enhanced by adding hyperlinks or expandable sections to allow users to explore more detailed information if desired.

The diagram can also help identify which sectors, management bodies, or policy areas should be engaged in addressing particular pressures.

Methodological developments such as SCAIRM (Spatial Cumulative Assessment of Impact Risk for Management) could improve transparency through continuous scales and more explicit data inputs, offering the potential for semi-automated updates.

The current five-year revision cycle is too slow to capture dynamic pressures such as offshore wind or climate-driven changes, reducing the relevance of the information presented. Updating cycles, however, can occur in real time or annually for some components. Capacity to update products more frequently would improve the relevance of information conveyed.

The diagram is static and descriptive, showing linkages but not trends or rates of change; a more dynamic format could highlight whether pressures or impacts are increasing or decreasing.

Cumulative and cross-sectoral effects are not clearly represented, and the additive or interactive nature of multiple pressures remains difficult to interpret.

Ecological representation is limited, focusing on biomass groups rather than mechanisms such as productivity, recruitment, or trophic interactions, and it omits ecosystem functions and services such as carbon storage or biodiversity benefits.

Social–ecological feedbacks between human activities, ecosystem responses, and management decisions are not shown, making it harder to represent the iterative nature of ecosystem management; frameworks such as DAPSIR could help integrate this.

Connections to policy objectives, such as biodiversity or Good Environmental Status, are missing; a complementary policy overview could help link pressures and ecosystem states to management targets.

Users have questioned whether the width of diagram links reflects magnitude or certainty, and whether colour or symbol size could help clarify causal relationships or the strength of evidence.

The current format does not account for spatial variation between coastal and offshore subregions or show differences in the intensity of pressures.

Breakout group 2, Question 2: How is this section relevant to societal needs (e.g. the provision of ecosystem services?) [Either the existing format or the broader subject area, i.e. the potential for this section]

For this question, breakout group 2 focused on the wire diagrams included in the Ecosystem Overviews. The points below summarize main topics of discussion:

The wire diagram has strong potential to link ecological pressures and states to societal needs by integrating ecosystem services (ES; as explored by ICES Workshop on ASsessing CAPacity to supply Ecosystem Services (WKASCAPES)).

Incorporating ecosystem services directly into the diagram, either as an additional step or as part of the right-hand side representing outcomes, would help make the connection between

ecological processes and human wellbeing more explicit. This addition could increase the policy relevance of EOs by directly linking pressures and ecosystem components to policy objectives.

The wire diagram already provides a foundation for prioritizing pressures and sectors with the greatest ecological impact, but it could also be used to prioritize those most critical to societal benefits and values. One option would be to carry out a comparable analysis for human activity sectors according to their social or economic value and visually incorporate this information (potentially as an additional product) to show trade-offs between societal benefits and ecosystem impacts.

Including change over time, for example, through trend indicators, colour shifts, or scorecard-style arrows, could highlight whether pressures and impacts are improving or worsening. A scorecard or trend comparison across editions of EOs could make temporal changes and management progress more visible and accessible to non-specialists.

There is scope to integrate management implications, indicating how changes in pressures or ecosystem state affect the delivery of key ecosystem services and informing adaptive responses.

The representation of data gaps is also important: including links marked as "no data" could improve transparency and prevent misinterpretation that missing connections are unimportant rather than uncertain.

Breakout group 2, Question 3: How is this section relevant to legal and institutional frameworks and objectives? [Either the existing format or the broader subject area, i.e. the potential for this section]

Breakout group 2 did not have time to discuss this question.

Breakout group 2, Question 4: What parallels can be drawn between this section and the objectives or indicators included in existing frameworks (e.g. MSFD GES, OSPAR, KM-GBF [links provided above])?

For this question, breakout group 2 focused on the wire diagrams included in the Ecosystem Overviews. The points below summarize main topics of discussion:

Although it currently lacks explicit links to management objectives, many of its components, particularly the biotic groups and habitats, map directly onto MSFD GES descriptors and could be cross-referenced within the diagram.

By integrating multiple pressures and their cumulative impacts, the wire diagram supports broader policy objectives such as those under the KM-GBF and OSPAR's ecosystem approach, both of which emphasize understanding interactions among pressures and states.

Breakout group 2, Question 5: How could this section evolve to provide recommendations and formal advice? Consider the following for each suggestion:

- What are the opportunities for explicit advice (based on answers to Qs 2-4)?
- What could the operational objectives be [definition provided above]?
- What are the relevant management levers to consider?
- How appropriate is the current structure?

For this question, breakout group 2 focused on the wire diagram and selective extraction sections included in the Ecosystem Overviews. The points below summarize main topics of discussion:

Wire Diagram:

The group discussed the potential for the wire diagram to evolve from a descriptive communication tool into a spatially explicit, semi-quantitative advisory product. The group discussed how

the SCAIRM framework could offer an opportunity to add layers of detail, such as ecosystem service linkages, without losing the visual simplicity of the wire diagram. SCAIRM also incorporates spatial information would allow users to identify hot spots of cumulative risk from multiple activities, improving the ability to prioritize management responses. The group discussed that if an updated approach is developed, a technical workshop should be recommended to establish guidelines for data integration, visualization standards, and update frequency, ensuring consistency and transparency across ecoregions. Future iterations should include clear metadata and transparency regarding the evidence base behind each link and node, improving credibility and reproducibility.

Selective extraction of species:

The group considered how the section could evolve to provide explicit advice on sustainable extraction levels by linking fishing pressures to both ecological and societal outcomes, such as ecosystem service delivery and food provision. Developing cumulative indicators, for example, total biomass removed or bycatch rates of marine mammals, would enable quantification of overall extraction pressure and its distribution across the ecosystem. These indicators could then underpin risk-based operational objectives, ensuring that total extraction remains within limits that safeguard trophic structure and biodiversity. Model-based projections could be used to explore future scenarios under climate change or varying exploitation intensity, providing forward-looking insights into sustainability thresholds and trade-offs. Such developments would help inform trade-off among sectors.

Discussion

Discussions across the breakout groups reached a consensus that EOs need to evolve from static, descriptive documents into more dynamic, integrated products that aim to explicitly link to management and policy objectives. Participants agreed that future EOs should move beyond listing species, pressures, or processes to explicitly link these elements through indicators, thresholds, and management levers that reflect societal and legal objectives. The group discussed the adoption of a more risk-based, spatially explicit, and visually communicative approach, linking ecological change to ecosystem services, biodiversity targets, and climate drivers.

Along with the breakout sessions, the group received a series of presentations aimed at informing the future direction of EOs and how they could be made more useful for decision-makers. These included examples of innovative tools and approaches that enhance accessibility, interactivity, and policy relevance. Presentations on the ICES FisheriesXplorer app and ICES Working Group on the Integrated Assessment of the Greater Norwegian Sea pelagic ecosystem (WGINOR) use of large language models demonstrated how interactive, data-driven platforms can make EO content more transparent and accessible. Presentations of the SCAIRM and SMMART (Spatial Marine Management Assessment and Reporting Tool) frameworks provided examples of how ICES may adopt spatially explicit, modular tools to develop cumulative impact and trade-off assessments. A presentation on NOAA's State of the Ecosystem reports provided the group with a comparable example of an EBM product. The group was particularly interested in NOAAs application of key messages and status report cards which were more directly tied to management objectives. Finally, discussions on the integration of EOs, FOs and AOs emphasized the need for streamlined, online, and holistic products that link human and ecological dimensions to facilitate EBM decision-making.

Discussions from breakout groups and presentations were used during WKEO4 to construct an initial pitch for the design and content of the fourth generation of ecosystem overviews (Chapter 6.1) along with a workplan to implement the steps necessary to integrate the priorities identified under ToR a (Chapter 6.3).

5 Priorities

5.1 Overview

At WKEO4, discussions under ToR a led to a deliberate shift in focus from expanding the existing list of priority topics for EOs to refining and consolidating the foundational themes that should underpin all EO advice. Rather than identifying new areas of interest, participants aimed to strengthen the conceptual and practical coherence of EOs by defining a core set of cross-cutting priorities. Through breakout sessions, the group identified five overarching themes: trade-offs across the three pillars of sustainability, cumulative impacts, climate change, biodiversity and ecosystem function, and foresight, as central to ensuring that EO content becomes more policy-relevant, forward-looking, and integrated across ecological, social, and economic dimensions. The group then developed initial reflections on the meaning, scope, and application of each theme in the context of ICES advice, with the outcomes of those discussions summarized below. Note that the entries below are not exhaustive or final; they are representative of the initial discussions held by the group.

5.2 Trade-offs across the three pillars of sustainability

Definition:

The process of balancing competing demands on marine resources and space, and the benefits humans derive from them. The three pillars, environmental, social, and economic sustainability, must function together.

Why this is a priority:

Understanding and explicitly representing trade-offs provides essential context for management decisions, supports equitable and integrated policy outcomes, and adds value by linking ecological change to societal and economic consequences.

Current inclusion in EOs:

Currently addressed only indirectly, with strong emphasis on environmental and fisheries dimensions. Social and economic aspects are poorly represented or absent.

How this could be integrated into EO structure:

Trade-offs could be explored for key connections in the EO "wire diagrams" by explicitly linking ecosystem components and pressures to regional-scale, sector- and components-specific operational objectives, integrating existing advice products where possible. At this level, where multiple objectives interact, trade-offs may become more visible, enabling identification of areas where some objectives may come at the expense of others. Separate, wire-like diagrams could be used to visualize impacts of ecosystem and management changes on the social system, identifying implications for different sectors and communities. Each EO section could include a brief qualitative assessment of social and economic implications, focusing on priority areas such as offshore renewable energy, MPAs, and restoration. This could be framed in terms of ongoing progress, challenges and opportunities given (i) current ecosystem state and trends and (ii) the management levers available.

Potential indicators or methods:

Contextualised by maker commitments to domestic and international objectives for the marine environment. Adopt or align with social and economic indicators developed by STECF, WGSOCIAL, and related ICES groups.

Difference from non-ICES products:

Few international ecosystem products (with the exception of NOAA) include explicit social and economic dimensions. ICES could provide a unique internationally harmonized, ecosystem-based approach that integrates human and ecological systems within a single advisory framework, complementing national initiatives such as the UK Marine Spatial Prioritization programme.

Links to objectives and policy drivers:

Directly supports UN Sustainable Development Goals (SDGs), the EU Common Fisheries Policy (CFP), the EU MSFD, the UK Fisheries Act, UKMS, British Energy Security Strategy, and global frameworks such as Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) nexus and transformative change assessments (and forthcoming Biodiversity and Business Assessment, 2026).

Relevant ICES expert and steering groups:

WGBESEO, Working Group on Resilience and Marine Ecosystem Services (WGRMES), WGENGAGE, WGSOCIAL, WGECON, Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT), Working Group on the Northwest Atlantic Regional Sea (WGNARS).

Operational next step / tangible outputs:

Strengthen data and knowledge workflows between groups; support wider use of DPT with secretariat support and nominations for and coordination with data champions; explore and identify spatial scales, starting from ecoregion scale and zooming in, that are relevant to evaluating social, economic and ecological trade-offs for different human activity sectors; identify measurable social and economic indicators.

Steps to move forward:

Develop an inventory of management objectives and their operational equivalents within one pilot ecoregion; create capacity (e.g. Secretariat or student support) to carry out a management/policy objective mapping exercise in collaboration with WGBESEO; coordinate and synthesize ongoing social–ecological trade-offs to align methods work across ICES.

5.3 Cumulative impacts

Definition:

Cumulative impacts, in an environmental context, refer to the combined effects (including their interactions) of multiple actions or stressors on environment

Why this is a priority:

Assessing cumulative impacts provides context for understanding how multiple pressures interact, supports more integrated and risk-informed ecosystem-based management advice, and adds

value by linking human activities to ecosystem vulnerability in increasingly complex marine spaces. It also brings opportunities to better integrate ICES steering groups and expert groups to proactively prepare for future non-recurrent advice requests.

Current inclusion in EOs:

Cumulative impacts are generally not considered in current EOs. While the wire diagrams map and rank individual pressures, they do not assess how these pressures interact or accumulate across ecosystem components.

How this could be integrated into EO structure:

Cumulative impacts could be integrated by evolving the current pressure assessment approach to move beyond ranking individual pressures toward evaluating their combined and interacting effects on ecosystem components. Stronger integration of sections within EOs would also better enable a cumulative assessment of impacts on ecosystem components etc.

Potential indicators or methods:

The group discussed the potential to use a spatially resolved Spatial Cumulative Assessment of Impact Risk for Management, SCAIRM, an approach which ICES have recently applied in practice for a special advice request (ICES, 2025d).

Difference from non-ICES products:

The group recommended that the proposed evolution of the ICES pressure diagram explores ways to include social and economic links as well as ecosystem services.

Links to objectives and policy drivers:

EU MSFD (pressures assessment), OSPAR and HELCOM assessment, UKMS, and CFP. This does not represent an exhaustive list but rather reflects the areas of discussion among the group.

Relevant ICES expert and steering groups:

Working Group on Cumulative Effects Assessment Approaches in Management (WGCEAM), Workshop on Cumulative Impact Assessments (WKCIA), WGSOCIAL, WGECON, Joint ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB)

Operational next step / tangible outputs:

As an operational next step, the group proposed to follow up on the products and roadmap developed by WKASCAPES through an intersessional meeting to support the work of WKTRANSPARENT2. This should include exploring and identifying spatial scales relevant to cumulative effects assessments.

Steps to move forward:

Next steps include planning WKTRANSPARENT2 to discuss the evolution of wire diagrams and cumulative effects assessment (CEA) approaches, with explicit links to ecosystem services. The group also recommended progressing toward more tractable, automated, and data-driven methods (e.g. SCAIRM) to enhance consistency, transparency, and dynamism in assessing and visualizing cumulative impacts across ecosystems.

5.4 Climate change

Definition:

The effects of climate change on the physical environment, ecosystem components, human dimension, and the management of existing or planned human activities (see ICES Ecosystem Overview Technical Guidelines for more details).

Why this is a priority:

Climate change is already considered a priority for the EOs, as outlined in the ICES EO technical guidelines. The direct and indirect impacts of climate change will increasingly influence the science and advice delivered by ICES. Incorporating its current and expected effects into ICES science and advice will be fundamental to support measures which mitigate and adapt to the risks of climate change.

Current inclusion in EOs:

EOs currently include a climate change section, but there was consensus among the group that its inclusion should not be limited to a single section: it should also be integrated across all sections where appropriate to provide a more integrated advisory product.

How this could be integrated into EO structure:

Climate change could be better integrated into the EO structure by, for example, explicitly considering its effects on foodweb linkages and key ecosystem processes, such as those driven by marine heatwaves or species distribution shifts. This should extend to capturing the potential social and economic implications of ecological change, such as how shifts in ecosystem structure and function may impact fishing opportunities.

Potential indicators or methods:

Climate vulnerability assessments and indicators for human activities and ecosystem components were identified through discussions as a priority approach for the inclusion of climate considerations in the EOs. Other approaches discussed included the Climate Risk to European Fisheries and Coastal Communities framework (Payne *et al.*, 2021), and indices such as the Total Catch Index and Ecosystem Production Potential (Link and Watson, 2019). Additional approaches could incorporate species distribution metrics, measures of community or catch temperature, and outputs from strategic ecosystem models to track trends, variability, and shocks.

Difference from non-ICES products:

This approach would differ from other non-ICES climate products by focusing on integration within the ICES advisory framework, linking climate information directly to ICES science and advice rather as opposed to providing stand-alone climate analyses. It would emphasize operational relevance in the context of ICES and the needs of ICES requesters.

Links to objectives and policy drivers:

The group agreed that climate change is a cross-cutting driver relevant to all marine objectives and policy areas, influencing ecological dynamics, management priorities, and socio-economic outcomes across the full spectrum of ICES advice.

Relevant ICES expert and steering groups:

ICES-PICES Strategic Initiative on Climate Change Impacts on Marine Ecosystems (SICCME), Working Group on Integrative, Physical-biological and Ecosystem Modelling (WGIPEM), WGECON, WGSOCIAL

Operational next step / tangible outputs:

As operational next steps, it was proposed that SICCME coordinate with the upcoming EOs being updated to assess what short-term climate integration is feasible, but more widely explore longer term opportunities for systematic inclusion of climate information across EOs. This should be supported by reviewing and developing the role of SICCME, data pipelines, and shared code for climate products, and by identifying spatial scales suitable for communicating demonstrated, anticipated, and projected climate effects. To some degree the process above has been happening for some time, albeit without clear tangible outcomes. Steps to take in 2025/26 therefore include (i) formalizing mechanisms for coordination between SICCME, EO leads, and relevant expert groups, (ii) developing a standardized climate product(s) within TAF that can be integrated into EOs, (iii) implementing vulnerability/risk assessments within EOs that convey the demonstrated and anticipated effects of climate change on regional human activity sectors and ecosystem components, and (iv) piloting the inclusion of future climate projections and associated risk narratives.

5.5 Biodiversity and ecosystem function

Definition:

The conservation, restoration, and resilience of biodiversity and ecosystem function, concerning the diversity of life and the ecological processes it sustains within social-ecological systems, including humans.

Why this is a priority:

Numerous international and domestic legislative and policy drivers, such as the Convention on Biological Diversity (CBD) and KM-GBF, require robust understanding and monitoring of biodiversity and ecosystem function to inform management and conservation decisions. Through necessity, existing approaches which focus on single species in isolation are transitioning to also consider broader ecosystem function.

Current inclusion in EOs:

Included implicitly in the context of EOs (e.g. foodwebs and the inclusion of multiple ecosystem component sections) but there is no explicit exploration of biodiversity or wider ecosystem function.

How this could be integrated into EO structure:

As an example, the group discussed how biodiversity and ecosystem function could be incorporated into EOs by explicitly considering foodweb linkages and their contribution to overall ecosystem functioning, moving beyond species lists to capture ecological roles and interactions. The group discussed how this could include the use or development of a biodiversity or ecosystem function index for each ICES ecoregion.

Potential indicators or methods:

Numerous expert groups across the ICES community are involved in the development of biodiversity indicators. These need to be compiled building on the recommendations and exercises of WGECO and Workshop on the operational use of Food Web indicators and information (WKFoodWeb).

Difference from non-ICES products:

This approach would differ from non-ICES products by embedding biodiversity and ecosystem function within an advisory context, directly linking ecological patterns and processes to management-relevant outcomes/levers such as those related to fishing opportunities, ecosystem resilience, and sustainable use.

Links to objectives and policy drivers:

CBD/ KM-GBF, UN SDG, UN Fish Stocks agreement 1995, OSPAR, EU MSFD, UKMS, EU Nature Restoration Regulation, CFP, UK Joint Fisheries Statement (JFS), UK Environment Act, MEAs, IPBES, Welsh Future Generations Act, Aarhus Convention

Relevant ICES expert and steering groups:

WGBIODIV, Working Group on Multispecies Assessment Methods (WGSAM), Ecosystem Processes and Dynamics Steering Group (EPDSG), Working Group on the Value of Coastal Habitats for Exploited Species (WGVHES), WGNARS.

Operational next step / tangible outputs:

Suggested operational next steps included exploring potential social and economic indicators linked to biodiversity and ecosystem function, making linkages between ecosystem components explicit in either the wire diagram or foodweb products, and assessing whether outputs from WKFoodWeb (visual foodweb network product) and WKASCAPES (links between biodiversity and ecosystem services) can be incorporated into the EO product pipeline. The group also recommended linking with the upcoming SCICOM KM-GBF subgroup to ensure alignment and inform the future structure of EOs.

5.6 Foresight

Definition:

The systematic exploration of possible future conditions to inform spatial management, Ecosystem-Based Management, Ecosystem-Based Fisheries Management, and the emerging opportunities and potential risks facing ecoregions and the ecosystem services they provide.

Why this is a priority:

The group recommended foresight is a priority theme as an approach to enhance the relevance of EOs to requesters and managers by anticipating emerging opportunities and issues and future management needs and/or challenges. The group discussed how it could also enable evaluations to be downscaled to relevant spatial and temporal scales, supporting more context-specific decision-making.

Current inclusion in EOs:

Current inclusion in EOs is very limited as the content focuses predominantly on status and retrospective trends. While this may implicitly inform an assessment of emerging conditions and risks, the EOs do not explicitly explore these risks.

How this could be integrated into EO structure:

The group were keen for foresight to be integrated into the EO structure by introducing spatial products that visualizes future ecosystem and management scenarios and identify the possible consequences of alternative management strategies, or lack thereof. The group discussed that these could communicate projected changes in species distributions, ecosystem conditions, or human activities under different scenarios, helping to **frame the risks and benefits associated with** potential futures and support spatially explicit Ecosystem-Based Management discussions.

Potential indicators or methods:

To be further explored.

Difference from non-ICES products:

To be further explored.

Links to objectives and policy drivers:

To be further explored.

Relevant ICES expert and steering groups:

Working Group for Marine Planning and Coastal Zone Management (WGMPCZM), WGSFD, WGECON, Workshop on fish distribution shifts (WKFISHDISH), Working Group on Marine Protected Areas and other Spatial Conservation Measures (WGMPAS).

Operational next step / tangible outputs:

Considered operational next steps included compiling relevant spatial data layers and reviewing existing foresight and scenario exercises carried out across the ICES community and projects (e.g. CERES, FutureMARES, ACTNOW, Copernicus) to identify transferable methods and outputs. The group also proposed engaging with ICES data teams to clarify current pathways for spatial data flows and determine how these could be built upon to support foresight integration within EOs.

Steps to move forward:

Next steps discussed included aligning foresight activities with the ongoing EO integration process and the development of an ICES Spatial Hub, or an equivalent collaborative framework. This would help map and mobilize the spatial capabilities of the ICES community.

6 Fourth generation concept

6.1 Overview and fourth generation concept pitch

Following the identification of EO priorities and the discussions of the week, the WKEO4 meeting ended with a pitch for the next generation of EOs. The purpose of the pitch was to visualize the progress of the week and provide a discussion point to help the group move forward.

The presented pitch outlined a vision for a "dream EO", which was envisioned as a consistent, highly visual, and user-focused product designed to enhance the accessibility, integration, and practical value of ICES advice. The envisioned EO began with key recommendations presented upfront, supported by clear visual indicators, thresholds, and trends for major ecosystem components such as marine mammals, seabirds, fish, benthos, and plankton. The proposed structure of ecosystem components would be modular and adaptable by ecoregion, incorporating foresight elements to anticipate future changes and emerging risks (Figure 6.1). Moving from the existing linear approach to EO structure towards a more modular approach, where sections can be updated more readily as self-contained methods, code, and analyses, will help to streamline updates as well as their integration into an online application.

The pitch proposed the development of an ICES EcosystemXplorer app (akin to the existing FisheriesXplorer app), which would include interactive spatial maps linking pressures, cumulative impacts, and ecosystem services (Figure 6.2), alongside dedicated sections on climate change and human dimensions. It would integrate foodweb dynamics and ecosystem function (based on the proposal of WKFoodWeb) with social and economic considerations, demonstrating how oceanographic and ecological changes affect management objectives and human wellbeing, operationalizing FEISA and aligning with EBM principles (Figure 6.3;).

The previous sections could be considered as the overarching summary for the ecoregion, while the following section provides more specific information for ecosystem components, which were proposed to serve as the central organising framework for the remained of the EO. This section connects information on pressures, climate impacts, and social and economic drivers for each ecosystem component. Each component could be represented through concise, visual advice sheets summarizing current status, operational objectives, trade-offs, and interactions within the wider ecosystem (Figure 6.4). This structure is proposed in-line with requesters commitments to Good Environmental Status, where ecosystem components are often focal to objective design but also policy and science team organizational structure. This structure may make EOs more useful in an operational context and help facilitate co-development with stakeholders and requesters of ICES advice.

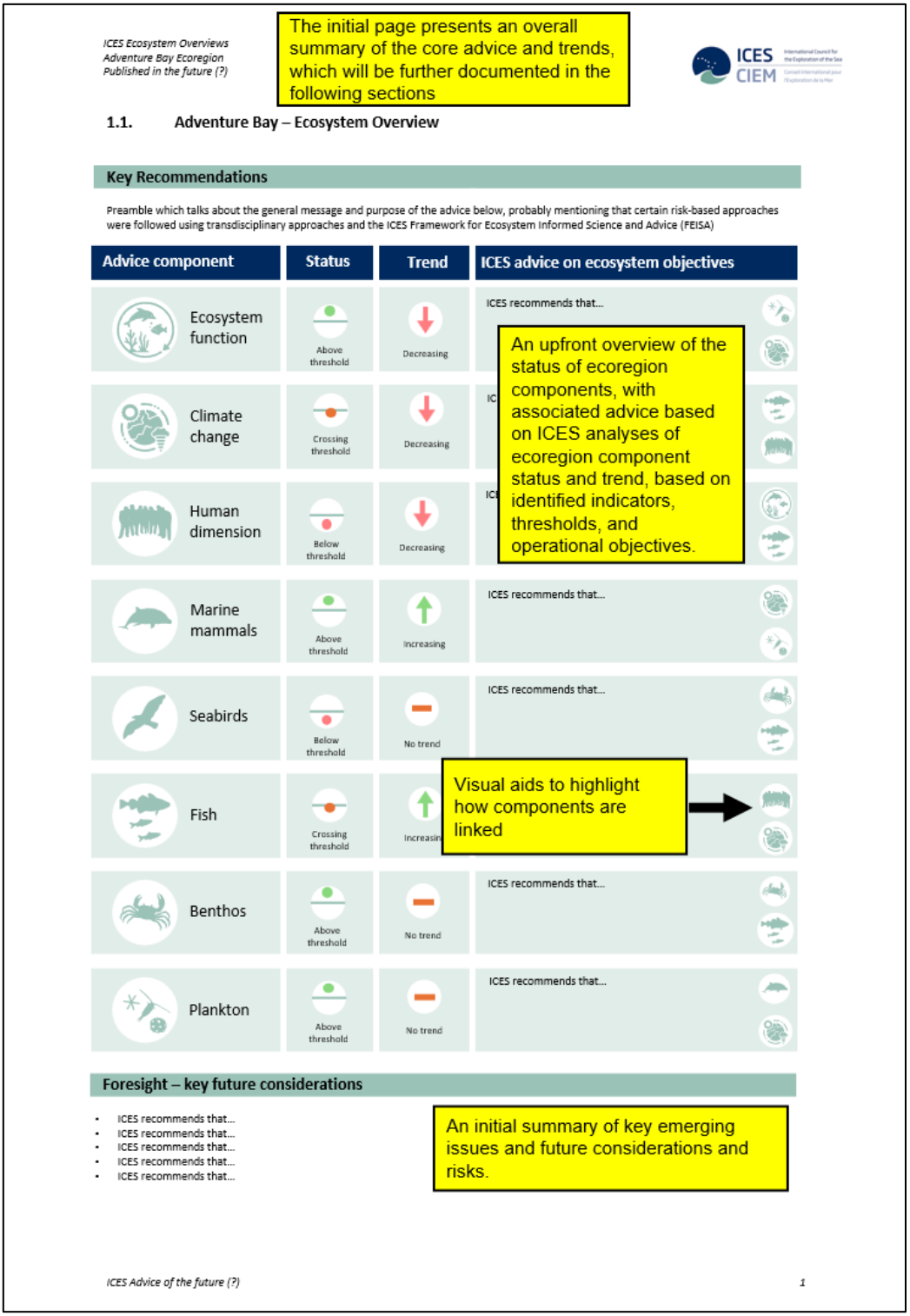

Figure 6.1 Ecosystem Overview key advice and recommendations summary sheet. Yellow boxes provide contextual details of what was discussed at WKEO4.

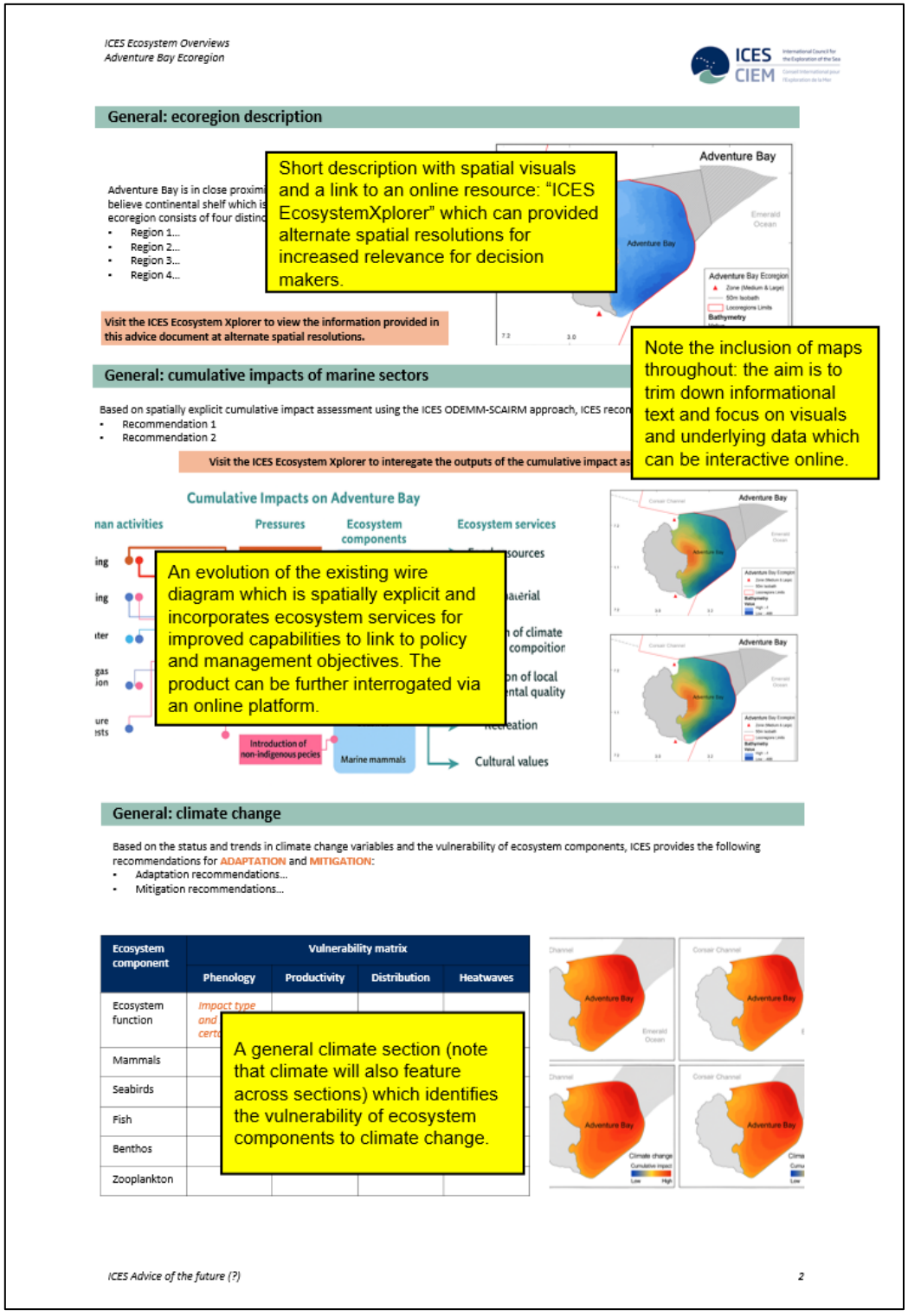

Figure 6.2 Ecoregion summary and key recommendations: ecoregion description, cumulative impacts and pressures diagram, and climate change. Yellow boxes provide contextual details of what was discussed at WKEO4.

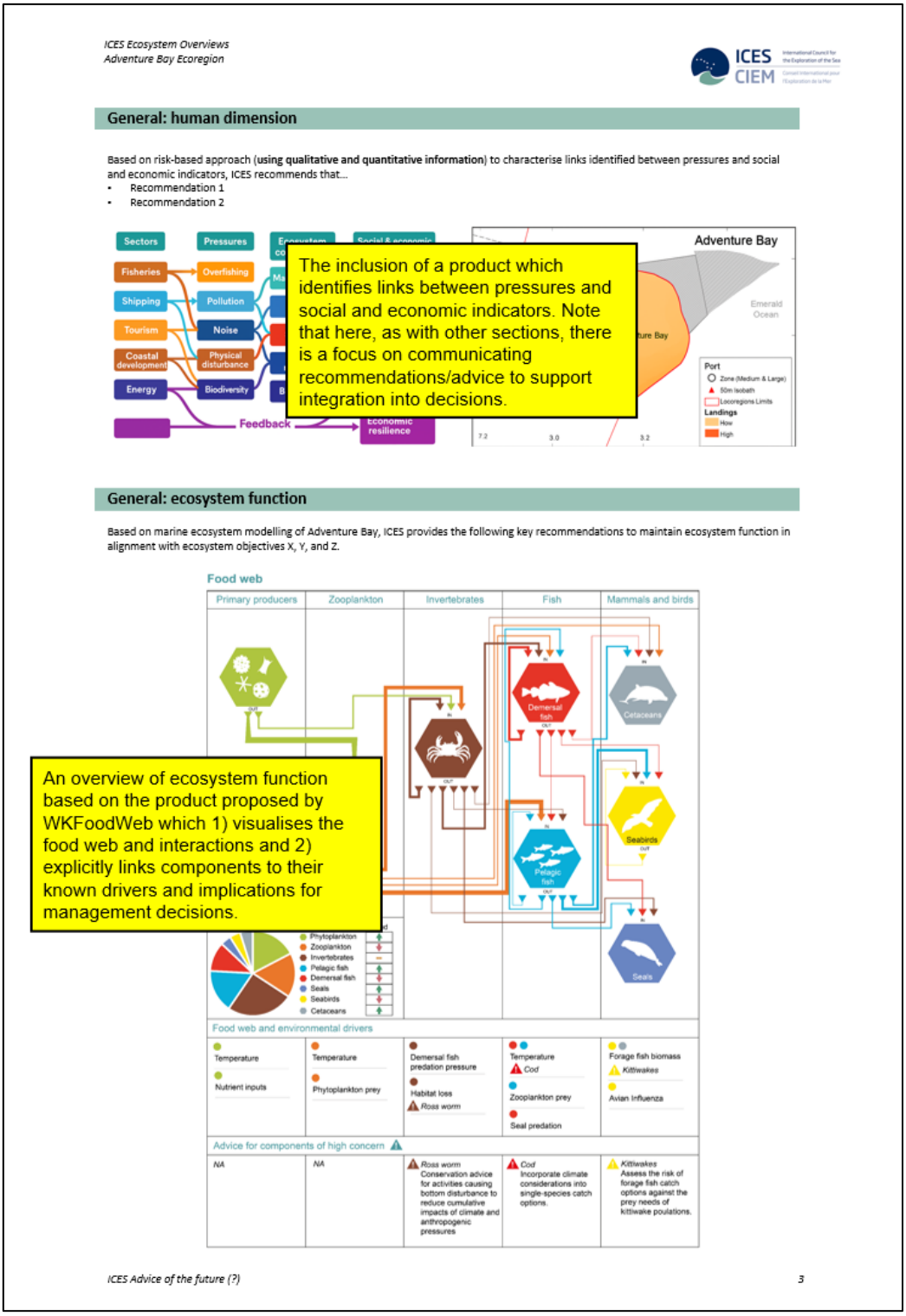

Figure 6.3 Ecoregion summary and key recommendations: pressures and social and economic indicators and ecosystem function. Yellow boxes provide contextual details of what was discussed at WKEO4.

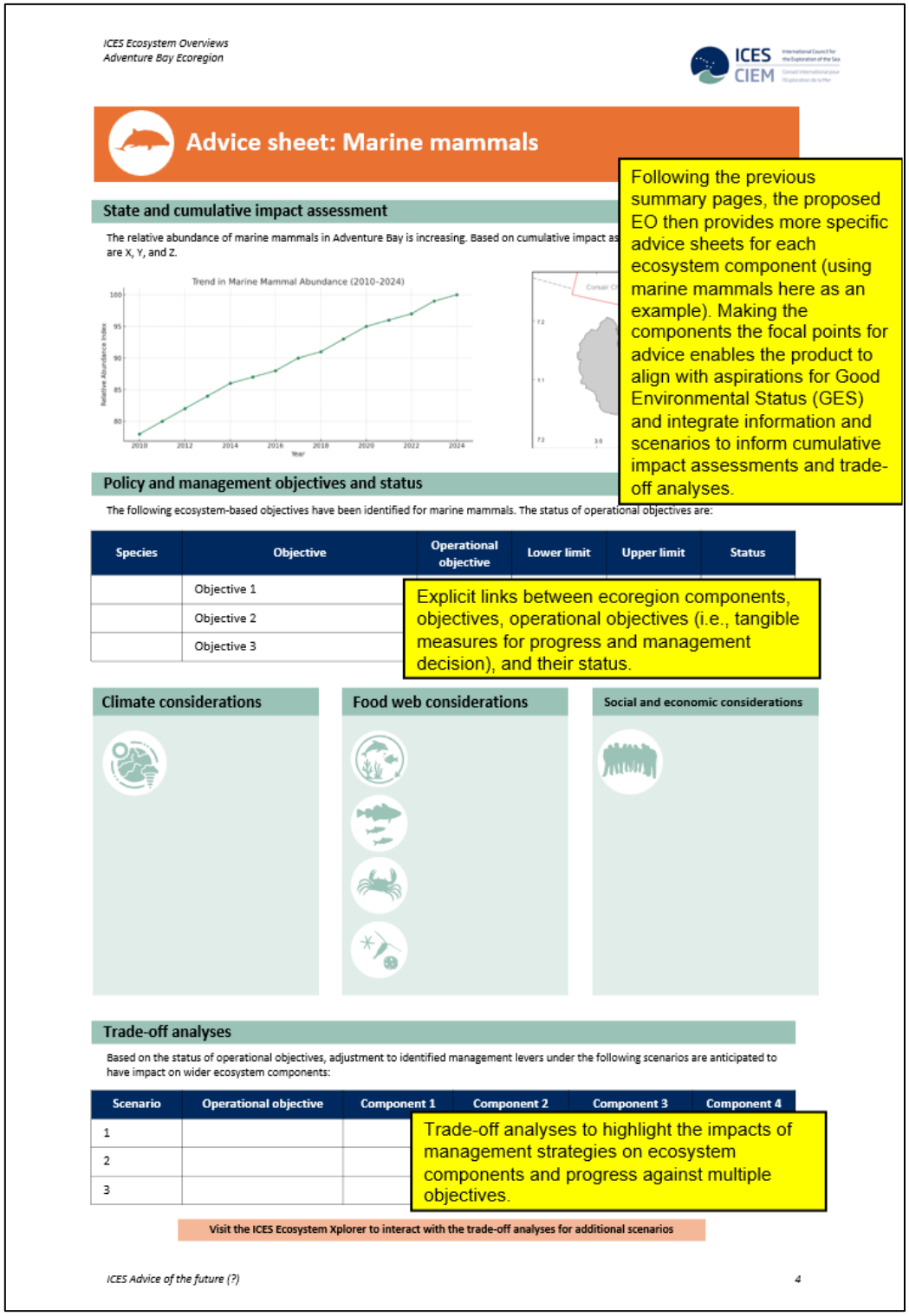

Figure 6.4 Advice sheets for ecosystem components, using marine mammals as an example. Yellow boxes provide contextual details of what was discussed at WKEO4.

6.2 Fourth Generation pitch feedback

Following the pitch, the group used an online interactive board to post notes and comments regarding the pitch: both pros, cons, and suggestions. Following this exercise, the group fed back in plenary and discussed the proposed EO structure.

Responses to the EO pitch were broadly positive, with support for the greater visual clarity, concise text, and practical orientation toward advice users. Participants supported opening with key recommendations and graphical summaries to make the documents more usable as advice and urged a shift to a more integrated, risk-based approach that captures cross-component interactions, biodiversity, and management implications. Participants also recommended 1) stronger risk communication and clarity around the separation of "advice" vs. "recommendations," 2) the integration of oceanography throughout (linking physical drivers to ecological and socio-economic processes), and 3) explicit links to existing advice products (e.g. stock, bycatch, and fisheries overviews) to improve coherence.

Participants discussed the potential resource intensity of the proposed EO, where the group recognized the need for incremental development that builds on ICES processes and systems (e.g. the Transparent Assessment Framework) to support progress. It was also raised that management levers in relation to trade-offs may only appear at the end of a process. There was support for adding foresight or near-term forecasts, balanced by caution about model limits and ICES quality-assurance constraints. Stakeholders offered strong user-side support, noting the design could address longstanding frustrations that current EOs are underused. Overall, participants viewed the vision as a valuable aspiration to guide EOs toward more integrated, interactive, and actionable products, to be pursued through the development of a shadow EO and strengthened coordination, data systems, and cross-group collaboration within ICES. These recommendations, along with the priorities identified for the EO themes, were used to construct a workplan for the fourth generation EO.

6.3 Workplan

WKEO4 proposed a multiyear workplan (2025–2028) to operationalize the group's five agreed priority themes, trade-offs, cumulative impacts, climate change, biodiversity and ecosystem function, and foresight, within the EO process (Figure 6.5). The roadmap was developed as a Gantt-style plan structured around recommendations, activities, and products, distinguishing between expert-group-led work, Secretariat-led process and data initiatives, and tangible deliverables. The timeline aimed to align incremental improvements in EO structure with ICES benchmark cycles and the 2030 horizon.

The proposed workplan emphasizes a 'learning by doing' approach, focusing on immediate, incremental steps and avoiding inertia, recognizing that while full implementation may take several years, early actin supports co-development and co-optimization of EO content among Expert Groups and nominated members of the advisory process (i.e. ADGs).

Participants suggested elevating the roadmap's status beyond the workshop report to a recognized ICES-level planning document, similar to existing roadmaps on bycatch and offshore renewables, to enable SCICOM and ACOM oversight. It was proposed that WKEO reconvene as a follow-up event (WKEO5) around 2028, after key proposed activities like WKTRANSPARENT2 and management objectives workshops had concluded, to review progress and shape the next phase of EO development. There was strong support for establishing a collaborative way of working to oversee roadmap implementation, coordinate across expert groups, and maintain momentum between workshops.

Across the report, a common message emerges that strengthened coordination, data systems, and cross-group collaboration within ICES are required for the effective delivery of the fourth generation of EOs. The workplan seeks to (i) strengthen coordination by clarifying roles, responsibilities, and deliverables and identifying points of interactions between expert groups (ii) developing, or making better use of existing data pipelines (e.g. TAF), and (iii) support all three aspects by moving towards a modular architecture, in which individual EO components (e.g.

sections, indicators, figures, analyses) are developed, documented, and maintained as self-contained units with clearly defined experts, inputs, methods, and outputs. This approach aims to reduce repetitive technical burdens, improve transparency and reproducibility, and enable the incremental improvement of EOs over time, rather than requiring repeated redevelopment.

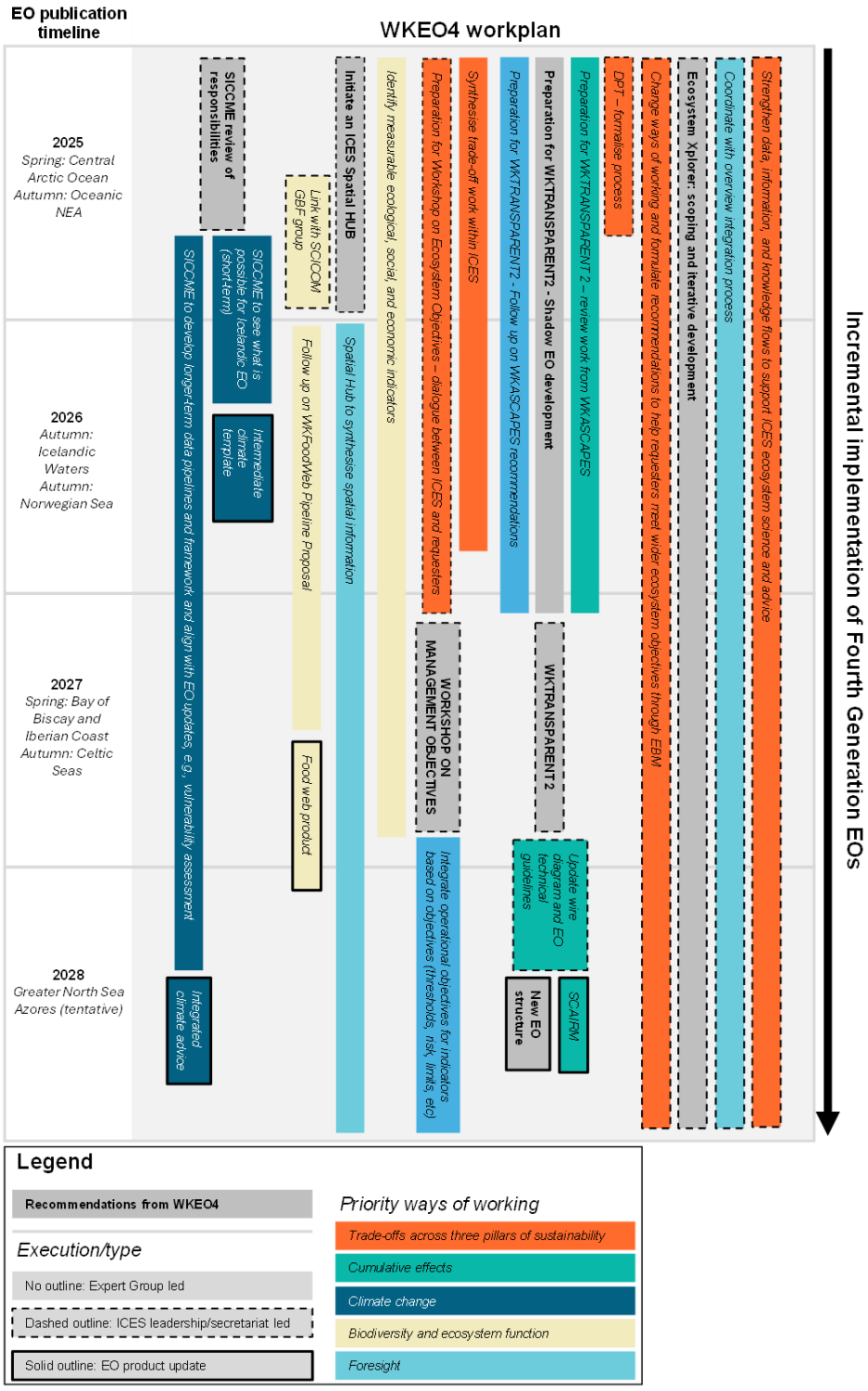

Figure 6.5 Proposed workplan for the fourth generation of Ecosystem Overviews.

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Annex 2: Resolutions

2024/WK/EAMSG01 The Workshop on fourth generation ecosystem overviews (WKEO4), chaired by Henn Ojaveer (Estonia), Jacob Bentley (**UK**), Nathalie Steins (Netherlands) will work on ToRs and generate deliverables as listed below.

	Meeting Date(s)	Venue	Report Deadline
2025	16 June - 20 June	ICES HQ, Copenhagen, Denmark	

ToR	Description	Background	Science Plan Codes	Year	Expected Deliverables
a	Review and update priority topic lists for the Ecosystem Overviews (EOs). Identify and document progress to date, existing gaps and emerging topics, and prioritize based on available knowledge and advice users' needs. Produce updated medium (3-5 years), and long-term (5-10 years) priority lists, taking into account the ICES Framework for Ecosystem-informed Science and Advice (FEISA).			2025	

b	Considering FEISA, advance specific sections in the EOs to meet end-user needs and by developing/proposing:	i) A common template structure for the climate change section (flexible to regional needs and available data), to be piloted in the Central Arctic Ocean and Oceanic Northeast At-lantic ecoregions. ii) A common template structure for the social and economic context section, flexible to regional needs and available data, and flagging future needs/directions iii. A general schematic summary for communicating the main key signals of the EO.	2025
c	Develop recommendations on how to improve the utility of EOs to meet advisory and decision-making needs, improve communication and accessibility, and address capacity challenges by:	i. Reviewing Integrated Ecosystem Assessment (IEA) and EO production processes to identify opportunities for streamlining and improving information flow and integration across groups and products, including data and evidence management. ii. Investigate how to improve alignment and integrate indicators, data, and information from other state of the environment reporting (e.g. OSPAR, HELCOM, Norway, EU MSFD, NAFO) into the EOs to reduce redundancy and address capacity challenges. iii. Critically review current EO format to assess how to improve accessibility, such as via interactive outputs from IEA and EOs (e.g.	2025

	Shiny apps, ArcGIS Story maps, Web Services, etc.).

Scientific Justification

High; the EOs are part of the recurrent advice in the Administrative Agreement (AA) signed between the EU and ICES, included MoUs with other requesters and are a key mechanism for ICES to deliver its advice on ecosystem-based management EBM with incorporation of climate change impacts. This WK is strategic for the development of ICES EAM and HUDI Steering Groups, advancing the implementation of the ICES Framework for Ecosystem-Informed Science and Advice (FEISA) and following up on the work of WKEO3, WKCONSERVE and WKCLIMAD. The outcomes of the workshop will be relevant to any future iterations and formats of the ICES overviews taking ac-count of ACOMs discussion on improving integration.

Resource Requirements

Assistance of the Secretariat in maintaining and exchanging information and requirements data to potential participants. ICES Data Centre participation required.

Assistance from ACOM leadership in obtaining input from stakeholders for ToR A (e.g.) through the MIRIA and MIACO meetings.

Linkages to other ICES Committees or Groups

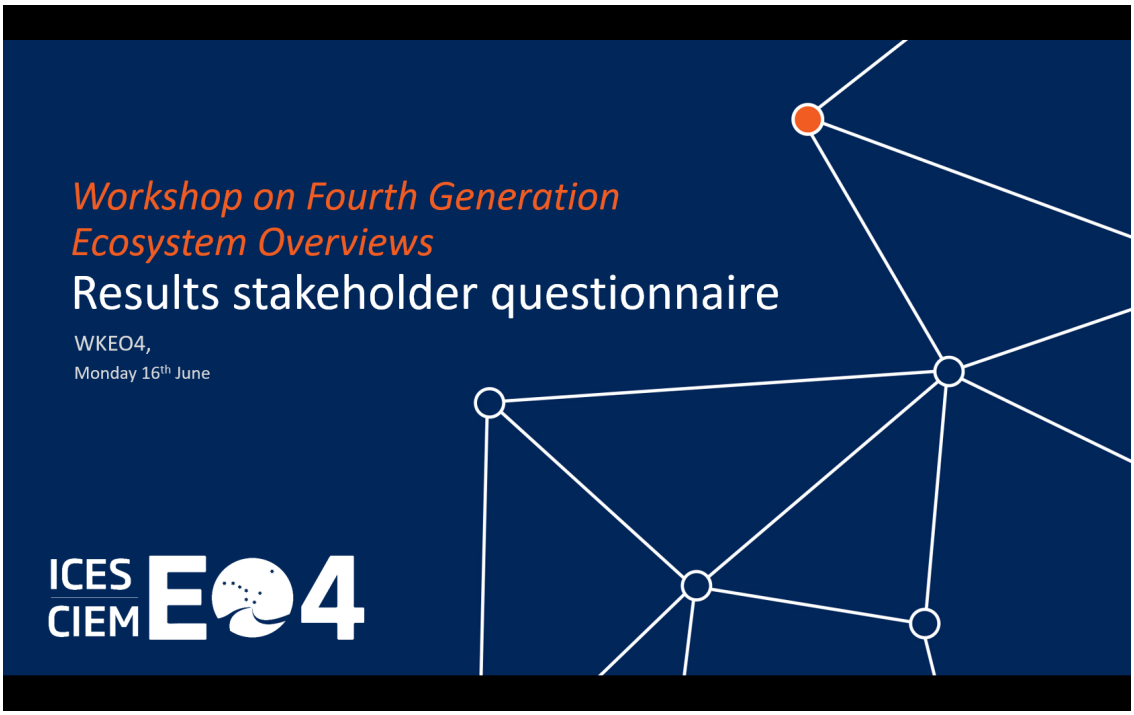
ACOM, DSTSG, EAMSG, EPDSG, HAPISG, HUDISG, MIACO, MIRIA, SCICOM, SICCME

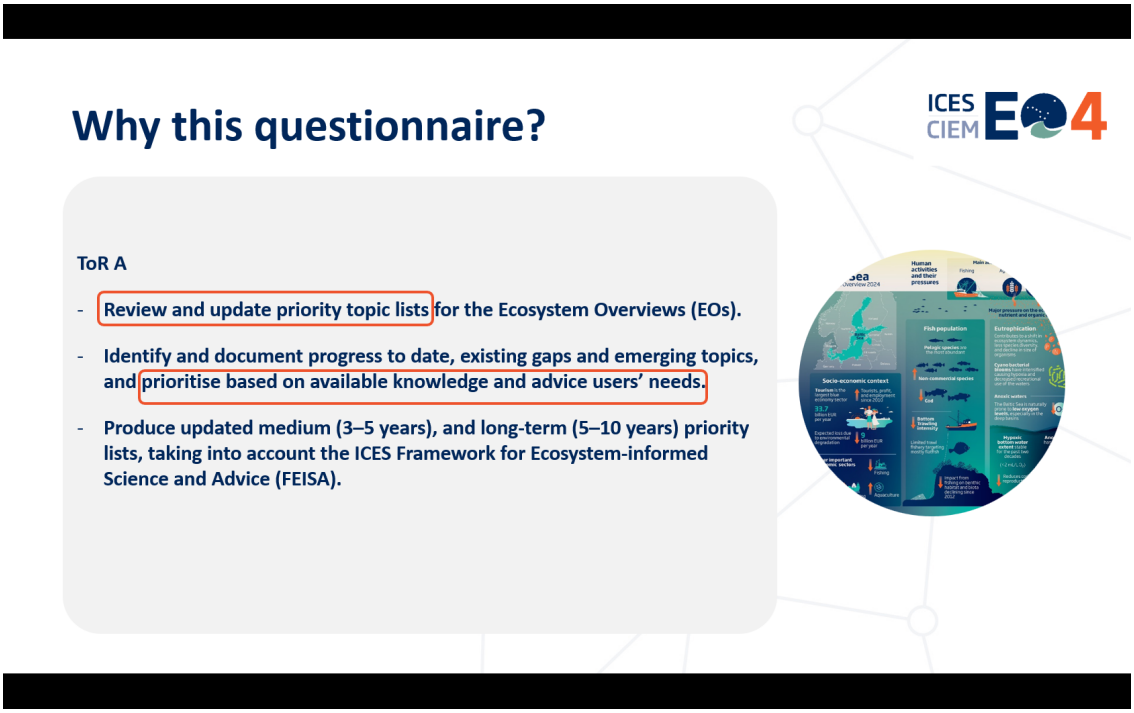
Linkages to other Organizations

EC, HELCOM, NEAFC, OSPAR, PICES

Annex 3: Results of stakeholder questionnaire

The results of the stakeholder questionnaire and its limitation are described in Chapter 2.2 of this report. The full PowerPoint containing the results is shown below.





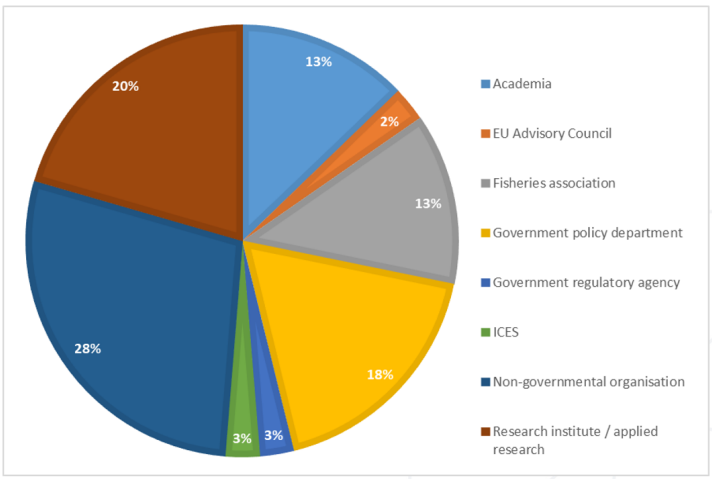
Limitations

- Questionnaire sent to MIRIA (ICES advice requesters), MIACO (ICES observers), MIAC (coordination ICES and EU Advisory Councils) and WKEO4 participants
- 39 responses
- Criteria for quantitative and qualitative representatives not met

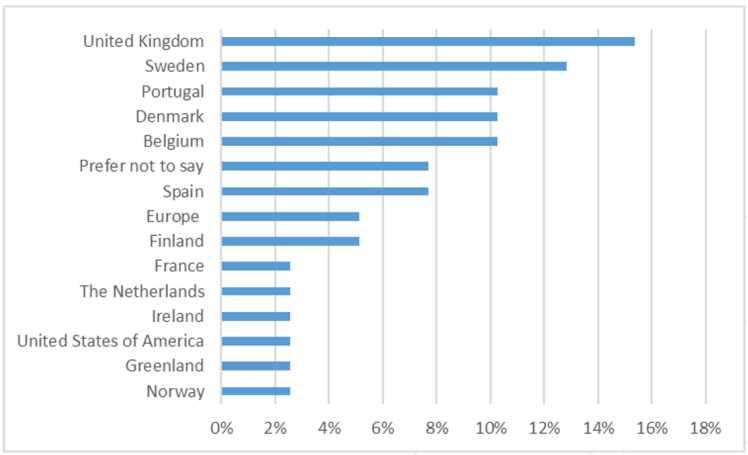
➢ Results are indicative!

Respondents' organisation type

Questionnaire (N=39)

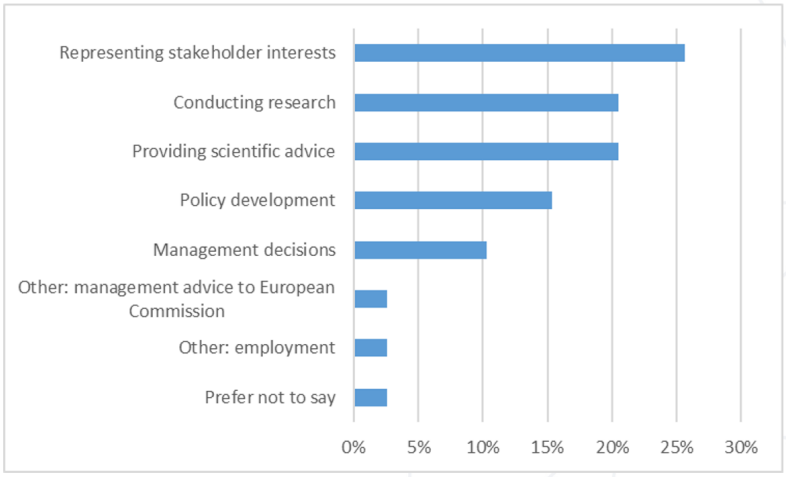


Organisation's country



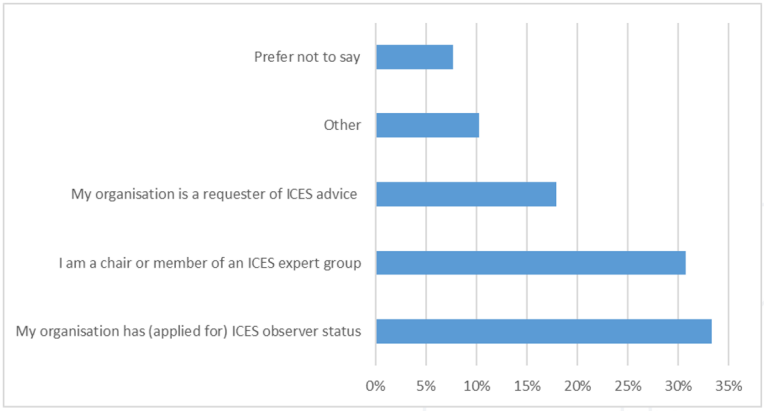
Questionnaire (N=39)

Most important activity of organisation



Questionnaire (N=39)

Organisation's relation to ICES



Questionnaire (N=39)

(Future) EBM topics for ICES advice (1/2)

Inclusion of ecosystem-based fisheries considerations in ICES fishing opportunities advice	17%
Effects of climate change	10%
Biodiversity, functional diversity	9%
Spatial management (e.g. fisheries, multiple ocean uses, protected areas, etc.)	9%
Cumulative effects	8%
Economic welfare of coastal communities and resource users	7%
Ecosystem conservation/restoration	7%
Sustainable seafood production (fisheries and aquaculture)	6%
Trade-offs between ecological, social and economic sustainability	6%
Trophic interactions	6%

Questionnaire (N=39)

- **max 3 responses (n=117)**
- **All scores > 5%**

(Future) EBM topics for ICES advice (1/2)

Knowledge (experiential) from resource users or stakeholders	5%
Emerging human activities and associated pressures (e.g. from Offshore Renewable Energy, deep sea mining, etc.)	3%
Social welfare of coastal communities and resource users	3%
Ecosystem Services	2%
Tourism and recreation	2%
Governance and policy integration	0%
Knowledge (traditional/experiential) from rightsholders or indigenous communities	0%
Multi-sectoral, integrative assessment	0%
Oceanographic conditions	0%
Other	0%
Pollution (contaminants, litter, microplastics, etc.)	0%
Stakeholder perceptions	0%
Vulnerability/resilience to environmental change	0%

Questionnaire (N=39)

- **max 3 responses (n=117)**
- **All scores ≤ 5%**

Familiarity with ICES EOs

	Not familiar at all	Moderately familiar	Slightly familiar	Very familiar
I am a chair or member of an ICES expert group	1	1	3	7
My organisation has (applied for) ICES observer status		9	2	2
My organisation is a requester of ICES advice		4	3	
Other		2		2
Prefer not to say			2	1
Grand Total	**1**	**16**	**10**	**12**

Questionnaire (N=39)

Use of EOs in work

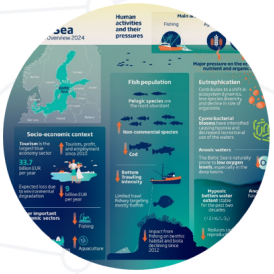
	No	Maybe	Yes
I am a chair or member of an ICES expert group	4	5	3
My organisation has (applied for) ICES observer status	1	3	9
My organisation is a requester of ICES advice	2	4	1
Other		1	3
Prefer not to say		1	2
Grand Total	7	**14**	**18**

Questionnaire (N=39)

For what purposes are EOs used?

- **Advising or giving recommendations to managers (scientists, ACs, NGOs, others)**
- **Advocacy work (NGO's, fisheries associations)**
- **Comparative analysis (scientists, NGOs)**
- **Draw managers' attention to wider ecosystem considerations as opposed to single species fisheries management (NGOs)**
- **Education (scientists)**
- **Information source (scientists, ACs, NGOs, others)**
- **In support of management decisions (policy)**

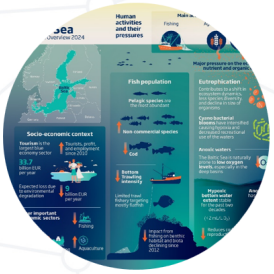
Questionnaire, open, optional question



Why not use the EOs?

- Lack of transparency about applied methods, data used, and scientific basis of their conclusions (scientists)
- Too general and largely inapplicable to stakeholder interests (fisheries associations)
- Too many reports, too little time (policy)
- Unsure of how EOs can help (policy)
- Not relevant for particular advisory role (scientists)

Questionnaire, open, optional question

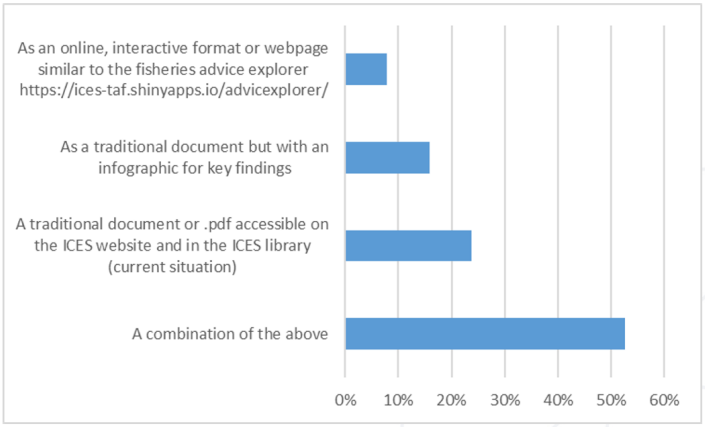


Ranking of the 6 subheadings in the EOs

Heading	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Weighted
Climate change effects	1	6	10	6	9	7	119
Ecoregion description	4	9	2	4	5	15	114
Key signals (document summary)	17	4	5	4	4	5	167
Pressures (of human activities)	6	11	3	14	4	1	154
Social and economic context	1	3	6	6	16	7	102
State of the ecosystem	10	6	13	5	1	4	163

Questionnaire (N=39)

Future presentation of EOs



Questionnaire (N=39)

Annex 4: Lists of presentations and summaries

Presentations given at WKEO4 are listed below, organized per ToR, followed by a summary in the same order.

ToR A

WKEO4: Results stakeholder questionnaire – Nathalie Steins (WKEO4 chair)

ICES Framework for Ecosystem Informed Science and Advice (FEISA) – Jacob Bentley (WKEO4 chair)

Working Group on Balancing Economic, Social, Institutional, and Ecological Objectives in Integrated Assessments - Lea Schönen

ToR B

WGECON and WGSOCIAL contribution to Ecosystem Overviews – Katell Hamon (Wageningen Social and Economic Research)

Climate Change in Ecosystem Overviews – SICCME (ICES/PICES Strategic Initiative on Climate Change Impacts on Marine Ecosystems - Bryony Townhill and Kirstin Holsman (SICCME chairs)

A general schematic summary for communicating the main key signals of the EO and potential interactive formats/outputs – Benjamin Planque

ToR C

Ecosystem Overviews: purpose, guidelines and future directions – Henn Ojaveer (WKEO4 chair) and Marie-Joulie Roux (ACOM vice-chair)

NOAA State of the Ecosystem report – Sarah Weisberg (ICES Secretariat)

Modular Tools for Smarter Marine Management: Integrating Trade-offs, Risk, and Deep-Sea Protection into ICES Ecosystem Overviews – Sebastian Valenko (ICES Secretariat)

SMMART: Spatial Marine Management Assessment and Reporting Tool: Integrated evidence for ecosystem status assessment and trade-off analysis for Good Environmental Status (GES) - Will Le Quesne, Roi Martinez, Oli Hogg (Cefas)

SCAIRM Spatial Cumulative Assessment of Impact Risk for Management – Gerjan Piet (Wageningen Marine Research)

Communicating, visualizing, and promoting Ecosystem Overviews – Celine Byrne (ICES secretariat)

ICES X-plorers: A suite of apps that makes ICES products interactive and accessible – Sarah Louise Millar (ICES Secretariat)

WKEO4: Results stakeholder questionnaire – Nathalie Steins (WKEO4 chair)

Reported in Chapter 2.2 and Annex 3 of this report.

ICES Framework for Ecosystem Informed Science and Advice (FEISA) – Jacob Bentley (WKEO4 chair)

Working Group on Balancing Economic, Social, Institutional, and Ecological Objectives in Integrated Assessments - Lea Schönen

The ICES Working Group on Balancing Economic, Social, Ecological, and Institutional Objectives (WGBESEO) is currently working on two key tasks outlined in its Terms of Reference (ToRs).

Under ToR A, they are developing a framework to help ICES expert groups identify and standardize ESEI (Economic, Social, Ecological, Institutional) objectives derived from legal and policy documents. This goes beyond summarizing legislation - the goal is to extract strategic insights, highlight potential legal gaps or conflicts, and ultimately inform ICES Ecosystem Overviews, particularly the management section. The final product might include a graphical or scorecard-style visualization that shows which sectors are governed by which policies and where specific ESEI objectives are articulated. While they will not evaluate the policies themselves, they aim to clarify the coverage of ESEI areas across different sectors. Key considerations include the tools and resources they can apply - including potential AI tools and expertise within or outside the group, especially from those with legal backgrounds.

Under ToR B, they are working to establish best practices for conducting salient, legitimate, transparent, and multidisciplinary trade-off analyses. Their focus is on reviewing ICES current approaches, analysing case studies, and developing a best-practice checklist. They aim to understand how trade-offs are made; meaning whether all ESEI dimensions are considered, and if data are available for each - without conducting trade-offs themselves. The goal is to raise awareness of how ESEI priorities are weighed, recognizing that trade-offs often reflect tensions between stakeholder interests and policy objectives. They also want to bring attention to equity issues, which are often absent from formal documents but are critical to sustainable management.

Moving forward, they are currently expanding their networks and knowledge base, including potential collaborations, in and outside ICES. They are actively seeking new contributors, particularly those with legal expertise. WGBESEO also discusses how they might support other ICES groups - as a consulting body - through tools or digital products that they aim to develop by the end of their term. For more information or to get involved, please reach out to the WGBESEO Chairs directly.

WGECON and WGSOCIAL contribution to Ecosystem Overviews – Katell Hamon (Wageningen Social and Economic Research)

The current contributions of WGECON and WGSOCIAL to ICES Ecosystem Overviews (EOs) particularly focus on fisheries. This is due partly to the expertise of the people doing the analysis and writing in in Eos and partly to the available data. Social and economic information have been added by WGECON and WGSOCIAL experts in 3 EOs, the Celtic Sea (as a pilot), the North Sea (where the Celtic Sea analysis was expended) and the Baltic Sea where a different approach was taken.

For the Celtic Sea and the North Sea, the contribution included i) maps showing effort, landings, and values linked to ports of landings (used as proxy for fishing communities) and vessel size categories, ii) ecoregion employment and economic indicators and iii) recent social and economic drivers (such as Covid-19, Brexit or the Russian invasion of Ukraine). Different data sources have been used: ICES RDB for the maps i); STECF AER data for the employment and economic indicators ii) and the other drivers iii) were mainly qualitatively described based on expert knowledge.

In the Baltic Sea EO, the analysis of the fishing sector is less detailed but more Blue economy sectors are characterized in addition to fishing (tourism, shipping, eutrophication mitigation costs, offshore wind and aquaculture).

Work in progress includes moving from RDB to RDBES database of ICES, developing a standardized data workflows via shared generic R scripts (GitHub suggested). However, there are still limitations with the current approach, especially in the coverage of non-EU countries or small-scale fleets.

In addition to deploying the current analysis to more EOs (where data availability allows it), WGECON and WGSOCIAL have also been looking at other (still fisheries focused) analysis like

understanding links across ecoregions (harbours may be linked to a sea region they are not bordering, e.g. Dutch harbours with the Celtic Sea); understanding the specificities of harbours (which species/gears are they linked to) which can inform on their resilience or vulnerabilities (to be linked to management changes or climate change); collaborating with WGSFD to get finer scales maps using VMS/AIS data. Some of those would probably fit better in FOs as very fisheries focused.

Climate Change in Ecosystem Overviews – SICCME (ICES/PICES Strategic Initiative on Climate Change Impacts on Marine Ecosystems - Bryony Townhill and Kirstin Holsman (SICCME chairs)

Including climate change impacts sections in EOs is important to help provide context for decision-making and planning, and to facilitate information exchange that can lead to innovation in assessments and advice. The sections should communicate a consistent understanding of observed and projected climate change impacts across the different ecoregions, build awareness of how climate change is already and may affect ecosystems and human activities in each region, and provide information to support planning for adaptation strategies.

A presentation was given describing what the present EOs contain regarding climate change, and the inconsistencies. This set the scene for why the climate change sections of the EOs need to be standardized. A new template had been developed and was shared which included sections on past and projected climatic changes in the ecoregion, including key variables and the ecosystem components impacted, and key knowledge gaps. Discussions were then held about how to operationalize the climate change sections, and potential data sources, what to include in the new template, and whether to include socio-economic data and climate adaptation.

On operationalizing, the general consensus was that the EO working groups do not have the expertise to write the climate sections themselves, and that they need help from SICCME to identify others who can draft these. The sections should use a human pressures, ecosystems and services framework. Open science tools and code on Github should be used to standardize the data used in across ecoregions. Regarding what to include, the group favoured more inclusion of figures and infographics rather than only text, including maps of species shifts and calibrating language for consistency. There was also consensus that adaptation and social and economic information should be included in the EOs, with this round of EOs including what they can, but more detailed information being included in future rounds. This will require new expertise in the expert groups.

The next steps on the climate change sections are to start incrementally, bringing the new sections into the EOs as they are written. The process should be developed through workshops and templates on a continuous and case by case basis. The Greater North Sea EO was used to demonstrate the template and so can be further developed, with other EO updates to follow.

A general schematic summary for communicating the main key signals of the EO and potential interactive formats/outputs – Benjamin Planque

IEA explorer: In parallel with the current developments of Xplorers applications at ICES, WGINOR has prototyped an IEA-explorer, a shiny app that provides graphical and data access to the time-series used by the IEA working group. Discussions between WGINOR and the secretariat (Luca Lamoni) have been conducted. Further development of this tool would require stronger/more formal collaboration between the ICES secretariat and the IEA group, and could ultimately benefit all ICES IEA groups.

IEA Oracle: Large language models (LLMs) offer capabilities to extract knowledge through open text request, and in multiple output formats. WGINOR has prototyped an IEA-Oracle which is a ChatGPT-based tool tailored to answer questions relevant to the IEA in the Norwegian Sea. The oracle is also informed with the IEA indicator time-series and can deliver precise figures,

graphical representations, and numerical analyses. The oracle could provide ICES-users an entry point to information and advice. We recommend that this approach is considered in parallel with graphical summaries and other communication tools.

TAF in IEAs: There are few examples of implementation of the Transparent Assessment Framework (TAF) in IEAs, but there are few (WGINOR has 2). These recent implementations can be used to strengthen the dialogue between IEA groups, the TAF group, and the TAF-Xplorer teams, with the ultimate goal of developing transparent integrated ecosystem assessments.

Ecosystem Overviews: purpose, guidelines and future directions – Henn Ojaveer (WKEO4 chair and Marie-Julie Roux (ACOM vice-chair)

The meeting participants were reminded that the purpose of Ecosystem Overviews is to: i) complement other types of advice, providing supporting context and allowing users to understand the implications of sectoral decisions and impacts in an ecosystem context, and ii) advance the delivery of integrated ecosystem-informed advice, taking account of the effects of multiple human pressures on the environment and the most influential environmental and ecosystem processes, while considering multiple objectives. The overviews have the following major sections: Key signals; Ecoregion description; Pressures; Climate change effects; Socio-economic context, and State of the ecosystem.

Before finalizing the priority topics list in WKEO4, it was reminded that the following 8 priority topics were suggested by WKEO3 in 2019 to be included to EOs in the short- and medium-term perspective: management objectives; fisheries impact on the seabed; climate predictions and projections; productivity changes; mapping vulnerable areas; linking pressures to ecosystem functions and processes; a general overview of ecosystem structure; and foodweb modelling to quantify links and impacts. There was relatively limited success in inclusion of these prioritized topics to EOs.

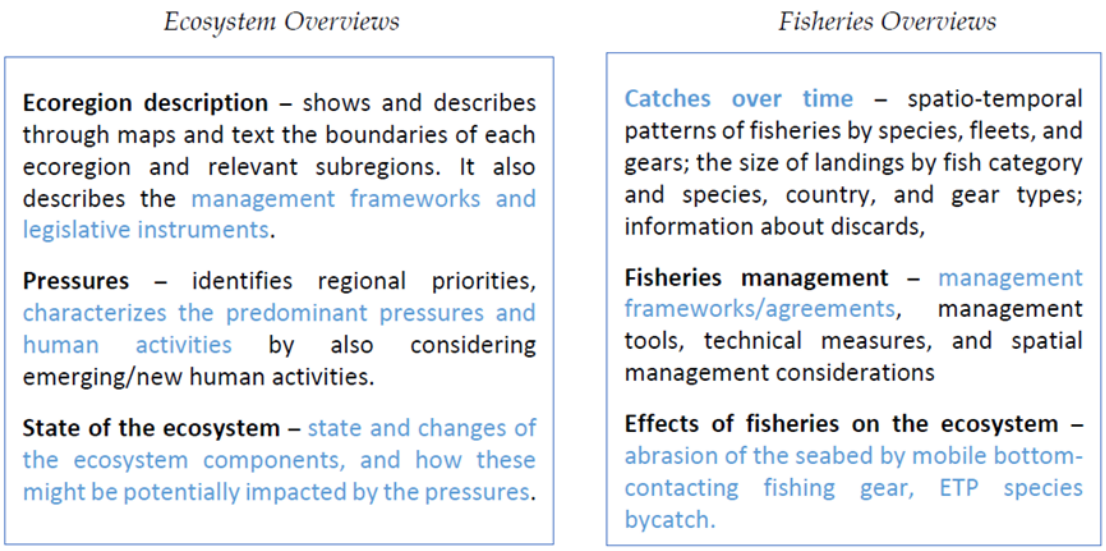
In 2024, ACOM has initiated the process of integrating Ecosystem, Fisheries and Aquaculture Overviews. The purpose of the integration is to: i) Minimize content overlap/redundancies; ii) Optimize format; iii) Streamline production (full revisions and annual updates), and iv) Improve relevance and utility to inform EBM decision-making.

Ecosystem, Fisheries and Aquaculture Overviews have both content specificities and overlaps.

The content specificities are:

EO	FO	AO
1. Key signals 2. Ecoregion description 3. Pressures 4. Climate change effects 5. Socio-economic context 6. State of the ecosystem	1. Key signals 2. Introduction 3. Catches over time 4. Description of fisheries 5. Fisheries management 6. Status of the fishery resources 7. Interactions between fisheries and the ecosystem 8. Effects of fisheries on the ecosystem	1. Executive summary 2. Introduction 3. Description and location of marine aquaculture activities and practices 4. Production over time 5. Policy and legal foundation 6. Management frameworks 7. ecosystem/environment interactions 8. Social and economic context 9. Interaction of environmental, economic and social drivers 10. Future projections, and emerging threats and

The content overlaps are:



ACOM subgroup has suggested to implement the following two processes in parallel: 1) Full structure and content revision to remove overlap and better link/integrate relevant sections; and 2) Create a more holistic overview, focusing on: i) establishing putative management objectives; ii) evaluating the suitability of existing and developing EOs, AOs, FOs indicators; and iii) evaluating progress and risks to meeting management objectives. It was fully recognized that establishing a holistic overview requires close collaboration and input from advice requesters and stakeholders.

The Overviews Intelligence (OI) group was formed to work on the overviews integration. The agreed preliminary directions of the activities of OI are: i) Focus on the broader ecosystem/socio-ecological system status; ii) Develop online; iii) Engage advice requesters while maintaining a strong foresight component; and iv) Tackle all three overviews from the start.

NOAA State of the Ecosystem report – Sarah Weisberg (ICES Secretariat)

In the US, NOAA's Northeast Fisheries Science Center annually releases State of the Ecosystem (SOE) reports, which are in many ways analogous to ICES Ecosystem Overviews (EOs). The SOE reports have been developed in close consultation with relevant fisheries management bodies, over several years. In their current form, the SOE reports contain elements that could be adapted for the next generation of ICES EOs in order to increase their use in management contexts, including:

Graphical cover pages containing key messages;

A 'report card' indicating trends and status with respect to management objectives;

Concise text delivered in pdf form to stakeholders, accompanied by online components with full datasets and documentation. The latter are aimed at a scientific audience and ensure transparency and reproducibility.

A brief overview of these components will be used to spark a discussion on how to best apply lessons learned from the American context in the European one.

Modular Tools for Smarter Marine Management: Integrating Trade-offs, Risk, and Deep-Sea Protection into ICES Ecosystem Overviews – Sebastian Valenko (ICES Secretariat)

How can managers balance seabed protection with productive fisheries? ICES now delivers operational advice and interactive tools that support transparent trade-off analysis, enabling users to weigh ecological benefits against economic impacts of reducing bottom-fishing activity.

Using a modular framework, much like the ICES Fisheries Explorer, recent advice products evaluate multiple spatial management scenarios across four shelf-sea ecoregions. Results show that large ecological gains—e.g. 50% habitat protection—can often be achieved with relatively small losses in landings value (e.g. ~20% in the North Sea and Celtic Seas). These results are presented via interactive maps, downloadable data layers, and reproducible workflows (ICES TAF)—allowing policy implementers to adjust spatial thresholds and visualize ecosystem "tipping points."

This same modular approach has been extended to deeper waters. A parallel tool for Vulnerable Marine Ecosystems (VMEs), developed in response to EU Deep-Sea Access Regulation, provides the first recurrent spatial advice identifying areas where VMEs are known or likely to occur. Five spatial management scenarios are presented with associated interactive HTML maps, allowing exploration of closure areas, fishing activity, and habitat distribution down to depths of 800 meters.

Next-gen integration: These shelf and deep-sea tools—grounded in impact indicators, spatial fisheries data, and interactive maps—offer an evolving platform for embedding risk, uncertainty, and trade-off information into the next generation of ICES Ecosystem Overviews, supporting holistic, regionally tailored, and ecosystem-based decision-making.

SMMART Framework for transparent, repeatable, modular, integrated evaluations of ecosystem impacts and trade-offs - Will Le Quesne, Roi Martinez, Oli Hogg (Cefas)

The Spatial Marine Management Assessment and Reporting Tool (SMMART) Framework is being developed in Cefas to support transparent, repeatable, modular, integrated evaluations of ecosystem state, and the impacts and trade-offs associated with management decisions with a focus on spatial management options. The framework has been developed iteratively (Le Quesne *et al* 2021, Clare *et al* 2023, Hobbs *et al* 2025, Hogg *et al* 2025) and is designed to support streamlined information flow, collaboration across groups, and integration of indicators related to ecosystem status, including OSPAR and MSFD indicators, and evaluation of spatial management measures, including MPAs, and multi-sectoral operations and interactions, including fishing activity and offshore wind development.

The SMMART Framework was initially conceived to evaluate trade-offs between potential spatial management scenario, but it also provides opportunity to calculate and present information on current ecosystem status. It will provide integrated evaluations of the direct impacts of human activities. It is expected that it could be deployed alongside a suite of modelling tools optimized to consider pressure-state links for specific ecosystem components as part of a more holistic long-term coordinated ecosystem evaluation process.

The current application of the SMMART Tool, the analysis component of the SMMART Framework, is able to calculate GES and ecosystem indicators based on methodologies developed through OSPAR and ICES. This includes indicators for:

- Extent of Physical Disturbance to Benthic Habitats: Fisheries with mobile bottom-contacting gears (BH3),
- Exposure of Sensitive Fish Species to Fisheries based on the list of sensitive fish considered in the OSPAR and GES indicators for Recovery of Sensitive Fish Species (FC1). The Exposure of Sensitive Fish Species is an indicator under development that is a forward-looking indicator to compliment the retrospective looking formal OSPAR indicator for Recovery of Sensitive Fish Species.
- Relative Benthic Status (RBS) indicator assessing the extent to which benthic communities have been degraded due to direct impact from mobile contacting gears.

The ethos behind the SMMART Framework is to recognize the policy and advisory needs for integrated assessments and scenario evaluations of state, trends and drivers impacting

ecoregions with respect to multiple societal and ecological objectives, as well as addressing the practical needs for a framework and process that is repeatable, transparent, accessible and communicable, cost-effective, and efficient to implement on a routine basis.

Several principles have been applied in the conceptual development of the SMMART Framework to meet these policy and advisory needs. These are summarized below.

Separating the process of compiling the spatial data inputs from the process of evaluating ecosystem analysis:

The process of establishing the spatial data inputs as a Marine Ecosystem Data Bundle (MEDAB) is separated from the process establishing the ecosystem analysis routines in R code (SMMART Tool). This separation aids transparency, efficiency and collaboration. It allows the MEDAB to be updated on a routine basis, or MEDABs prepared for different regions, areas or, if needed, at a different spatial scale and resolution. Given the standardized format of MEDABs, identical analysis routines can be applied meaning that stakeholders only need to consider the updates in the data inputs without dependencies to update the analysis code – and vice versa.

It is emerging that establishing a stand-alone ecosystem data package, the MEDAB, has value as a product in its own right, and provides a focus for collaborative development of a coordinated ecosystem dataset in support of Ecosystem Overviews and additional ecosystem studies. For example the MEDAB could be used as the basis for SCAIRM cumulative impact assessments (Piet *et al.*, 2003). The use of standardized data products through an openly accessible bundle could also support consistency and transparency in analytical and advice products.

Full implementation of the SMMART Framework (Figure A4.1) requires a third module, the SMMART scenario configuration file that allows comparative evaluations to be run comparing current (baseline) and different spatial use-case scenarios.

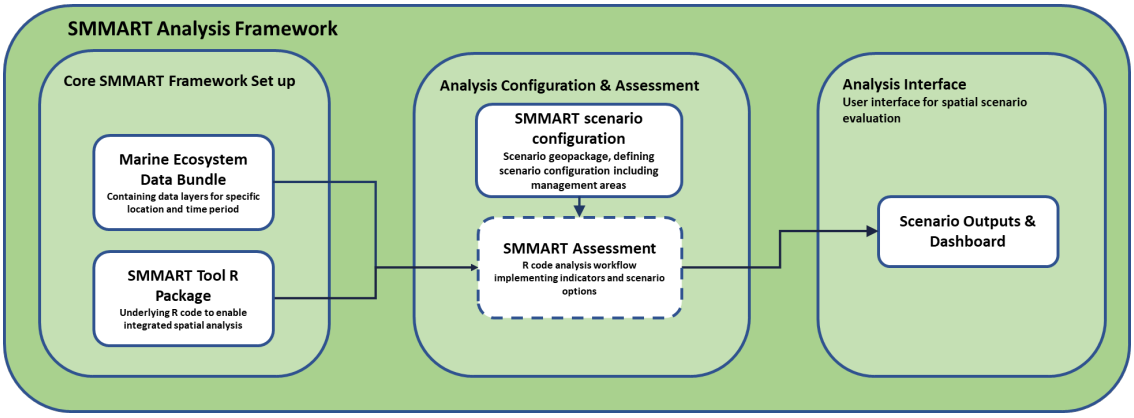


Figure A4.1 Schematic summary of the modular components of a SMMART Framework analysis.

Applying a common spatial data reference framework and scale across ecosystem data inputs:

The ecosystem data layers, covering ecological attributes, human activities and management areas are compiled at a common spatial scale using the C-square spatial grid reference format before incorporation into the MEDAB. This sets out a clearly specified format for data submission into the MEDAB. Separating the standardization of data inputs from the calculation of ecosystem interactions by the SMMART Tool, facilitates establishment of streamlined data flows and integration of data products derived by multiple groups as well as aiding transparency and communication.

Establishing data inputs at a common spatial scale has potential drawbacks as there is no single spatial scale that is optimal for the description of all ecological processes, and not all data collection activities are designed to provide outputs at the same spatial resolution. Therefore,

summarizing data inputs at a common spatial scale provides benefits as it allows integrated analysis across multiple ecosystem layers, but it requires a trade-off with accuracy and precision in some ecosystem attributes. Recognizing this limitation, the ecosystem analysis conducted by the SMMART Tool only considers short-term direct impacts (see point 3 below).

Focusing on short term direct impacts rather than long-term pressure-state relationships

A full evaluation of ecosystem status and the impact of management options should consider the full chain of interactions and feedbacks between management action and ecosystem status (Figure A4.2).

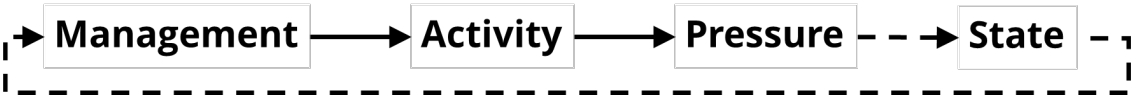


Figure A4.2 Simple schematic representation of links between management decisions and change in ecosystem state. Solid arrows are the links that are primarily considered within the SMMART framework.

The approach being developed for the SMMART Framework is to conduct an integrated assessment of the links between management options, spatial distribution of activities and evaluation of the resulting pressures on multiple ecosystem components. This is conducted at a common spatial, temporal and taxonomic scale.

It is expected that longer term dynamic evaluation of pressure-state links can be conducted separately using a suite of complementary modelling and evaluation tools configured with the spatial, temporal and taxonomic scale required to represent the ecological process in question.

Applying a data-driven modular approach to incorporation of data inputs, ecosystem interaction terms and scenario evaluation routines:

The SMMART Framework is being developed through a data-driven iterative and modular approach. The current implementation of the Framework only incorporates a limited number of ecosystem data layers and interaction terms based on data that is available for English waters (North Sea and Celtic Seas). It is expected that this will be built on as new data inputs and interaction terms are available. This could be facilitated and accelerated through engagement with ICES expert groups.

This approach supports collaboration and integration across groups as the SMMART Framework simply sets out the core workflow and processes. Individuals or expert groups can then develop additional data inputs or interactions terms that can be combined into the framework, thereby enhancing its overall capabilities, without each group having to redefine the overall structure of the SMMART Framework, the Marine Ecosystem Data Bundle (MEDAB) or SMMART Tool code.

Proof-of-Concept Application of the SMMART Framework for English Waters

A proof-of-concept application of the SMMART Framework to evaluate the impact of a possible future offshore wind development scenario is presented. These outputs are presented to demonstrate the emerging capability of SMMART and should be seen as purely illustrative and need to be considered in the context of limitations to the data inputs and analysis routines.

This analysis was based on a MEDAB compiled at a scale of 0.05^{O} for English Waters (Hobbs *et al* 2025) and using the version of the SMMART Tool R Code described in Hogg *et al* (2025), a schematic overview of the analysis is presented in Figure A4.3.

The primary dashboard of indicators from the analysis (Figure A4.4) presents high-level information on ecological impacts, fishery impacts and spatial interactions between sectors and conservation measures.

A series of more detailed outputs are available in addition to the headline ecosystem performance indicators. Examples are provided for the Extent of Physical Disturbance to Benthic Habitats: Fisheries with mobile bottom-contacting gears (Figure A4.5), and Exposure of Sensitive Fish Species to Fisheries (Figure A4.6) indicators.

The impetus behind the development of the SMMART Framework, and its component parts, aligns with the WKEO4 ToR c, to provide assessments of marine ecosystem components that meet advisory and decision-making needs in a way that is transparent, accessible and reproducible. SMMART represents a proof-of-concept approach that, through closer engagement with ICES expert groups, could provide an operational framework for streamlining and improving information flow and integration across groups and products. Its modular design facilitates collaboration between different expert groups with each developing and contributing to different elements of the framework. Frameworks such as SMMART offer an example of how different ecosystem indicators can be aligned under a coordinated assessment framework with the potential for compatibility with interactive outputs such as Shiny apps and ArcGIS Story maps.

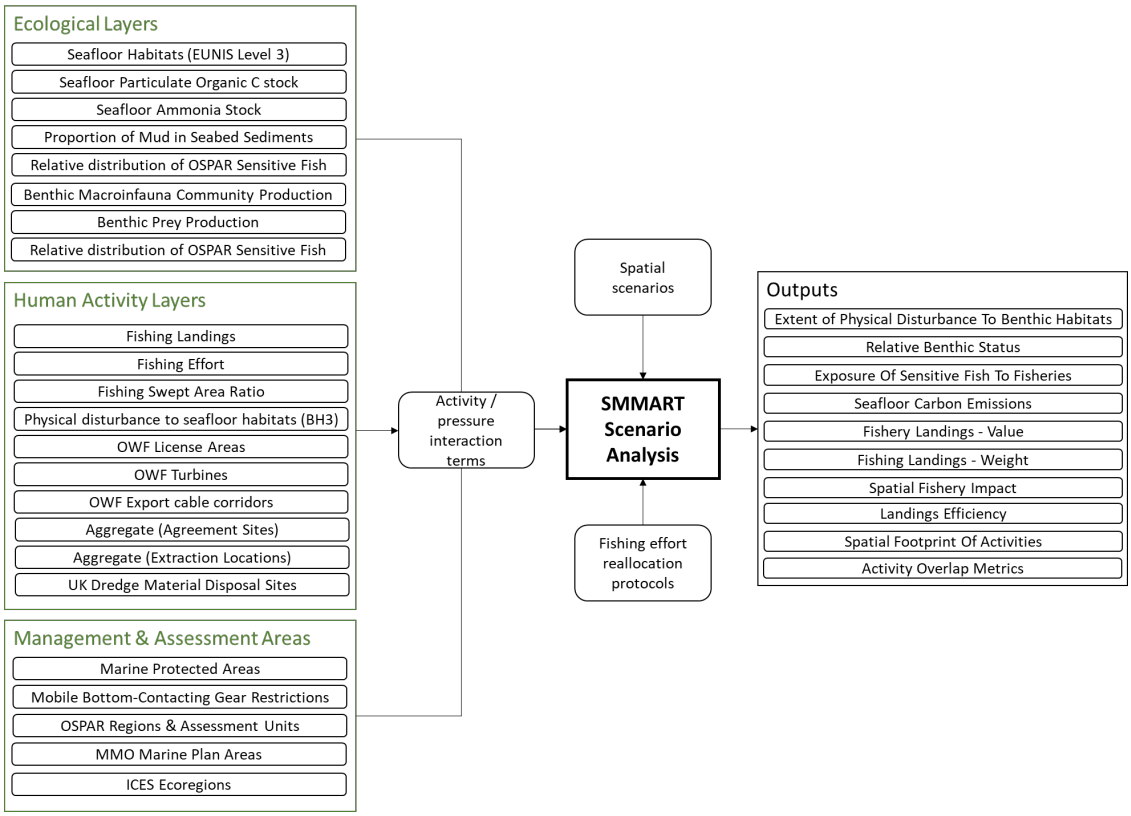


Figure A4.3 A schematic summary of the structure, inputs and outputs of the proof-of-concept application of the SMMART Framework based on Hobbs *et al* (2025) and Hogg *et al* (2025). OWF = Offshore Wind Farm, MMO = UK Marine Management Organization.

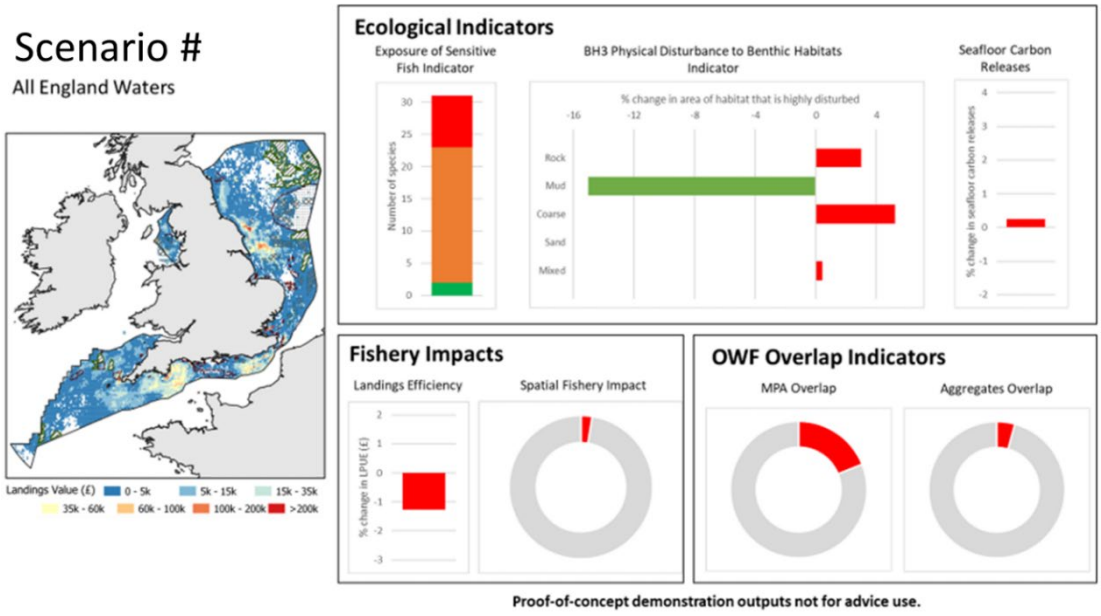


Figure A4.4 Summary scenario evaluation outputs for the test scenario compared to the baseline showing: Left panel - annual landings value per unit area, Top panel - the number of sensitive fish species showing a relative increase (red), similar or decrease (green) in exposure to fishing, the change in the percent of different habitat types considered highly disturbed, and percent change in seabed carbon emissions due to trawling, Bottom Left panel – percent change in landings per unit effort, proportion of the total value of landings derived from areas under modified management in the test scenario (red), Bottom Right panel – proportion of the total area of MPAs that coincides with an offshore wind farm (red), and the proportion of the licensed aggregate areas that coincides with licensed offshore wind farms (red).

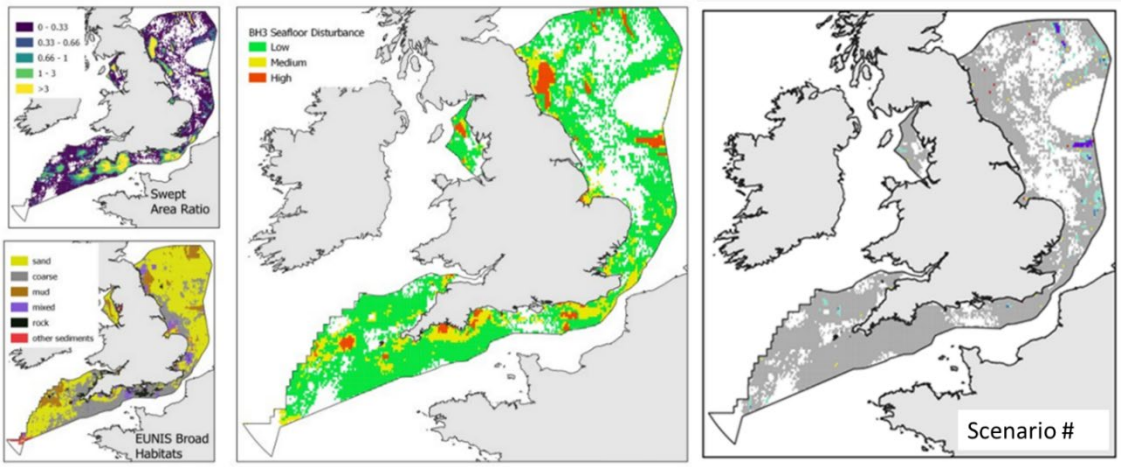


Figure A4.5 Top Left panel - Swept area ratio per unit area under the test scenario, Bottom Left panel – primary EUNIS habitat per unit area, Central panel – the seabed disturbance category per unit area under the test scenario, Right panel, the change in seabed disturbance category per unit area in the test scenario compared to the baseline, red = 2 category increases in disturbance, yellow = 1 category increase, light blue = 1 category decrease, purple = 2 category decrease in disturbance.

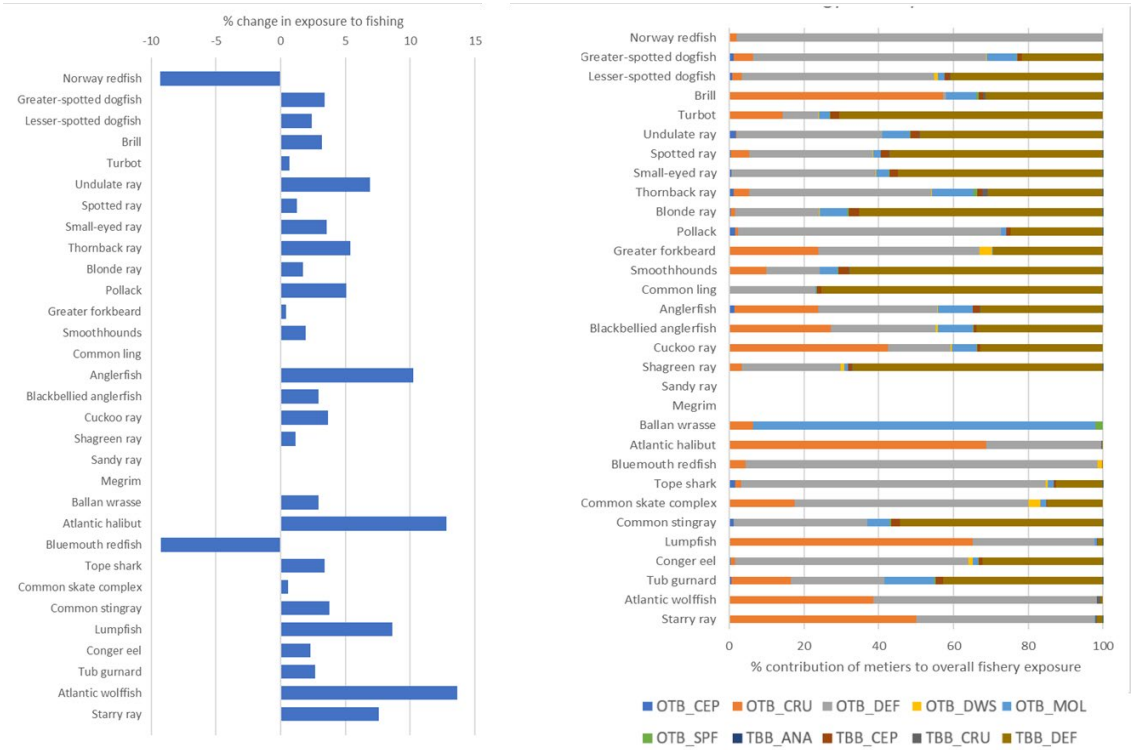


Figure A4.6 Left panel - the percent change in exposure to fishing for individual species in a test scenario compared to the baseline, Right panel – the proportional contribution of different métiers to overall fishery exposure risk for each species under the test scenario.

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SCAIRM Spatial Cumulative Assessment of Impact Risk for Management – Gerjan Piet (Wageningen Marine Research)

The SCAIRM (Spatial Cumulative Assessment of Impact Risk for Management) tool was developed as part of the ICES WGCEAM and in collaboration with various EU-funded projects specifically with the aim to inform Ecosystem-based Approaches to Management including MSP. To that end the tool combined the use of spatially explicit information (i.e. maps) as first done by Halpern (2008) together with an extended use of the effect/impact parameters according to ODEMM and the possibility to link this to various management interventions like the BowTie (Piet *et al.*, 2021, 2023).

The tool was first applied in the Greater North Sea but its application is now extended to other marine ecosystems across Europe. Figure A4.7 and Figure A4.8 are primarily intended to show the main threats, Figure A4.9 and A4.10 are more relevant for assessments of future scenarios and/or in combination with MSP.

The linkage framework is explicitly intended to be comprehensive and aligned as much as possible to the MSFD. In order to match the categories (notably of the activities) to entities in the socio-economic system and that resonate with sectoral stakeholders the activities can be further divided into operations. All possible pressures are included. Similar to the activities a hierarchical/nested approach was developed for the receptors where seven ecosystem components can be further subdivided into 29 habitats and an infinite amount of species that is only limited by the availability of data. Without information that allows a distinction between species in terms of their spatial distribution, sensitivity to a pressure or recovery after impact there is no point distinguishing the species. The limitations of current expert-judgement categories have prevented an assessment beyond the level of the ecosystem components. At present the tool distinguishes 13 activities consisting of 115 operations, 30 pressures and 7 ecosystem components. A recent data-driven study in the Greater North Sea shows how one of those ecosystem components, i.e. birds, was subdivided into 15 species.

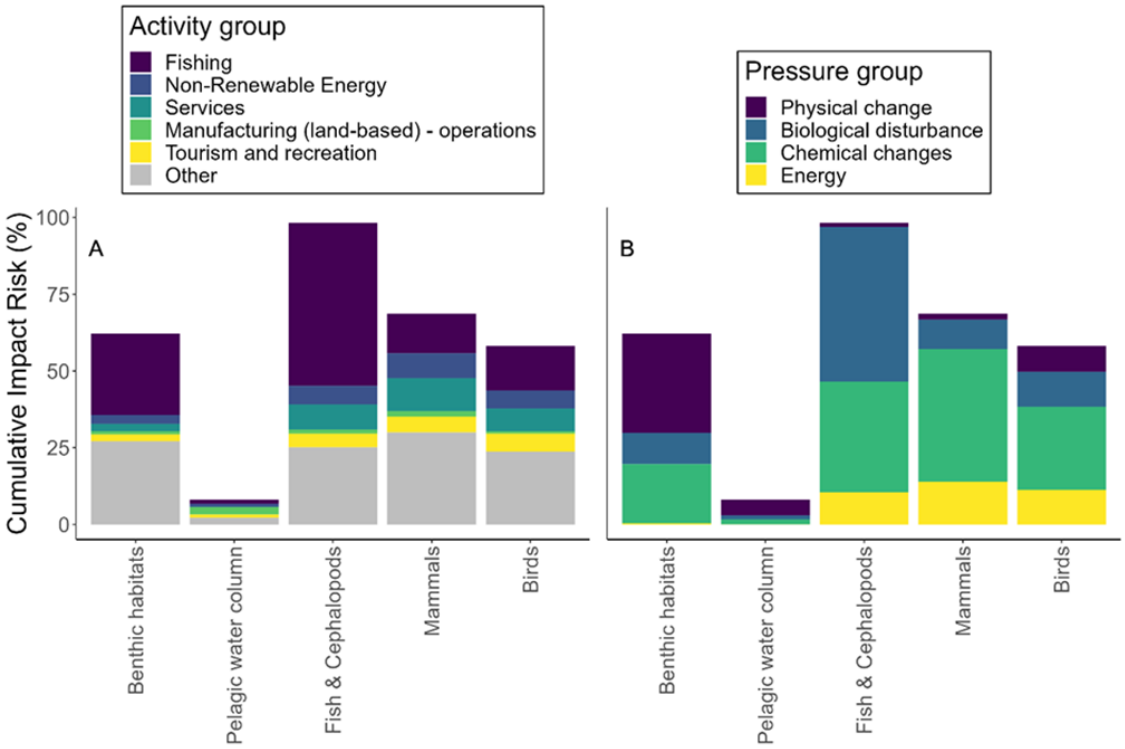

Figure A4.7 The amount of cumulative risk per ecosystem component and the main activities and pressures causing the threat

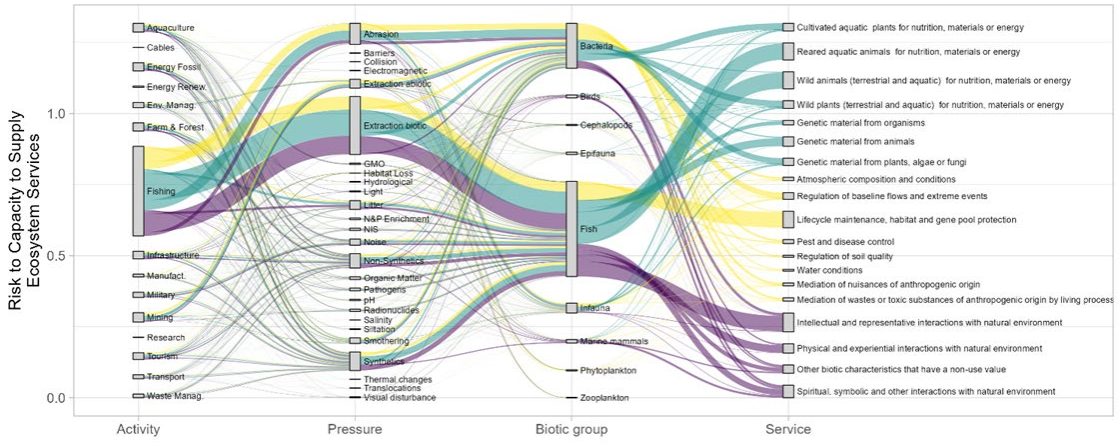

Figure A4.8 Sankey diagram showing the flows of Impact Risk through the linkage framework. Here the linkage framework is expanded to also include ecosystem services (Piet *et al.*, 2024).

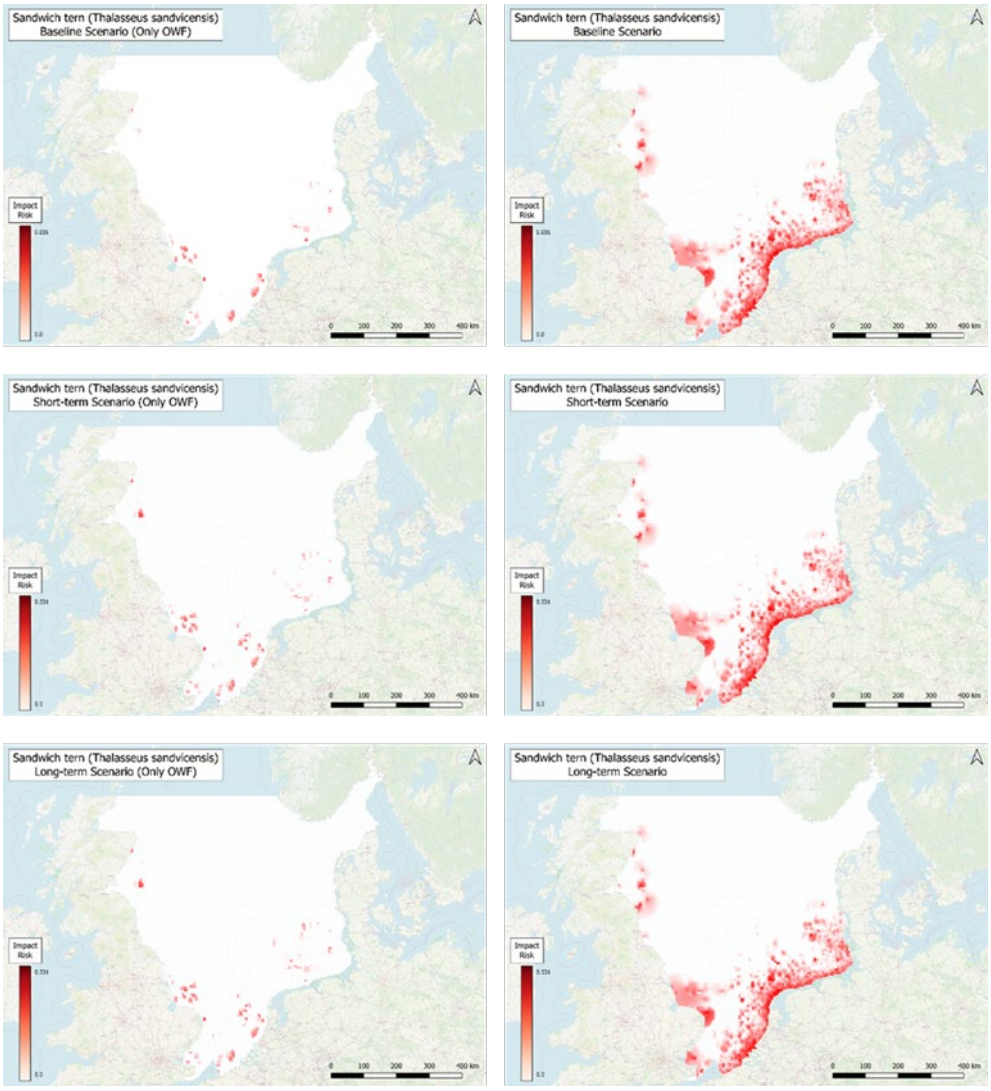

Figure A4.9 Maps showing the spatial distribution of Impact Risk from Offshore Wind Farms only (left) and with all other human activities (right) on Sandwich tern under three scenarios, from top to bottom: Baseline (=present), short term (up to 2030) and long term (after 2030).

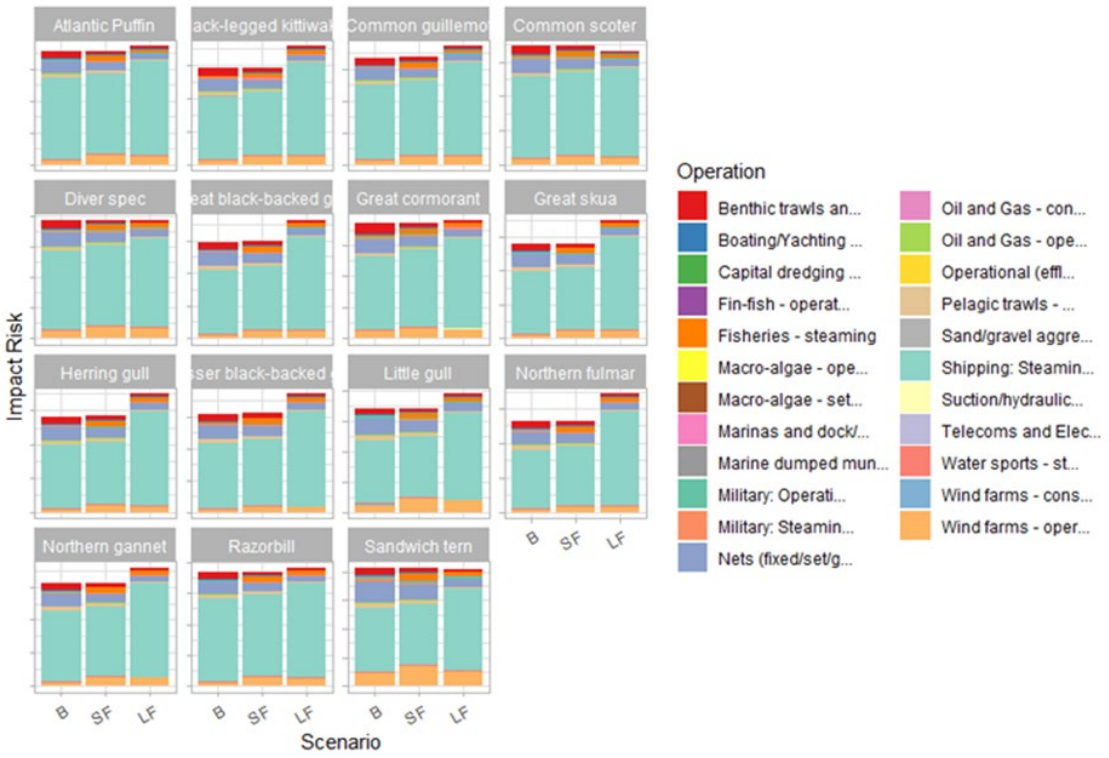

Figure A4.10 Contribution of each human activity to the Impact Risk experienced by each of the selected North Sea bird species under three scenarios, from left to right on the x-axis: Baseline (=present), short term (up to 2030) and long term (after 2030).

The tool was designed for maximum flexibility allowing the use of both expert-judgement and quantitative information, including spatial maps and a piecemeal process of improving the risk-based approach as more information becomes available without compromising the applicability of the tool during this process. A recent cumulative impact assessment only on birds showed that in the Greater North Sea only 29% of the activities-operations (but representing 44% of the Impact Risk) can be covered one-to-one with information readily available in international databases (e.g. EMODnet). Applying good-enough proxies allows the incorporation of another 15% of the activities-operations (but representing 38% of the Impact Risk). Together this makes up 82% of the Impact Risk in one of the most information-dense marine ecosystems which gives a good indication of the gap in coverage of the stressors contributing to risk between the spatial and flexible method-types.

The tool also includes an improved method to estimate Effect Potential now based on five parameters, i.e. Hazard, Frequency, Magnitude, Recovery, Behaviour, with definitions and embedded in a mechanistic approach so that its parameterization is consistent and theoretically grounded. The added benefit of this is that the output of the assessment is a single metric, Impact Risk, that is meaningful and can be readily understood by the recipients of advice. Impact Risk is the potential % change in State relative to an undisturbed situation. Thus 0% represents a pristine situation while 100% implies there is a potential that the ecosystem component will be lost in that marine regions or grid cell.

Strengths:

Linkage framework:

- Comprehensive in that it consists of all manageable activities and any pressure through which any ecosystem component (i.e. biodiversity) may be impacted
- Consist of meaningful categories, recognizable for all relevant stakeholders in the socio-economic system and governance actors

Risk-based approach:

- Applicable both in data-rich and data-limited ecosystems
- Applies the best information available
- Allows a piecemeal improvement process without compromising its operability

Output:

- Impact Risk is interpretable (i.e. decrease compared to undisturbed)
- Can do all applications including MSP (but limited by data availability)

Weaknesses:

- The main weakness is the consequence of the design that resulted in the above strengths: it requires considerable effort before it can be applied in a new marine ecosystem. To some degree this can be circumvented by adapting an existing application from another ecosystem.

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Communicating, visualizing, and promoting Ecosystem Overviews – Celine Byrne (ICES secretariat)

ICES Ecosystem Overviews translate complex marine science into accessible, policy-ready knowledge for regional seas. Communicating this information to of these products scientists, managers, and the public began with pdf documents, interactive diagrams, and news articles on ICES website. Recent communication efforts aimed to improve visibility and accessibility and include the development of infographics (Figure A4.11 and Figure A4.12) to be used on social media and by those scientists explaining the overview. These infographics have increased the audience, including requests to be included in high-school student material.

By combining clear narrative summaries with visual infographics, ICES enhances understanding of human pressures, climate impacts, and ecological status across ecoregions. This approach supports evidence-based management, strengthens stakeholder engagement, and positions the overviews as a core tool for ecosystem-based advice.

At WKEO4, it was discussed how we can further support the communication, visualization, and promotion of the overviews.

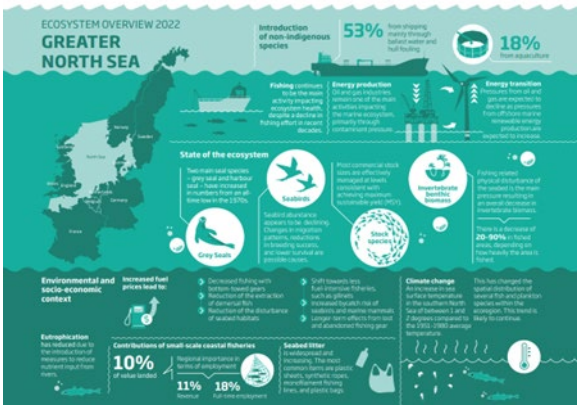

Figure A4.11 Ecosystem overview infographic 2022.

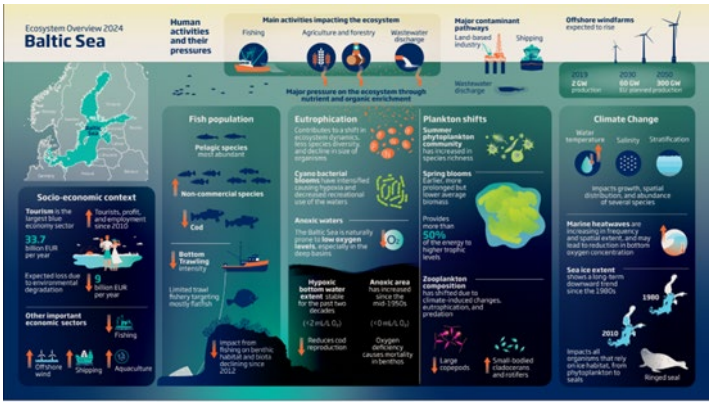

Figure A4.12 Ecosystem overview infographic 2024.

ICES X-plorers: A suite of apps that makes ICES products interactive and accessible – Sarah Louise Millar (ICES Secretariat)

The International Council for the Exploration of the Sea (ICES) has developed the **ICES Xplorers**, a suite of interactive, web-based applications designed to enhance accessibility, transparency, and usability of fisheries assessment data and advice. Built using R's Shiny framework, these tools connect directly via database API's to ICES databases and services, ensuring that the data displayed remain always up-to-date and aligned with FAIR (Findable, Accessible, Interoperable, Reusable) principles. By offering customizable, user-friendly interfaces, the Xplorers serve a wide range of stakeholders, from policymakers to scientists, supporting evidence-based decision-making, ecosystem-based management, and improved public understanding of fisheries science.

Three applications are at the core of this initiative:

- **adviceXplorer**: facilitates access to ICES single-stock fishing opportunity advice and the underlying data, covering advice from 2018 until the present day.
- **fisheriesXplorer**: visualizes fishing activities across ICES ecoregions, integrating products such as Fisheries Overviews, Mixed Fisheries Considerations, and bycatch data.
- **TAFXplorer**: enhances findability and visualization of Transparent Assessment Framework (TAF) outputs, supporting code audit, reproducibility, and integration with the TAF Server and database.

adviceXplorer has been released in 2023 and it still in function; fisheriesXplorer is going to be released at the end of November 2025 and finally, TAFXplorer will be released in Q1 of 2026.

ICES Framework for Ecosystem Informed Science and Advice (FEISA) –Jacob Bentley

Two presentations were given at WKEO4 to summarize the ICES Framework for Ecosystem Informed Science and Advice (FEISA) and develop conversations on its practical alignment with the needs of ICES requesters and society to operationalize FEISA through ICES Ecosystem Overviews. FEISA provides the architecture, flexible approach, and common ground required for iterative and incremental adaptation of ICES science and advisory practice to better inform EBM. A component of FEISA is feedback between science, advice, and societal goals and management objectives. In the conceptual illustration of FEISA, this is included as a small orange box. The presentation widened this box to explore pathways within societal needs and management objectives which link to legislation and management levers (illustration shown in Figure 4.1 of this report). Understanding these links can help support the applied use of ecosystem science within ICES.