

WORKSHOP ON THE DESIGN AND SCOPE OF THE 3rd GENERATION OF ICES ECOSYSTEM OVERVIEWS (WKEO3)

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WORKSHOP ON THE DESIGN AND SCOPE OF THE 3RD GENERATION OF ICES ECOSYSTEM OVERVIEWS (WKEO3)

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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 WKEO3 explored and discussed both stakeholder/client and expert views on the development of the EOs, and assessed new products to be included in shorter or longer terms.

There was general agreement to maintain EOs as brief synthetic products to provide the narrative for each ecoregion and thereby setting the broader ecosystem context for other ICES (and usually more focused) advice products (such as fisheries overviews, fishing opportunities and environmental impact assessments). Also, it was suggested that EOs can highlight the broad expertise of ICES and point to the range of our excellent products to support advice and management.

Based on stakeholder views and suggestions by meeting participants on the importance and maturity of scientific products, the WKEO3 identified 8 high-priority candidate sections to be included into the EOs over the next 1–3 years, that have the potential to meet the requirements related to quality, accessibility, transparency and reproducibility. These topics include i) management objectives, ii) fisheries impact on the seabed, iii) climate predictions and projections, iv) productivity changes, v) mapping vulnerable areas, vi) linking pressures to ecosystem functions and processes, vii) a general overview of ecosystem structure, and viii) food web modelling to quantify links and impacts. An EO pipeline process should be established to secure the development of EOs on the longer term, which should encourage wider engagement, harvesting of new ideas from the expert groups, and provide a more formalized development process and testing ground for new products.

The EOs technical guidance document should include a short introduction that clarifies the current position on a series of questions and debates such as the targeted audience, ICES areas following EEZ and some biogeographical features, and guidance on update cycles. In particular, the use of references in the text may be better integrated if web-based formats are developed.

The technical guidelines for the EO conceptual figure on human activities, regional pressures and ecosystem state components, together with the associated risk assessment framework, need revision to ensure consistency and transparency of assessments. A dedicated workshop was proposed as a high priority action, to review approaches and frameworks assessing and prioritizing among activities, pressures and impacts, and to adapt a simplified set of best guidelines for the EOs.

The workshop supported the move of EOs from PDF formats to web-based products, that provide new opportunities for tailoring product presentations to different audiences. Such development is challenged by limited capacity in the ICES secretariat. To strengthen the science communication of ICES in general, including the EOs, the meeting participants suggested exploring opportunities for establishing an ICES Strategic Initiative on Science Communication.

A record should be kept of where and how EOs are being used by the community including the clients, stakeholders, and the public and communicated to the IEA group as feedback.

ii Expert group information

Expert group name	Workshop on the design and scope of the 3rd generation of ICES Ecosystem Overviews (WKEO3)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair(s)	Mette Skern-Mauritzen, Norway
	Henn Ojaveer, Denmark
Meeting venue(s) and dates	2–4 April 2019, Copenhagen, Denmark 26 participants,

Introduction

ICES sees Ecosystem-based Management (EBM) as the primary way of managing human activities affecting marine ecosystems. The ICES strategic plan highlights the importance of providing evidence for EBM, with the Ecosystem Overviews (EO) being one of the three main advice products to support EBM. The EOs have been developed through a system of consultations with the recipients of ecosystem advice, through a series of scoping and framing workshops.

WKEO3 was organized to develop the 3rd generation EOs and facilitate movement towards providing quantitatively supported products that are broadly informative and useful to regional managers. The Terms of Reference for the workshop were to

- a) define a long term strategy for EOs, and establishing a plan for the main steps and how they should be developed and updated,
- b) identify products to be incorporated on short term perspective and new inputs needed,
- c) liaise with the ICES Data Centre to clarify expectations for data provision for the ICES EOs that conform with the FAIR principles,
- d) update cycles and protocols to develop the conceptual EO figures, and
- e) to assess how the visual presentation of EOs can be improved, and explore options to further develop the presentation of EOs focusing on operational outcomes.

The full terms of reference, meeting agenda and the participants list can be found in Annexes 1–2.

To identify the products to be considered for incorporation into EOs in both the short and long-term perspective, the following process was applied: (1) invitation to the key clients/stakeholders to express their needs and requirements for EOs, (2) workshop participants were invited to provide candidate topics for the 3rd generation EOs, by delivering the requested information according to a template, (3) prioritization of the candidate topics by workshop participants and evaluation of the feasibility for inclusion into EOs against key criteria (partly as outlined by WKECOVER2 (ICES 2018a)). The group also discussed and designed the long-term strategy for EOs, the conditions and requirements for data needs to meet FAIR principles and Transparent Assessment Framework, the arrangement and guidelines for conceptual figure(s), linkages between EOs and Fisheries Overviews (FOs), and finally the visual presentation of EOs.

We thank the ICES Secretariat for their support in planning, arranging and running this workshop.

1 Ecosystem Overview purpose and links with ICES Ecosystem Advice Framework, advisory processes and management objectives

1.1 Clients and stakeholder views on Ecosystem Overviews

To scope for client and stakeholder needs and views on the EOs, representatives from European Commission Directorate-General for Environment (DG-ENV), European Environmental Agency (EEA), OSPAR and HELCOM were invited to attend the first day of the workshop and deliver their views (for the input request, see Annex IV). Only EEA was represented at the meeting in person, while HELCOM and DG-ENV provided input prior to the meeting.

EEA reported that they will by mid-2020 publish a series of environmental assessment reports on European Seas, on topics including nutrient enrichment and eutrophication, contaminants, biodiversity, pressures and impacts, marine protected areas and sustainable use. EEA flagged the usefulness of ICES support on approaches and products that demonstrate cumulative pressures and impacts, climate change impacts, socioeconomics, and links to land-based activities. Also, EEA highlighted the central role of ICES as a provider of quality assured data, also to EEA and their assessments.

Input from HELCOM was received from HELCOM Professional Secretary Jannica Haldin, interviewed by Henn Ojaveer at HELCOM premises before the WKEO3 [Annex V]. HELCOM presented a list of specific products/improvements they see useful to include in the next generation EOs: Increased focus on ecosystem processes and mechanisms, quantification of the links between activities, pressures and states and present information at spatial scales relevant for management actions, including conceptual figures for smaller subregions within ecoregions. Furthermore, HELCOM suggested to include ecosystem services, forward looking perspectives, and a general overview of ecosystem structure in the EOs.

DG-ENV provided some thoughts, informally, to the ICES secretariat (Inigo Martinez) before WKEO3. These thoughts included the questions

- What is required for obtaining Good Environmental Status (GES) in all ecosystem components?
- Are there redundant indicators?
- What are the options for bringing all stocks to GES - what would be the impact on the ecosystem?
- Relationships between the individual components represented by the different indicators and the state of the whole ecosystem
- Are we missing important properties of the ecosystems that are not covered by current approaches?

The EOs were also presented for ICES clients and stakeholders at the Meeting between ICES and Recipients of ICES Advice (MIRIA) and the annual Meeting between ICES, Advisory Councils and other Observers (MIACO). Suggested priorities for further development of the EOs from these meetings include

- Quality Assurance for the different sources of data used in the overviews
- EOs should become a more operational advice product
- EOs should include mixed fisheries considerations

Finally, ACOM chair Mark Dickey-Collas presented examples of use of the EOs by stakeholders. The Marine Stewardship Council use the EOs to assess the importance of fisheries as a pressure in the ecoregions, while the more targeted FOs are now used as information in Council negotiations. These examples illustrate that the use of these products, providing the wider context to the more focused advisory products, are spreading in a relatively unpredictable manner and supports other, more focused ICES advice products such as fishing opportunities, viewpoints and responses to special requests.

1.2 Long term strategy for EOs and plan for the main steps and how they should be developed and updated

The EOs have been developed in consultations with the recipients of advice, and include content that is requested by client commissions. However, the EOs also show ICES' capability in providing advice that is expected to be relevant or useful for client commissions in future, and of interest for the informed public. The EOs are now part of the recurrent advice in the Administrative Agreement signed between the EU and ICES, and a key mechanism for ICES to deliver its advice to support EBM.

A range of IEA EGs and other ACOM and SCICOM EGs have been involved in producing the EOs for the different ecoregions. While the key principles and guidelines for EOs were developed by WKECOVER (ICES 2013a) WKDECOVER (ICES 2013b), the further development of EOs should also follow the guidance of WKECOFRAME2 (ICES 2018a), proposing a framework for ecosystem advice that ensure:

- high scientific quality
- appropriate expertise
- match client expectations
- development and use of tools that are fit for purpose
- working processes that enable an efficient and accurate delivery of product.

The importance of scoping and identifying the audience

The WKEO3 welcomed the different stakeholder perspectives and suggestions to improve the EOs and their role of supporting ICES advisory processes. The more specific suggestions were brought into the discussion of new products to be included in the EOs on shorter and longer term (see Section 2).

Following the discussions about stakeholders and clients, and throughout the meeting, the workshop participants frequently contemplated the purpose and audience of the EOs. Collectively, the group emphasized that this needs to be understood more in order to help guide future revisions of the EO contents. The WK recognized the importance of using EOs to promote conversations with clients and stakeholders for further development of ecosystem advice in ICES. In this respect, the EOs are important as 'shop windows' of excellent scientific products to support advice and management. Yet, the WK repeatedly experienced that planning and prioritizing for short and long-term development of the EOs, without having a better knowledge of who the audience is and how the EOs are used and received, was challenging. This challenge relates to both *how* information is presented in the EOs and what information is presented. For instance, the top five pressures may differ if assessed from a fisheries management or an environmental management point of view. Finally, the WK recognized the importance of identifying synergies between the regional assessment and advisory processes such as HOLAS in the Baltic Sea and EEA assessments in European waters. The role of ICES is not to provide competing assessments, but to be an evidence provider and a quality assurer regarding data, data products, scientific

approaches and scientific products, in addition to provide the wider context for the more focused assessments.

Hence, there is a continuous need for scoping for both short-term and long-term development of EOs, identifying both the relevant audiences and advisory processes, to support efficient knowledge transfer from science to recipients through the EOs. The scoping must be seen in relation with scoping needs for other developments of advice to ecosystem-based management, including e.g., integrated ecosystem assessments. The WKEO3 did not propose a specific strategy for scoping but recognized a need for such a strategy. The strategy should also include (informal or formal) guidance on how to bring information on the uses of EOs, and on stakeholder and client responses to the EOs, back to the ICES community. One option is to have client and stakeholder responses and signals (regarding EOs and other matters) on the agenda annually at the WGCHAIRS, SCICOM and ACOM meetings. Finally, the WK recognized that there is a unique opportunity for defining and presenting more tailor-made products when migrating the EOs into more dynamic representations (see Section 5) to enhance the knowledge transfer from science and advice to a diverse audience (e.g., the general public, schools, students, managers, policy makers). A dynamic, interactive presentation of EOs gives more flexibility in defining and presenting products at varying levels of detail, and at different spatial and temporal scales, although based on the same background information.

Key points for long-term development of EOs

The EOs should be maintained as brief synthetic products to provide the narrative for each ecoregion and thereby serve as the broader context for more focused products such as FOs, fishing opportunities and environmental impact assessments. EOs should be kept as advice products containing information on the key human activities, associated pressures and links to ecosystem state components, in order to maintain the generality of the product and ensuring to reach a wide audience.

Other general points that were raised during discussions on more long-term development were:

- the need to strengthen the coupling between the sea and society, to reflect the new ICES science plan. The EOs should include both impacts on and benefits from human use of the sea, as well as refer to high level management objectives (e.g., UN SDGs, MSFD, Aichi Biodiversity Targets, Norwegian cross sector management plans, Icelandic management objectives).
- the need to strengthen the synthesis across drivers and components in the EOs, currently the presentation is too oriented towards the different ecosystem components.
- further development of the risk assessment framework, including increased transparency and consistency across regions (relevant for the conceptual graph, see Section 5). The comparability across regions provides a significant added value of the EOs.
- to make the EOs more operational, with defined, relevant update cycles for the different sections/products.
- the need to define a process for uptake of new products to the EOs (further elaborated below, in Ecosystem overview pipeline).
- to use the EOs as a shop window of excellent data and science products; with high scientific quality and transparency. This is not only relevant for new products, but also improving products already in the EOs (see Section 4).

Ecosystem Overview pipeline

The inclusion of new products over the next decade depends on both the scientific maturity, data availability and quality of data products, capacity of expertise in the relevant expert groups and

in ICES secretariat, in addition to the relevance to stakeholders. Hence, for the long-term development of the EOs it is more important to establish a thorough process that ensures and motivates a continuous development of the EOs, rather than defining specific sets of products to be included over the coming decade. Such an Ecosystem Overview pipeline should:

- provide a more formalized development and testing ground for processes and products that may ultimately become part of the EOs
- harvest ideas for overviews from the community
- allow science groups space to explore advances that may make a future contribution to EOs, but in a flexible working environment and without the pressure and disappointment linked to a very high bar for immediate inclusion of their material.
- familiarize EGs and researchers with the quality thresholds for inclusion of products into the advisory evidence base.
- encourage engagement of more expert groups in thinking about the contribution of their work to ecosystem overviews in a structured way.
- provide groups with regular feedback, review and steering to guide them towards developing processes and products that would support the EOs.
- convey good practice and awareness of expectations for advice processes/products.
- get more data handling and processing aligned with approaches for fisheries and environmental decision making.

The pipeline should not be overly formalised to be welcoming, encouraging and motivating to engage experts in the process. A suggestion is to run annual workshops to allow scientists at different stages of the product production process to meet and discuss progress, maturity of processes/products and the extent to which they are meeting the relevant criteria. Involvement of ICES Secretariat and ACOM in the pipeline process is crucial, to both ensure capacity for inclusion and advisory relevance of the developing products. The EO pipeline should be presented regularly at WGCHAIRS, encouraging scientists to bring in emerging knowledge and propose new candidate subjects.

Recommendation: Henn Ojaveer and Mette Skern-Mauritzen to prepare a draft document proposing an EO pipeline process, to be presented for SCICOM and ACOM in September 2019.

2 Candidate products to be incorporated in the short term (e.g., next 3 years or next update cycle) that fit with the narrative developed with managers during the scoping for the 2nd generation and new inputs needed.

Workshop participants were provided with an input template (Annex VI) and asked to prepare a written document and a presentation for suggested products. Following the individual presentations, three break-out groups were formed to evaluate the candidate products suggested by clients/stakeholders, WKEO3 participants, and WGCHAIRS 2018 meeting (ICES 2018b) in terms of their potential inclusion into EOs by three different time-frames (1–3, 3–5 and 5–10 years). The break-out groups were asked in their evaluation to follow WKECOVER2 and WKECOFRAME2 guiding principles and also take into account client and stakeholder needs (Section 1.1). Outputs of the three break-out groups were then presented in the plenary, followed by detailed discussions to find a consensus agreement about the final evaluation of all candidate products. Thus, the final evaluation represents the common judgement of WKEO3 participants. Table 1 below briefly summarizes the results of the evaluation. More detailed information is provided in Annex VII, which was asked to be filled in by WKEO3 participants after the meeting.

Table 1. List of candidate products to be considered for inclusion into EOs for three different time-frames. The products were divided into a high priority (bold) and lower priority, but not prioritized within these two categories (hence shown in a random order within category). Detailed information on individual products are presented in Annexes VII and VIII.

Product name	Time-frame		
	1-3 years	3-5 years	5-10 years
Fisheries impact on the seabed	x		
Climate predictions and projections	x		
Management objectives (e.g. MSFD, UN SDGs)	x		
Mapping vulnerable marine areas (CBD, EBSA)	x		
Productivity changes*	x		
Linking pressures to ecosystem functions/processes*	x		
General overview of ecosystem structure*	x	x	
Food web modelling (to quantify impacts)	x		
Ecosystem services*		x	x
Biodiversity**	x		
Land-based activities /pressures*	x		
Cumulative impacts		x	x
Economy (e.g., GDP, main sectors, employment)		x	x
Forward look / future scenarios*		x	
Warning signals of relevance for management		x	
Trade-offs*		x	x
Fishing and shipping ports		x	
Fishing communities		x	
Dependence between ecosystem services, impacts and sector values		x	
Conceptual figures established by sub-regions*		x	
Information on less important pressures*		x	x
Indicators for good ecological status (WGINOR)			x

* added to the list based on feedback from clients/stakeholders

** added to the list during the breakout group discussions

There was also a discussion about where ecosystem impacts of fishing belong in ICES advice products, as some topics are included in FOs, such as bycatch, and others are planned for the EOs, such as benthic impacts. The guidelines need updates and more clarity on the scope of the FOs and EOs that identifies the delineation between these products, and where they intendedly overlap.

3 Expectations for data provision for the EOs that conform with the FAIR principles for the candidate products

ICES is keenly aware that the provision of its scientific advice, and the underlying data that informs this, is framed by the various Directives and Conventions in which the requestors of advice operate. This means that the candidate products of the EOs need to meet a set of requirements related to quality, accessibility, transparency and reproducibility that fulfil the expectations from the advice requestors and the Directives that they adhere to. Ultimately, all advisory products will be described within a quality management framework, one aspect of this is data management.

ICES has produced a user handbook for the data management life cycle (ICES 2019), which in a very simple and broad way attempts to explain the main aspects to consider when producing scientific products. Briefly this outlines considerations on:

- Data Acquisition: documentation of methods of collection and processing, using recognized standards and nomenclature
- Data Roles: clear understanding of ownership of data and any resulting outputs, understanding of legal frameworks etc.,
- Request and Delivery: Agreed standards and format, timetable for process, provision of meta-data to aid usability and discovery
- Data Quality: Consistency, accuracy, uniqueness etc.

For each of the candidate EO products, these points should be taken into consideration to understand how mature the product is in relation to the expectation of the advice clients. It is important to note that each product may not fully answer to all of these aspects in the first iteration, but may still be relevant for the EOs if they still represent a high quality, relevant product.

Many of the data aspects are already enacted via FAIR principles (see www.force11.org/group/fairgroup/fairprinciples) for existing and established ICES data products and outputs related to scientific advice; **Findable** – data described through metadata published in ISO standards; **Accessible** – data published with a clear usage licence; **Interoperable** – using standards and web services; **Reusable** – documented quality and information on limitations of use. For good measure, **Reproducible** – is also seen as a desired attribute, that the entire product including data and method can be extracted and re-run with new data/settings by an independent user/scientist (see Transparent Assessment Framework (TAF; <http://ices.dk/marine-data/tools/Pages/transparent-assessment-framework.aspx>). Likewise, for the EO products ICES should aim follow these principles.

The workshop recognizes that following FAIR and TAF is an iterative, demanding process, and takes an investment of effort to achieve. However, the experience is that such processes have led to more rigorous, robust and better-quality products.

4 Upgrade of general figures, protocols to develop the conceptual EO figures and update cycles

The general guidelines should include a list of common figures and graphs to be included when possible. In some cases, guidelines on how to develop these figures and which EG have the expertise to do it should be included (e.g. WGITMO and the invasive species graph).

General figures: food-web diagram and fisheries graphs

The meeting discussed the audience of the EOs and how that would help guide the complexity of the figures that should be included in this advice. There was a general consensus (bearing also in mind feedback obtained from clients/stakeholders; see Table 1 above) that a (potentially simplified) diagram of the food web structure with its key components should be included in the EOs with a purpose to offer an easily accessible understandable introduction to the ecoregion ecosystem, following the regional map but before the current conceptual graph (Figure 3 in all EOs). There was also discussion on how simplistic and illustrative this figure should be, and the group concluded that some level complexity was desirable. Whenever possible, all introductory material in the EOs should be brief and summative and direct readers to references for additional background information. Some comments on the food web structure diagram were to: (1) use icons for ecological groups that could then be used throughout the ecosystem overview sections and also provide continuity across the regional EOs, (2) use line strength to identify the strengths of the trophic connections, and (3) consider whether the figure could also incorporate some advice relevant information up front.

The meeting also discussed the fisheries graphs in the EOs (by using the most recent Baltic Sea EO as an example) and concluded that it would be helpful to have 3 figures in the EOs:

1. Figure on nominal fishing effort separated by gear type (i.e., to keep the figure unchanged);
2. Figure on temporal dynamics of landings (or catches if discards are available) preferentially by ecological groups (similar to Figure 4 from the Celtic Seas FO https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/CelticSeasEcoregion_FisheriesOverviews.pdf);
3. Figure on stock status – these figures should include information of stocks with status as good, bad and not assessed by ICES (data limited stock in grey in the example of Figure 1 below).

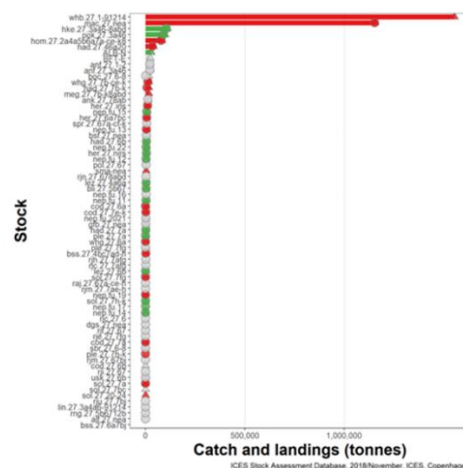


Figure 1. Catch (triangles) and landings (circles) of all assessed stocks at GES (green), non-GES (red) or unknown (grey) on an ICES ecoregion.

When a regional FO is available, EOs should refer to this document and avoid overlap (unless needed). In ecoregions without published FO, the document can expand with some extra graphs on the stock status.

Figure of human activities – pressures - ecosystem state

The conceptual graph linking the major regional pressures, human activities and ecosystem state components should remain as a core product of the EOs. While the general EO guidelines are useful and working well, the meeting agreed on the need for revising the guidelines for producing the graphs, to improve the quality, transparency and comparability of the decisions made when assessing and ranking the impacts. Since the guidelines were developed by WKDECOVER (ICES 2013b), there has been substantial development and experience gained in qualitative (e.g., ODEMM, Mental Modeler, Carstensen *et al.* 2016, DePiper *et al.* 2017, Holsman *et al.* 2017, Pedreshi *et al.* 2019), semiquantitative (e.g., Qualitative Network Models, Bayesian Network Models, Harvey *et al.* 2016, Carstensen *et al.* 2016) and quantitative approaches (statistical and numerical models, e.g., Holsman *et al.* 2017, Planque and Arneberg 2017, Solvang *et al.* 2019) to assess impacts and states, in both ICES EGs (e.g., IEA EGs, WGECO, WGIPEM, WKINTRA, WKINTRA2) and the wider scientific community. These approaches increasingly focus on both transparency and uncertainties (qualitative or quantitative), which are also being more clearly communicated through other integrated assessments, such as HOLASII (HELCOM 2018) and IPCC (Mach and Field 2017).

Recommendation: As the workshop did not have the capacity to review the relevant approaches and frameworks to reformulate the guidelines, a dedicated workshop addressing guidelines for the conceptual figure and hence the risk assessment framework was proposed as a high priority action. Key focus of the proposed WK should be to:

- review guidelines used in relevant approaches and frameworks for assessing and prioritizing among drivers, stressors and impacts.
- adapt a simplified set of best guidelines to EOs, that ensure
 - transparent assessments
 - communication of uncertainties
 - allow for different approaches being used in different ecoregions; adapted to data availability and EG skills and capacity

Update cycles

Regarding update cycles, it was recognized that the IEA EGs propose to update the conceptual graph once during the 3-years management cycle, which appeared to be a suitable update frequency for the participants of WKEO3. These updates should include a revision of the text included in the region. Annual updates of semi-automatic quantitative products (graphs) and other relevant advice produced (e.g. VME, VMS, etc.) should be produced the end of every year and presented during the corresponding ADG.

5 Improving visual presentation of EOs, options for securing capacity of technical staff to further develop the presentation of EOs focusing on operational outcomes.

ICES needs to improve the visualization of products and advice that will improve outreach to different audiences and increase transparency and traceability of data.

The EOs have the potential for wider outreach and the use of new technologies will allow addressing multiple objectives and audiences. Currently, the user needs several clicks to arrive to the EOs on the ICES website. In addition, there are currently two versions of the EOs on the ICES website: the pdf version and the first attempt on an online interactive version, that are identical in content as approved by ACOM. The interactive version (for example, see Figure 2) has the ability to convey or highlight multiple information at the same time and offers the user several options on a navigation panel. However, the current version lacks the ability to host the data behind the figures and any modifications are made *ad hoc* which makes the yearly updates cumbersome.

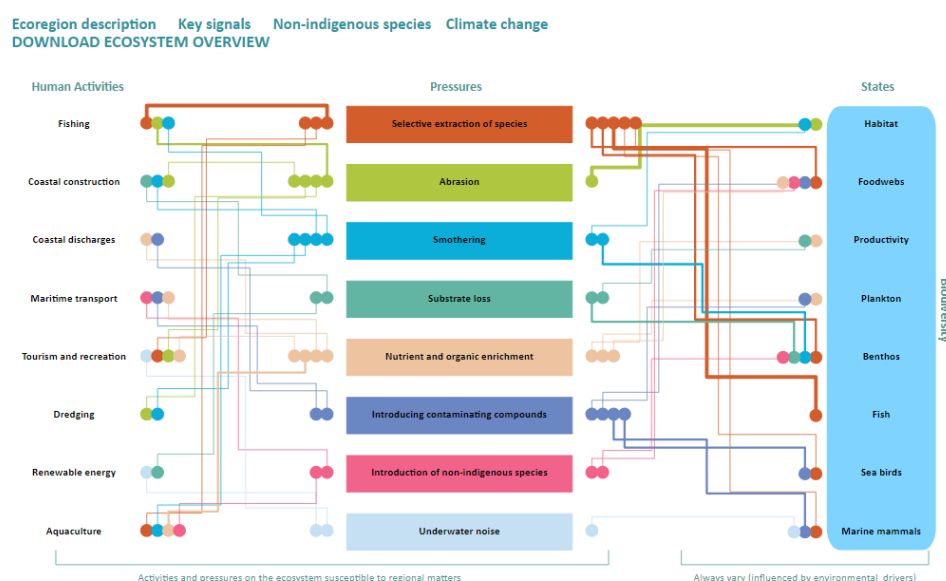


Figure 2. Conceptual figure of the Bay of Biscay and the Iberian Coast ecoregion linking the key pressures to human activities and states of ecosystem components (<http://www.ices.dk/explore-us/Action%20Areas/ESD/Pages/Bay-of-Biscay-and-the-Iberian-Coast-Ecosystem-overview.aspx?diagramid=7>).

There is a goal to move towards new online visualization tools. These will allow for the EO products to be fully linked to underlying data and with graphic representations being tailored for different audiences. This change in the presentation of advice will have cascading repercussions on the way we operate currently, where there is no clear data flow and quality assurance during the process, and the EOs can only show final results or figures (with some exceptions).

Some examples were presented where ICES is developing a web-based visualization of advisory products (e.g., ICES 2018c, Figure 3).

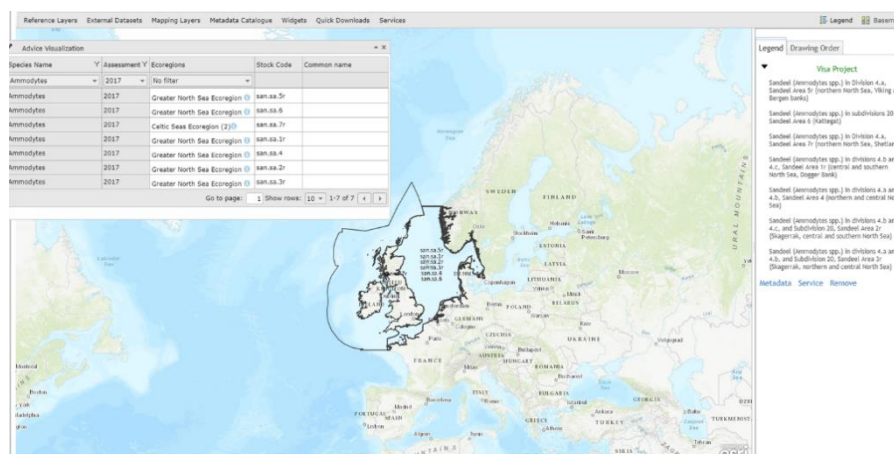


Figure 3. Example of web-based visualization of ICES advisory product with interactive GIS interface showing ICES areas, stocks within the areas and links to the single species advice with choice of year, stock, etc. (<http://gis.ices.dk/sf/index.html?widget=visa>).

The workshop discussed and advanced some ideas for future visualization of the EOs, but agreed that a more focused discussion on the future visualization is needed. The ideas from the workshop included:

- A catchy launch page based on a geographical display
- Need to define the target audience/s for the EOs: who do we want to reach?
- Products fit for different audiences (if these are clearly defined)
- There should be linked supporting documents that outline the methods employed in the EOs (e.g. links to the WG reports in the text, not just a list at the end)
- Numbered references could be used which keep the text relatively free of clutter.
- Need tools to evaluate the use and impact of the EOs
- Think on accessibility to user with disabilities (e.g. dyslexia, colour-blind, text size tools).

Further examples were discussed (e.g. ESRI storymaps – a tool that combines maps with text, images and multimedia content to engage and inspire audiences – see for example the aquaculture research map: <http://noaa.maps.arcgis.com/apps/Shortlist/index.html?appid=7b4af1ef0efb425ba35d6f2c8595600f>) and it was recognized that although desirable, they would need a level of external expertise that would need specific project funding not currently available.

A move from traditional pdf format to online interactive interfaces requires a) expertise to develop the code and products and b) maintenance, both with associated costs. As ICES is moving towards online advice, some of the development associated with the structure of the workflow can be done by the secretariat's Data Center, and with the work of expert groups (e.g. Fisheries impact on the seabed – see Annex VIII, or FOs outputs). Thus, before the EO products are fully automatized, the development and maintenance will rely on the work of a number of expert groups.

Recognizing the limited resources and capacity in ICES secretariat to further develop the EOs, the workshop discussed opportunities for strengthening the support. It was suggested to explore opportunities for collaboration between ICES and relevant institutes, and to establish an ICES Strategic Initiative (SI) on Science Communication, acknowledging the high (and increasing) importance of science communication in general. One of the routine activities of this SI could also

include annual networking meetings with partner institutes communications departments at ASC's – a practice that has been in place since 2015 and is administered via the Secretariat Communications department.

Recommendation: To establish a Strategic Initiative on Science Communication, for improved communication of scientific evidence to clients, stakeholders and the wider community, to speed up the conversations on advice to support EBM. One of the tasks should be helping to create, maintain and further develop attractive EO visual products to better meet the variety of needs by different target audiences.

6 Responsibilities and securing development and maintenance of EOs

While the responsibility for the development, content and maintenance should lay on the ICES community at large, the regional IEA EGs function as leads to both deliver the underlying knowledge for the EOs and for updating the EOs on a regular basis. In addition, several other EGs under other Steering Groups than IEASG contribute to several EOs, and have also proposed new products (Table 1). However, for regions where there is no IEA EG, the production and delivery of EOs is based on critical assistance from the Secretariat and individual experts (e.g., the Azores, Icelandic Waters, Oceanic Northeast Atlantic). Therefore, one of the near-future tasks should be to operationalize the EO process and agree on the leadership for these ecoregions (e.g. identifying coordinators from the institutes on the responsible Member States).

There is a need to communicate that experts in EGs responsible for delivering products to EOs would require adequate national support at home institutions, for attending the annual EG meetings and for preparing input.

7 Conclusions and further steps

1. For the shorter-term development of the EOs, a list of prioritized products has been produced by the WK, based on the WK views on maturity of science, relevance to stakeholders, and capacity in EGs.
2. For longer term development, the WK propose a 'pipeline process', which should be used to encourage and foster science input and development of new or improved products to the EOs. A draft 'pipeline process' document will be prepared jointly by Mette Skern-Mauritzen and Henn Ojaveer for discussions in ACOM and SCICOM in 2019 September meetings.
3. A dedicated workshop addressing guidelines for the conceptual figure and the risk assessment framework with the following major tasks: i) to review guidelines used in relevant approaches and frameworks for assessing and prioritizing among drivers, stressors and impacts, and ii) to adapt a simplified set of best guidelines to EOs, that ensure transparency in assessments, communication of uncertainties and allowing different approaches being used in different regions; adapted to data availability and EG skills and capacity
4. Arrange annual workshops in the EOs 'pipeline process'. This should include, amongst others, discussing both already advanced products as well as harvesting for new product ideas, discuss issues related to meeting requirements of FAIR data principles and the transparent assessment framework etc. Representative(s) from ICES Secretariat and ACOM leadership should attend these meetings.
5. Establish a Strategic Initiative on 'Science Communication', recognizing the need for increased capacity in science communication, including the further development of the EOs.
6. Operationalize the EO process and agree on the leadership for those ecoregions where there is no IEA EG at present. Currently, the production and delivery of EOs for those ecoregions is based on critical assistance from the ICES Secretariat and individual experts.

8 References

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Annex 1: List of participants

Participant	Institute	Country of Institute	Email
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Annex 2: Resolutions

2018/2/ACOM XX WKEO3 - Workshop on the design and scope of the 3rd generation of ICES Ecosystem Overviews chaired by Mette Skern Mauritzen, Norway, and Henn Ojaveer, Estonia, will be established and will meet in Copenhagen, Denmark, 2–4 April 2019 to:

- i) Define a long term strategy (e.g., 10 years) for Ecosystem Overviews (EOs) by focusing on purpose and links with ICES Ecosystem Advice framework and other advisory processes (e.g., OSPAR, HELCOM) and management objectives. Establish a plan for the main steps and how they should be developed and updated.
- ii) Based on gap analyses from current EOs and WGCHAIRS 2018 group discussions; Identify products to be incorporated on short term (e.g., next 3 years or next update cycle) that fit with the narrative developed with managers during the scoping for the 2nd generation and new inputs needed. Identify relevant Expert Groups responsible for these products (review the experience of Climate Change issues through SICMME).
- iii) Liaise with the ICES Data Centre to clarify expectations for data provision for the ICES EOs that conform with the FAIR principles for the products highlighted in ToR ii.
- iv) Update cycles and protocols to develop the conceptual EO figures. Modify ICES technical guidelines accordingly.
- v) Assess how the visual presentation of EOs at ICES.dk can be improved, and explore options to secure capacity of technical staff to further develop the presentation of EOs focusing on operational outcomes.

WKECO3 will report by 19th of April 2019 for the attention of the ACOM/SCICOM Committee.

Supporting information

Priority	High priority, the EOs are part of the recurrent advice in the Administrative Agreement (AA) signed between the EU and ICES and key mechanism for ICES to deliver its advice on ecosystem based management EBM.
Scientific justification	The EOs explicitly summarize the ecosystem effects of fisheries and other human activities of relevance in different ecoregions providing updated trends on pressures and state of the ecosystem and integrating climate change effects in the document.
Resource requirements	The national research programmes and ICES WG which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The WK will be attended by experts covering the areas of knowledge related to the ToRs, with a wide range of area coverage and with a room limit of 22 participants .
Secretariat facilities	ICES HQ room facilities and participation form Data Centre, Communications and Science/Advice.
Financial	No financial implications.
Linkages to advisory committees	Direct link to ACOM/SCICOM
Linkages to other committees or groups	WGINOSE, WGINOR, MFRI, WGIBAR, WGEAWESS, WGIAB, WGITMO, WGMME, WGZE, WGSAM, BEWG, JWGBIRD, WKSICCME-CVA, WGSFI
Linkages to other organizations	Links to OSPAR, HELCOM, NEAFC, PICES, etc.

Meeting agenda

Workshop on the design and scope of the 3rd generation of ICES Ecosystem Overviews

Chairs: Mette Skern-Mauritzen, Norway and Henn Ojaveer, ICES

ICES HQ, 2–4 April 2019

Tuesday 2 April

- | | |
|-------|---|
| 09:00 | Welcome (Eirini). |
| | Opening the workshop, adoption of the agenda and tour de table and goals (Chairs). |
| 09:15 | Introduction to Ecosystem Overviews and the process (incl. WKECOVER, WKECOFRAME2, EBM, current content of EOs, EO production process, ICES advisory process) (Iñigo and Henn) |
| 09:30 | Clients and stakeholder session: short and long-term needs |
| 11:00 | <i>Coffee break</i> |
| 11:30 | Clients and stakeholder session continues. |
| 13:00 | <i>Lunch</i> |
| 14:00 | Candidate products session: to be incorporated to EOs on short term |
| | <ul style="list-style-type: none">• Maciej Tomczak• Per Arneberg• Scott Large |
| 15:30 | <i>Coffee break</i> |
| 16:30 | Candidate products session continues (including WebEx contributions) |
| | <ul style="list-style-type: none">• Amber Himes-Cornell |
| 17:00 | Plenary |
| 18:00 | Reception |

Wednesday 3 April

- | | |
|-------|---|
| 09:00 | Candidate products session continues |
| | <ul style="list-style-type: none">• Sebastian Valanko• Andrea Belgrano• Maurice Clarke• Jörn Schmidt |
| 10:30 | <i>Coffee break</i> |
| 11:00 | HELCOM and Pan Baltic Scope work on cumulative impacts assessment in the Baltic Sea (Lena Bergström) |
| 11:30 | Guiding principles for Data provision to Candidate Products (ICES Data Centre) |

12:00	Breakout session 1: Further advance the proposed candidate products
13:00	<i>Lunch</i>
14:00	Continue breakout session 1
14:30	Plenary session: reporting from breakout session 1; designing short-term and long-term priorities for EOs
15:15	Cycles and protocols for conceptual figures (Iñigo)
15:30	<i>Coffee break</i>
15:45	Breakout session 2: Discuss the structure of the EOs and development of conceptual EO figures
17:15	Plenary session: reporting from breakout session 2
18:00	End of the day

Thursday 4 April

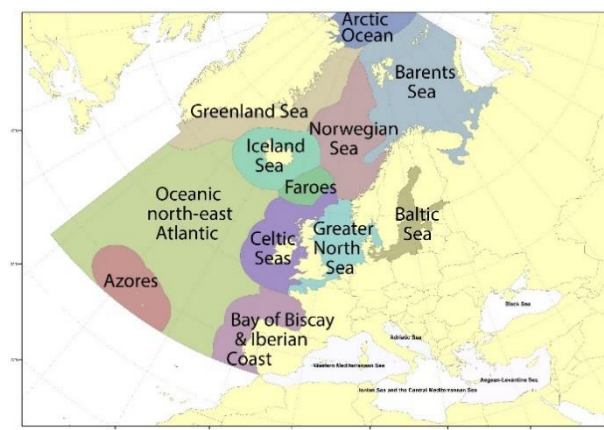
09:00	Finalising short-term and long-term priorities/strategies for EOs, establishing plan and main steps for further development and updates
11:00	<i>Coffee break</i>
11:30	Update cycles, Visualization and formats. (Iñigo and Terhi).
13:00	<i>Lunch</i>
14:00	Gaps and mismatches between clients' needs and contributions to the workshop.
14:30	Next steps (priorities and roadmap)
15:00	Wrap up and closing

Annex 3: Guidance for providing contribution from invited clients

Workshop on the design and scope of the 3rd generation ICES Ecosystem Overviews

The Ecosystem Overviews are intended to promote progress towards the delivery of integrated advice by ICES; where integration refers to

- the effects of multiple human pressures on the environment when developing management advice,
- the effects of the most influential environmental and ecosystem processes on advice, and
- considering multiple objectives.



ICES Ecoregions relevant for ecosystem overviews

The Ecosystem Overviews are produced to serve two purposes:

- alert ICES expert groups to key situations within the environment and ecosystems that are expected to significantly influence their advice
- provide advice requested by, and expected relevant to, client commissions

We invite clients and stakeholders to present their views how Ecosystem Overviews can be further developed to meet the current and emerging marine management needs

- on the short-term perspective – 1-3 years
- on the longer-term perspective – 10 years

The following questions may aid your preparations for the meeting:

- What are the relevant (and/or new) management objectives/issues for which advice is required (e.g., marine restoration, cumulative impacts, cultural values)?
- Which specific information/advice/scientific products are missing in the current EO's?
- Would you like to see the EOs structured otherwise than currently?
- How would you like to see the EOs presented and communicated (incl. main message, figures/graphics, EO format etc.)?

You are also invited to give a 10-minute presentation on these issues on the workshop.

Annex 4: HELCOM contribution

As HELCOM produces its own in-depth status assessments and directly works with most of the topics highlighted in the EOs the needs of HELCOM, and the below comments, are more related to potential future cooperation on overlapping topics (in the effort to avoid duplication of effort), and to the structure and content of EOs in general.

What are the relevant (and/or new) management objectives/issues for which advice is required (e.g., marine restoration, cumulative impacts, cultural values)?

1. Management objectives are stated in the HELCOM Baltic Sea Action Plan and in the HELCOM recommendations. The main pillars of the BSAP are biodiversity, eutrophication, hazardous substances and shipping, all are having multiple management objectives/targets. The state of the Baltic Sea ecosystem is assessed in two reports (HOLAS I in 2010 and HOLAS II in 2018).
2. The Baltic Sea Action plan is currently being updated, with the first step in the process being to identify baselines in the absence of measures, followed by identifying business as usual scenarios and distance to target, with the intention to support identifying appropriate measures to reach said targets. This analysis is being done for components under each of the pillars.
3. Regarding the proposed new topics: HELCOM has existing groups dealing with Economic and Social Analysis, Aquaculture, Shipping etc. Renewable energy is dealt with mostly from an MSP perspective.
4. Cumulative impacts assessment have been included both in HOLAS I and HOLAS II. Significant improvements have been made for the final version available in the 2018 State of the Baltic Sea report (an interactive version is available online in the HELCOM Map and Data services) though the need for further development and advancement is needed, especially regarding dataflows. A further development is underway in the PanBaltic Scope project.
5. Ecosystem services are included in HOLAS II, but need further attention and development. One option is to create a separate figure in EOs with explicit link to Fig. 3 (ecosystem state section). Thereby we can evaluate the effect of human activities to goods and services.

Which specific information/advice/scientific products are missing in the current EO's?

1. The ecosystem perspective. Currently the overviews focus on different, disparate, parts of the ecosystem (with a substantial amount of the information relating to anthropogenic activities and resulting pressures). Although this is valuable information on its own, the link to the ecosystem as a whole is missing (e.g. process thinking).
2. From a management perspective it is important to provide quantifiable links between human activities and pressures, and between pressures and state, to be able, in turn, to link activities to state and design measures (which is the ultimate objective). Especially pressing in this regard is to be able to quantify the link between pressures and ecosystem state. In HELCOM, relevant activities are ongoing under the ACTION and BSAP UP projects to provide such links. These can be shared with ICES once results are available.
3. Overall EO's should provide information at spatial, and temporal, scales relevant for management actions (this depends on the nature and scale of the main pressures) while at the same time being ecologically relevant.

4. Ecosystem processes/functions information is missing (linked to Fig. 3?). This means that there is currently also a lack of the effect of pressures on ecosystem functions and possible responses.
5. A section with a more forward-looking perspective (what can be expected/forecasting) would be useful.
6. From a management perspective (and with the gradients in the Baltic) it could be useful to have Fig. 3 (or some appropriate parts of it) by meaningful spatial subunits (regional ecosystems).
- 7.

Would you like to see the EOs structured otherwise than currently?

1. Focus on that these are ecosystem overviews. Currently, EOs lack generic overview of the actual ecosystem. This should be presented right at the beginning, and include generic description of biota (for example, see HELCOM HOLAS Fig. 5.0.2), abiota and where possible the link between these. If possible these figures should have the same basic format between regions, to make comparison and overview easier.
2. Also, appropriate sub-units (areas, systems etc.) should be identified and shown on the map.

How would you like to see the EOs presented and communicated (incl. main message, figures/graphics, EO format etc.)?

1. Define the audience, for whom is this made, for what use and why? This helps the reader interpret the information and clarifies the scope of the content.
2. Move to an interactive format where possible.
3. Appropriate facts and statements in the text should be referenced. Reference list at the end of the document is insufficient as they cannot be linked to the information in the document, making it very difficult to find supporting information for the statements.
4. Overall EO's should be presented at spatial, and temporal, scales relevant for management actions while at the same time being ecologically relevant. Using an interactive approach several levels can be made available at the same time.

Annex 5: Guidance for contribution from workshop participants

Guidelines for contributions to the Workshop on the design and scope of the 3rd generation ICES Ecosystem Overviews

The bullets below briefly summarise the main considerations to be taken into account when proposing candidate products to be included into the next generation ICES Ecosystem Overviews.

1. The proposed product should support the role of Ecosystem Overviews as previously outlined by WKECOVER (<http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2013/WKECOVER/WKECOVER%202013%20report.pdf>).
2. The proposed product should be of interest of a ICES client commission(s) and/or stakeholder(s).
3. Please be pragmatic and realistic from your Expert Group perspective, i.e. availability of experts with the required skills, and resources (incl. time) for providing and analysing data, and delivering text/contributions.
4. The feasibility of delivering the product for all ICES ecoregions (see Figure below).



5. The possibilities of delivering the product in a short-term perspective (in max. 3 years).
 6. Data availability and quality assurance, following FAIR data principles (Findable, Accessible, Interoperable, Re-usable).
 7. Please suggest a meaningful update frequency for updating the section after first inclusion.
 8. The maturity of science underlying the product, including reproducibility and transparency.
- ✓ Please provide text on each of these bullet points and example figure (can be also schematic or conceptual figure) of your candidate product by the start of the Workshop. The text will be included in the ICES WKEO3 report.
 - ✓ Please be prepared to give a 10 minute presentation at the meeting addressing the guidance points above.

Annex 6: The detailed information for the candidate products to be considered for inclusion into EOs

Group	Product name	1–3 years	3–5 years	5–10 years	Maturity of science (HIGH/ MEDIUM/ LOW)	Data availability	Relevant for most or all ecoregions?	Doable for most or all ecoregions?	Relevant to clients	High-level manage- ment objectives tar- geted	Suggested up- date fre- quency	Relevant ICES EG (name)
I	Fisheries im- pact on the seabed	x			High	Medium	yes	yes	high	The MSFD sets the broad requirement under Descriptor 6 that sea-floor integrity is at a level that ensures that the structure and functions of the eco-systems are safe-guarded and benthic ecosystems, in particu-lar, are not adversely affected (Directive 2008/56/EU), and the indicators will serve this purpose.	1 or every 3 years	WGFBIT
	Climate change projec- tions/predic- tions	x			High	Data is publically available and anal- yses can be made reproducible	Yes, although Baltic is trick- ier due to its small size	Yes	unclear		Depends on timescales: Seasonal fore- casts are up- dated monthly, De- cadal annu- ally, climate projections ~ 7 years	WGS2D, WGOH, WGOOFE

Group	Product name	1–3 years	3–5 years	5–10 years	Maturity of science (HIGH/ MEDIUM/ LOW)	Data availability	Relevant for most or all ecoregions?	Doable for most or all ecoregions?	Relevant to clients	High-level manage- ment objectives tar- geted	Suggested up- date fre- quency	Relevant ICES EG (name)
	Management objectives (e.g. MSFD, UN SDGs)	x			Medium	Yes, data is qualitative in legal texts	all	all	yes	these are the objectives	as soon as new legislative texts are published	WGBESIO and all IEA groups
	Mapping vulnerable marine areas (CBD, EBSA)	x	x	x	Medium	For some eco-regions, but QC lacking in general	all	all	yes	UN CBD	5-10 years	WGMHM, WGDEC, Regional Ecosystem Groups
	Productivity changes	x			High	With reference to Stock Assessment WGs for stocks productivity; with reference to OSPAR and HELCOM Assessments	All ecoregions	Yes	Yes	Not sure - possibly Stocks at GES; and MSFD	1-3 years	Stock Assessments WGs, WGIPEM, PGDATA, WGCERP, WGEAWESS, WGGOOFE
	Pressures link to ecosystem functions/processes	x			High/Medium	Yes*	Yes	Limited	Yes	Yes	multiannual (2-3 yrs)	IEA EGs; WGECO, WGSAM

Group	Product name	1–3 years	3–5 years	5–10 years	Maturity of science (HIGH/MEDIUM/LOW)	Data availability	Relevant for most or all ecoregions?	Doable for most or all ecoregions?	Relevant to clients	High-level management objectives targeted	Suggested update frequency	Relevant ICES EG (name)
	Generic overview on ecosystem structure	x	x		High	Available with reference to OSPAR and HELCOM Assessments	All ecoregions	Yes	Yes	Not sure	3 years	WGSAM, WGIPEM, IEAs WGs, WGMARS, WGECO, WGCERP, WGEAWESS, WGNARS
	Food web modeling (to quantify impacts)	x	x		High/Medium	Yes**	Yes	Limited	yes	Yes	multiannual (2-3 yrs)	IEA EGs; WGSAM
	Ecosystem services	x	x		High/Medium	Qualitative information available - Quantitative information see HELCOM example, need further time to find out what products are available, e.g EU level	All ecoregions	Partly	Yes	Not sure	3 years	WGRMES, SIHD, IEAs WGs, WGIMM, WGMARS, WGSOCIAL, WGEIA
II	Land-based activities /pressures	x			Medium	Medium	yes	yes	medium	mostly on contamination	as the whole EO	Regional IEA or leaders

Group	Product name	1–3 years	3–5 years	5–10 years	Maturity of science (HIGH/MEDIUM/LOW)	Data availability	Relevant for most or all ecoregions?	Doable for most or all ecoregions?	Relevant to clients	High-level management objectives targeted	Suggested update frequency	Relevant ICES EG (name)
	Cumulative impacts	(x)	x	x	Medium	For some ecoregions	all	all, but approaches may need to differ depending on (spatial) data availability	yes	SDGs MSFD, MSPD, CFP, Habitat directive, bird directive	3-5 years	WKCEAM?, WGFBIT
	Economy (e.g., GDP, main sectors, employment)		x	x	Medium	Some for some ecoregions	all	all	yes	CFP, MSFD, Habitat directive, bird directive, SDGs	some can be updated automatically every year, others maybe every 3 years	WGECON
	Forward look / future scenarios		x		Low	Some for some ecoregions (e.g. Baltic)	all	all	yes	CFP, MSFD, Habitat directive, bird directive, SDGs	3-5 years	WKPESTLE
	Warning signals of relevance for management		x		?	?	?	?	?		?	?
	Trade offs		x	x	Medium	Some for some ecoregions (e.g. Baltic)	all	all	yes	CFP, MSFD, Habitat directive, bird directive, SDGs	3-5 years	
	Infrastructure (fishing ports, shipping ports)		x		?	?	?	?	?		?	?

Group	Product name	1–3 years	3–5 years	5–10 years	Maturity of science (HIGH/ MEDIUM/ LOW)	Data availability	Relevant for most or all ecoregions?	Doable for most or all ecoregions?	Relevant to clients	High-level manage- ment objectives tar- geted	Suggested up- date fre- quency	Relevant ICES EG (name)
	Fishing com- munities		x		?	?	?	?	?		?	?
	Dependence btw. ecosys- tem services, impacts and sector values		x	(x)	Low	For some sectors. Generally not avail- able on the level of ecoregions but un- der development e.g. in Baltic Sea (HELCOM)	all	all	yes	SDGs ,CFP, MSFD, Habi- tat directive, bird di- rective	3-5 years	WGCERP and all IEA groups, connections to additional groups may be needed
	Conceptual fig- ures by sub-re- gions		x		High	Low	only in some regions	not enough information for all sub- areas	low	NA	difficult to up- date for sub- regions	Regional IEA or leaders
	Provide infor- mation on less important pressures				High	Medium	yes	yes	medium	NA	as the whole EO	Regional IEA or leaders
	Indicators for good ecologi- cal status (WGINOR)	x			Medium	Medium/High	yes	Yes, but not sure	yes	National-yes	3–5 years	WGIBAR, WGINOR, other regional IEA, WGEKO, WGCERP; WGBIODIV

Group	Product name	1–3 years	3–5 years	5–10 years	Maturity of science (HIGH/ MEDIUM/ LOW)	Data availability	Relevant for most or all ecoregions?	Doable for most or all ecoregions?	Relevant to clients	High-level manage- ment objectives tar- geted	Suggested up- date fre- quency	Relevant ICES EG (name)
	Biodiversity measures*	x			High/Me- dium	Available with ref- erence to OSPAR and HELCOM As- sessments	All ecore- gions	Yes	Yes	EU MSFD	3 years	WGBIODIV, WGECO, WGFBIT, WGCERP, WGEAWESS

* data availability but need to comapr data with ICESdata center
** data and models need be verife and quality protocol with TDA need to be introduced

Annex 7: Individual contributions by workshop participants

Fisheries impact on the seabed

Sebastian Valanko

The basis for ICES assessment of the seafloor is available within the WGFBIT report as “Annex 4 Technical guidelines document for assessing fishing impact from mobile bottom-contacting fishing gears”.

<http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/HAPISG/2018/01%20WGFBIT%20-%20Report%20of%20the%20Working%20Group%20on%20Fisheries%20Benthic%20Impact%20and%20Trade-offs.pdf>

The described methods are based on ICES (2016, 2017) advice that has established a set of indicators to assess seafloor integrity, in terms of the spatial extent and distribution of pressures classed under both assessment criteria (physical loss D6C1 and physical disturbance D6C2) and their impact for each broad habitat type, within each ecoregion and subdivision. WGFBIT is working towards (2018-2020) operationalizing the suggested seafloor assessment framework (Figure 8.1, see also [WGFBIT three-year work plan](#)), with respective indicators across the whole EU and ICES areas. This ICES work is being done using data management practices, for which ICES's TAF ([transparent assessment framework](#)) is an integral part of.

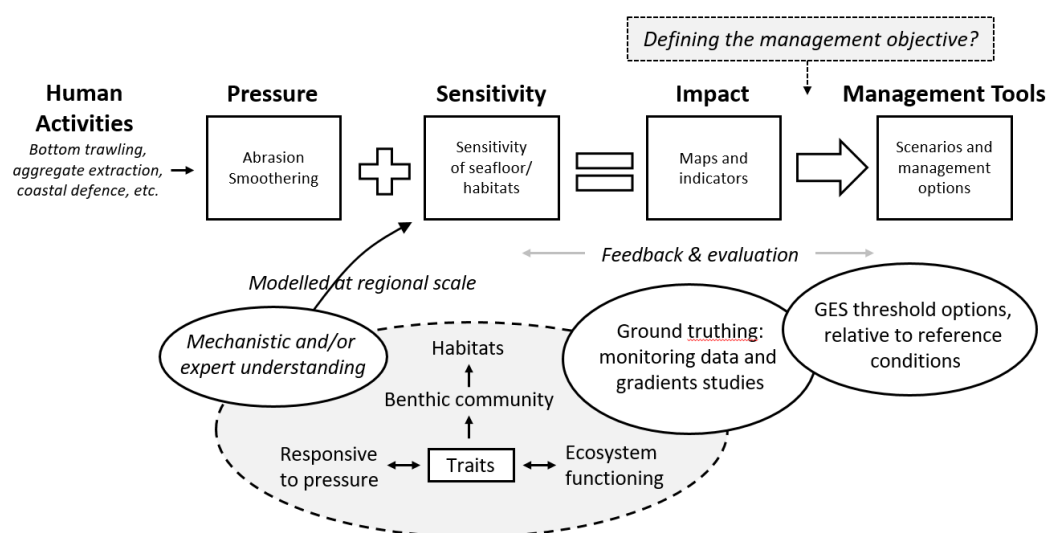


Figure 8.1. Conceptual diagram of the steps taken in developing management tools for assessing pressure and impact on the seafloor.

A good indicator to assess GES for D6 of the MSFD should relate to the biodiversity, structure and function of the benthic community (ICES Advice 2016, 2017). The method that WGFBIT is taking forward is based on a mechanistic model that is able to combine information on total benthic biomass (which is linked to the overall functioning of the ecosystem, see WGFBIT report section 3.2.1 on page 57) with the relative abundance of different longevity classes (that in turn relates to the structure and biodiversity). This assessment method has been considered by ICES to be the most suitable to assess GES of the seabed at a European scale because of its mechanistic nature means that it will be applicable outside of the specific region they were developed in.

ICES experts and those responsible for national level implementation of the MSFD have also over recent years joined together in a series of workshops to produce guidance on how to assess pressure from human activities that result in either habitat loss ([WKBEDLOSS](#)) and/or physical disturbance ([WKBEDPRES1](#)) to the seafloor. Cross regional generality can be achieved by combining trait based approaches with mechanistic understanding of how these pressures impact the seafloor. This will allow ICES to better explore some of the potential trade-offs between fishing and seafloor impact, in the context of future management needs (e.g. MSFD, CFP, and the deep-sea access regulation EU 2016/2336).

Climate predictions and projections

Mark Payne

There is a vast array of climate data and knowledge that could be incorporated into ecosystem overviews. As a tool for discussing these issues, we distinguish between 1. climate knowledge (e.g. projected impacts on a given species) and 2. data characterizing the state of the climate in an ecoregion. It is also useful to think about four different time-scales, which closely mirror the activities in the climate and oceanographic communities: historical observations, seasonal predictions, decadal predictions, and climate projections. We consider each of these in turn.

Historical data, spanning most of the 20th century, and often some of the 19th century are the most readily available of these data types, via products such as the Hadley SST dataset, and the products provided by the Copernicus CMEMS service and EMODnet. This can take the form of products based directly on observations, or from model runs. These products are usually in an advanced state of scientific maturity, and are usually delivered operationally, with high temporal and spatial resolution.

Global scale climate projections are also readily available, particularly via the Coupled Model-intercomparison project (CMIP) associated with the IPCC process. This data is readily available in the public domain, covering the period 2005–2100, conditional on a range of emissions scenarios (e.g. “business as usual” vs. “Paris agreement”). The data covers the entire globe, meaning that they can be applied to all ecoregions: however, the resolution of such models is typically coarse (e.g. 1 degree grid, although this can vary between models) so finer scale features, such as the Baltic and upwelling systems, are often poorly resolved. Higher resolution (“downscaled”) products also exist, but are generally regionally focused and often limited to research settings, making them less suitable for use in a generic manner across all ecoregions.

Climate predictions are a new field that has developed rapidly in the last decade. Today it is now possible to make reliable and skilful forecasts of the state of the oceans months (“seasonal forecasts”: 1–12 months) and even years (“decadal-forecasts”: 1–10 years) into the future. These products are approaching maturity, and seasonal forecasts are now being produced operationally both in North America and Europe: operational decadal forecasts do not exist at the moment, but initiatives are afoot to create such services and are expected to come online within the next 3–5 years. This are potentially highly valuable in an ICES context, as they match the time-scale on which the majority of decisions are made.

Combining these four timescales has the potential to give a complete overview of the past and future evolution of the state of the ocean climate. A mock-up of how this might look is included below, showing the average sea surface temperature for a hypothetical eco-region. The figure gives a sense of the interannual variability, multi-annual variability (e.g. differences in average temperatures between 1980s and 2000s), changes in the near term, and future variability under different emissions scenarios. Such data could also be complemented with spatial information e.g. maps of warming trends within a ecoregion.

Such climate data can generally be provided by the ICES community. Work performed previously by the ICES SICCME-CVA workshop has approached the issue of climate data for ecosystem overviews briefly, but there is clearly more that can be done to improve both the communication, coverage and usefulness of the data. WGS2D focuses on the climate prediction aspects, and has previously provided data to e.g. WGINOSE. WGOH and WGOOFE are specialized in historical and current observations of the state of the ocean. A summary of the readiness of climate data for ecosystem-overviews is included below as a table.

In addition to changes in the physical environment, climate change will also have important consequences for all organisms in the ocean. Unfortunately, while there is a tremendous amount of knowledge in this regard in the ICES community, it is not in a format where it can be readily collated and summarized for use in an ecosystem overview (as is possible with predictions / projections of physical climate variables). Much of this knowledge is distributed throughout the scientific literature and/or outputs of various research projects (e.g. the EU H2020 projects CERES and ClimeFish): synthesis and collation activities would be required before this information could be used in an ecosystem overview. The IPCC is a model for how this can be done: however, the scope of their work is very broad (global in nature), and when combined with the very broad range of topics involved, means that it cannot be used as a reliable resource for such information. An ICES-driven review process would therefore be required to collate current knowledge about climate impacts on species and ecoregions, and to summarise and reduce them down to a scale where they could be used in an ecosystem overview. The ICES SICCME initiative could potentially be a useful avenue where such activities could be developed and coordinated.

A final, and perhaps the most important, consideration of all, is how this information will be used by decision makers and the users of the ecosystem-overviews. There is such an overwhelmingly large amount of both climate data, and knowledge about the observed and projected impacts of climate change on life in the ocean, that it would be extremely easy to either drown in the deluge, to fail to address the needs of the user (by providing inappropriate information), or both. Clear dialogue between the ICES climate community and the ecosystem-overview target-audience to define and refine the climate information to be included in an ecosystem overview is absolutely critical to ensure a useful product.

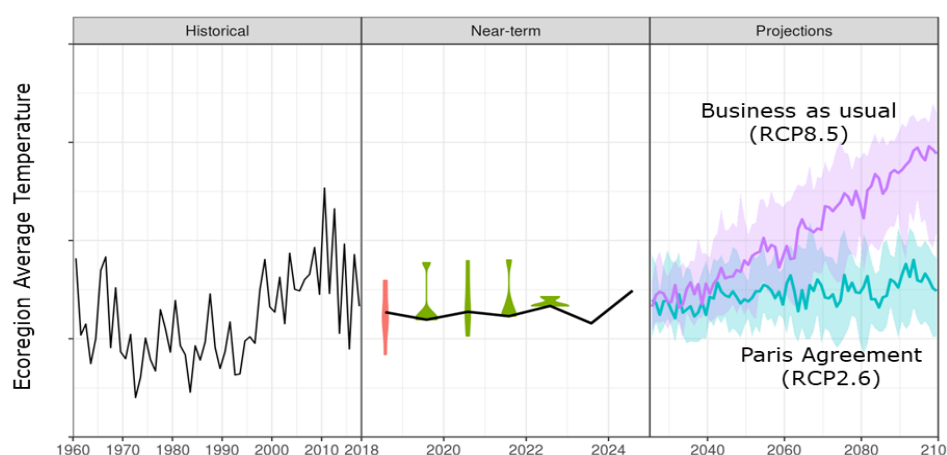


Figure 8.2. Mock-up of one way that climate data could be presented in an ecosystem overview. The figure shows three different timescales (historical, near-term climate predictions, and climate projections) to provide a complete overview of both the historical and future variation in a climate variable (e.g. average sea surface temperature in the ecoregion). Predicted and projected temperatures are shown with uncertainties (violin plots / coloured bands). Projections are shown under two different emissions scenarios.

Table 8.1. Summary of the current state of climate data for use in ecosystem overviews, following the proposed criteria laid down by this workshop.

	Historical Obs.	Seasonal Preds.	Decadal Preds.	Climate Projs.
Client/stakeholder interest	?	???	???	?
Expertise available in ICES	WGOH, WGOOFE, WGS2D	WGS2D	WGS2D	WGS2D, SICCME
All ecoregions can be delivered	Y	Y (Baltic?)	Y (Baltic?)	Y
Time scale for delivery	3-6 months to establish pipeline			
FAIR principles	Possible (help needed)			
Update frequency of underlying data	Not needed	Monthly	Not yet possible	~ 7 years
Scientific maturity (is the product operational)?	Full	Full	Partial	Full

Management objectives

Jörn Schmidt

Providing integrated ecosystem and management advice requires an understanding of the coupled social, economic, institutional and ecological system. The current basis for decision making are the objectives, which are given by the legal and regulatory frameworks on international, EU and national levels. These include on the international level, among others, the United Nations Convention on the Law of the Sea (UNCLOS), the UN Fish Stocks Agreement, the Sustainable Development Goals (SDGs) and the Aichi Biodiversity Targets. At EU level, these are for example the Common Fisheries Policy (CFP), the Integrated Maritime Policy and the different EU directives (MFSD, Habitat, Birds, etc.). In addition, all countries have national and subnational documents, further refining objectives regarding the conservation and use of marine space and resources. Although important for decision makers, the whole breadth of objectives are currently not expressed or analysed in the EOs and FOs.

A first step forward for ICES could be to add ESI objectives to the overviews, e.g. in a preamble, laying out the context for the EOs. Work necessary to do this has been initiated in the SIHD Workshop on Balancing Economic, Social, and Institutional Objectives in Integrated Assessments (WKSIED-BESIO) and will be continued in a newly to be developed WGBESIO.

Table 8.2. Summary of the current state of objective overview for use in ecosystem overviews, following the proposed criteria laid down by this workshop.

Item	Description
Client/stakeholder interest	Yes, relevant for decision makers and to understand context of information
Maturity of science	Medium
Expertise available in ICES	WGBESIO, IEA groups and national expertise
Data availability	Data is qualitative in legal texts

All ecoregions can be delivered	Y
Doable for ecoregions	Y
Update frequency of underlying data	as soon as new legislative texts are published
Scientific maturity (is the product operational)?	No, but can be achieved soon

Mapping vulnerable marine areas

Mette Skern-Mauritzen

There are two requests to ICES ACOM on mapping of vulnerable areas:

- Request from Ministry of Environment, Norway: ICES review and recommend criteria to be used in the Barents Sea Management plan for the Norwegian sector (May 2019)
- North Atlantic Workshop on EBSA criteria (Sept 2019)

While the first process will lead to ACOM approved advice on criteria used to define vulnerable areas (in the Barents Sea), the role of ICES in the second process is not yet resolved. However, central to both processes will review and assess the criteria defined for the Convention on Biological Diversity (CBD) to identify *Ecologically or Biologically Significant Areas* (EBSAs):

- Uniqueness or Rarity
- Special importance for life history stages of species
- Importance for threatened, endangered or declining species and/or habitats
- Vulnerability, Fragility, Sensitivity, or Slow recovery
- Biological Productivity
- Biological Diversity
- Naturalness

Hence, during 2019 ACOM will agree on guidelines on how to define vulnerable areas. These guidelines could be used to create maps of vulnerable areas in the EOs.

In relation to EOs, maps of vulnerable areas

- have high stakeholder relevance, as they are already asked for by stakeholders
- can be implemented for all ICES regions, although the science and data underlying the maps will differ between regions. These can include both qualitative and quantitative data and results, following transparent processes
- need limited updates perhaps every 5 years, to include potential climate change impacts on distributions of species and habitats

Vulnerable areas (CBD EBSA)

Maurice Clarke

The UN Convention on Biological Diversity (CBD) adopted criteria for identifying ecologically or biologically significant marine areas (EBSAs). This process supports the CBD’s key role in supporting the work of the UN General Assembly with regard to marine protected areas beyond national jurisdiction “by focusing on the provision of scientific and technical information and advice relating to marine biological diversity, the application of the ecosystem approach and the precautionary approach”.

The EBSA identification process is a scientific and technical exercise that aims to inform marine spatial planning both within and beyond national jurisdiction 2. Importantly, the identification of EBSAs and the selection of any conservation or management measures is a matter for States and competent intergovernmental organisations in accordance with international Law, particularly The United Nations Convention on the Law of the Sea (UNCLOS).

The definition of an EBSA from the CBD decision text is: “geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics, or otherwise meet the [EBSA] criteria”.

In the past, ICES has reviewed the ecological evidence supporting proposed EBSAs by an OSPAR NEAFC and the CBD. ICES came to different conclusions with regard to the rankings of the EBSA criteria.

It should be stressed that areas meet criteria for VMEs would be expected to meet one or more criteria for EBSAs as well. However, the reverse is not necessarily true and EBSAs do not necessarily contain VMEs. There is neither a policy nor an ecological rationale for automatically excluding bottom fishing (or any other activity) from areas proposed as EBSAs. The expected initial response of regulatory authorities is to conduct risk or threat assessments of the activities they regulate relative to the properties considered ecologically or biologically significant, and to subsequently undertake management appropriate to the outcome of these assessments.

Although EBSAs are not defined by or linked to any particular management actions by any authorities, it is appropriate to consider whether or not spatial management tools might benefit the conservation or sustainable use of the relevant features.

ICES EO should summarise succinctly extant ICES advice on EBSAs and current known designations per eco region.

Table 8.3. Summary of the current state of EMSA advice for use in ecosystem overviews, following the proposed criteria laid down by this workshop.

Item	Description
Client/stakeholder interest	Yes, from RSCs, RFMOs and UN CBD
Maturity of science	Medium
Expertise available in ICES	WGMHM, WGDEC, National expertise
Data availability	
All ecoregions can be delivered	Y
Doable for ecoregions	Y

Update frequency of underlying data	Upon request from clients
Scientific maturity (is the product operational)?	Yes

Food-web modelling

Maciej Tomczak

During the ICES Workshop on operational EwE models to inform IEAs (WKEWIEA) potential of using EwE models to inform ICES products such as the i.e Ecosystem Overviews, as an integral part of the ecosystem advice was explored. Several approaches and examples of using EwE were identified as useful to support IEA and ICES integrated advice i.e. to inform quota setting (see WKIrish5), exploring trade-offs, MSFD indicators and supporting stakeholders interactions. On current stage of EO's development only approach fulfil the requirement describe at EO's definition (see ICES, 2013) are presented below.

Using the EwE (or relevant end-to-end models) for quantification of links between activity-pressure and state to support EO's and interactive version of EO's. The sensitivity analysis on external forcing on main pressures included in the model. In most cases main ecosystem pressures (relevant for food-web dynamic) was identify at the existing EO's. Its within scope of WKECOVER and AA, relevant for EO's part of advice bringing the EO's from fully descriptive to semi - quantitate. WKEWIEA identify that models, expert and required skills are available for most of ICES areas. However, solid EGss or WKs network does not exist for food-web models (at operational level) to deliver results within one year. WGSAM could be a platform, but, regional IEA group are the place where analysis need to be performed, deliver and updated together with EO's. It's possible to deliver quantification of links between activity-pressure and state with in 3 year perspective but number of conditions need to be fulfil to accept model runs. WKEWIEA suggest before using EwE models model quality protocol and key-runs need to be develop to implement Transparent Assessment Framework (TAF) and FAIR data principles in to publish models. Models for number ICES ecoregions are already publish and described (in case of North Sea and Central Baltic ICES key runs exist). Right now, models exist as a simulations of ecosystem dynamic, describe in best possible way as a scientific tool and providing solid results. Implementing model quality protocol and key-runs should improve reproducibility and transparency.

ICES 2013. Report of the Working Group on the ICES ACOM/SCICOM Workshop on Ecosystem Overviews (WKECOVER), 7 – 11 January 2013, ICES HQ Copenhagen Denmark.

Cumulative impacts

Lena Bergström

Cumulative impact assessments provide a way to co-analyse the impacts of multiple pressures on a selected part of the ecosystem or a whole region, and to evaluate different pressures in relation to each other. As the cumulative impact assessments make it possible to evaluate the combined effects of different pressures and identify key pressures, they can also support a risk assessment. When linked to spatial planning scenarios, they can support the evaluation of management strategies.

The work is of high relevance for developing the ecosystem approach to sectorial management, such as fisheries, aquaculture and renewable energy, as well as general spatial planning, by providing a way to assess interdependencies, synergies and impacts across sectors. It is also of high relevance for evaluating the combined impacts of sea uses and land-sea interactions in relation to environmental management objectives.

Approaches to cumulative impacts assessments in ICES, and the inclusion of key results in Ecosystem Overviews, need to be developed further and should be possible within a medium time-frame through interaction with regional sea conventions and developing ICES working groups. In addition to the development of analytical approaches, the work is dependent on the availability of data products, mainly spatial data.

Cumulative impacts assessments tools are currently developed nationally in many countries, as well as for some regional seas, e.g. the Baltic Sea and North Sea. For example, in the Baltic Sea, the Baltic Sea Impact Index was updated in 2018 and new regional scale spatial data were made available (HELCOM 2018a). The HELCOM HOLAS II project with support from the EU co-financed TAPAS and BalticBOOST projects provided an overview of pressures and impacts on the Baltic Sea environment focusing on years 2011-2016, including new and improved spatial data sets on human activities, pressures, species and habitats in the Baltic Sea, as well as updated sensitivity scores (HELCOM 2018b). This work is currently under further development within the Pan Baltic Scope project (www.panbalticscope.eu) financed by the European Maritime and Fisheries fund. This project runs 2018-2019 and will extend the applicability of cumulative impacts assessment in the Baltic Sea when doing maritime spatial planning. This work also includes improving spatial data sets on essential fish habitats and making an openly available assessment tool.

HELCOM 2018a. State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Baltic Sea Environment Proceedings 155.

HELCOM 2018b. HELCOM Thematic assessment of cumulative impacts on the Baltic Sea 2011-2016. Baltic Sea Environment Proceedings 159.

Economy (GDP, main sectors, employment)

Jörn Schmidt

The ecosystem overviews are currently describing key ecosystem processes and include human activities as drivers and pressures for different ecosystem components. However, these human activities are part of the ecoregion and also produce benefits to society. Including information about main sectors besides a more general overview, illustrating the extend of these key maritime sectors in the region, will improve the usefulness of the Ecosystem Overviews for decision makers. Meaningful indicators can include national GDP and unemployment rates as general information and the contribution of main sectors to national economies as percentage of national

GDP and the contribution to employment. GDP is a disputed concept as it measures only economic growth in quantitative terms. However, it is still a meaningful concept as long as it is not the only measure, and can put the economic contribution of different sectors in context.

The data necessary to add this information to the ecoregion description are either readily available through EuroStat, the statistical database for the European Union, or through national statistical databases. Thus, most of the information could be updated automatically.

This information will also inform the EU blue growth strategy and provides means to understand the trade-off between benefit and impact of maritime activities like coastal tourism, ocean energy, seabed mining and other extractive industries, marine biotechnology and shipping.

Table 8.4. Summary of the current state of economic information for use in ecosystem overviews, following the proposed criteria laid down by this workshop.

Item	Description
Client/stakeholder interest	Yes, relevant to understand context of information
Maturity of science	Medium
Expertise available in ICES	WGECON, and national expertise
Data availability	Some for some ecoregions, e.g. EUROSTAT
All ecoregions can be delivered	Y
Doable for ecoregions	Y
Update frequency of underlying data	some can be updated automatically every year, others maybe every 3 years

Warning signals of relevance for management

Per Arneberg and Gro van der Meeren

WGINOR has decided to initiate the development of a framework for assessing warning signals of relevance for management. However, the work with this has not yet started and the input here is therefore limited. Several types of risk assessment frameworks can be considered as a basis for developing this, such as for example from NOAA, USA (Holsman et al. 2017).

Holsman K. et al. (2017) An ecosystem-based approach to marine risk assessment Ecosystem Health and Sustainability 3:e01256-n/a doi:10.1002/ehs2.1256

Fishing and shipping ports

Amber Himes-Cornell and Debbi Pedreschi

Ecosystem Overviews currently reference purely ecological systems (e.g., Figure 8.3). WGSOCIAL proposes to move toward a social-ecological system framework. Many ICES documents already include such language, but it is not yet reflected in the current Ecosystem Overviews. New language should explain how human activity contributes to society as well as how human activity can be a pressure on the environment.

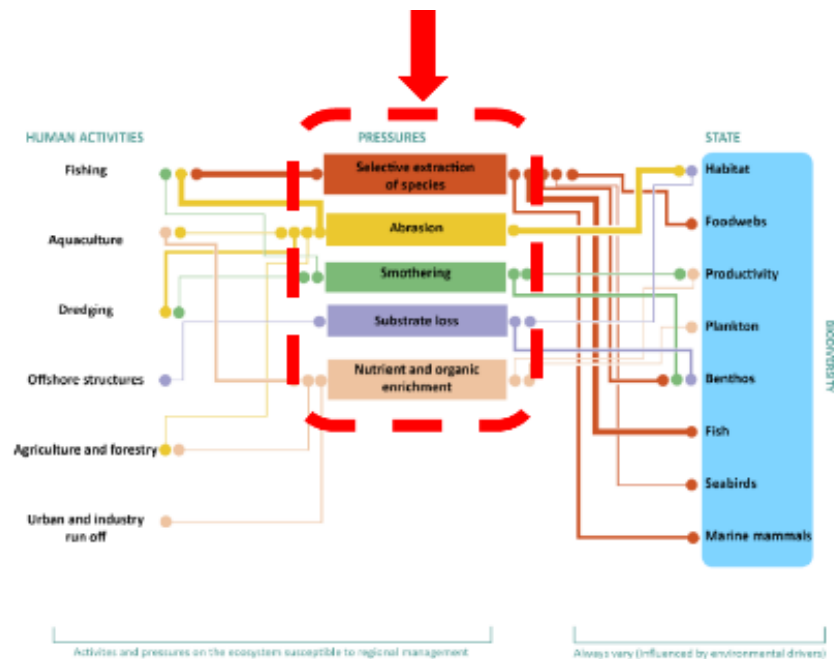


Figure 8.3. Standard diagram from EOs where humans are a pressure on the ecosystem.

WGSOCIAL recommends that ICES get a better understanding of what is currently included on the Ecosystem Overview maps. It is not clear what the definition of a port is and how size of the ports (medium and large) is determined. In addition, population size markers for cities also are not equal between Ecoregions. For example, WGSOCIAL noted these differences in what constitutes a port and how they distinguished the size of it are the Icelandic Waters and North Sea ecoregion maps (Figure 8.4). Note that the source for information on ports is different for Iceland. All other Ecosystem Overviews used ESRI but not Iceland which may explain the differences. We recommend that what constitutes a port and its size be standardized. WGSOCIAL also proposes to add fishing ports to this map or have a map of fishing ports on its own. This is particularly important for Ecosystem Overviews where fishing is identified as one of the pressures.

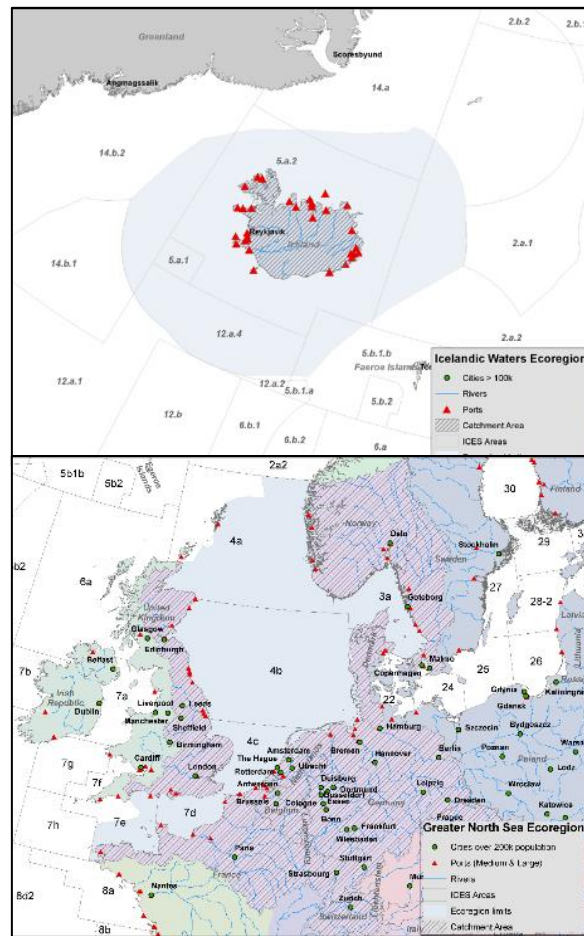


Figure 8.4. Maps of ports in the Icelandic Waters and Greater North Sea Ecosystem Overviews.

In order to develop a map of fishing ports, what constitutes a fishing port will need to be determined and the data acquired. An example of what is possible can be found on the [JRC website](#). The JRC used the [EU fleet register](#) to identify fishing ports based on where vessels are registered however this is a limited view of fishing ports. Examples of other data that could be used to identify fishing ports include where fish are landed and/or the number of fishers in a port. Each represents different facets of what constitutes fishing ports.

WGSOCIAL will endeavour to develop a proof of concept map of fishing ports using the Celtic Seas Ecoregion as a case study. This will require the identification of data sources and acquisition of data for the Celtic Sea while broadly evaluating how it would be accomplished for all ICES ecoregions. WGSOCIAL will then be in a position to discuss the availability and quality of data and recommend the frequency of updates.

Dependence between ecosystem services, impacts and sector values

Jörn Schmidt

To understand the link between ecosystem or ecosystem components and maritime activities, the ecosystem services approach can be helpful. What is the contribution of the ecosystem or elements of that ecosystem to a given maritime activity, what is the benefit for society and what is the effect that activity has on the marine environment. The HOLAS II report presents a possible method on mapping activities between ‘dependence on ecosystem service’ and ‘Impact on ecosystem service’ while visualizing the importance of that activity in terms of economic or employment contribution.

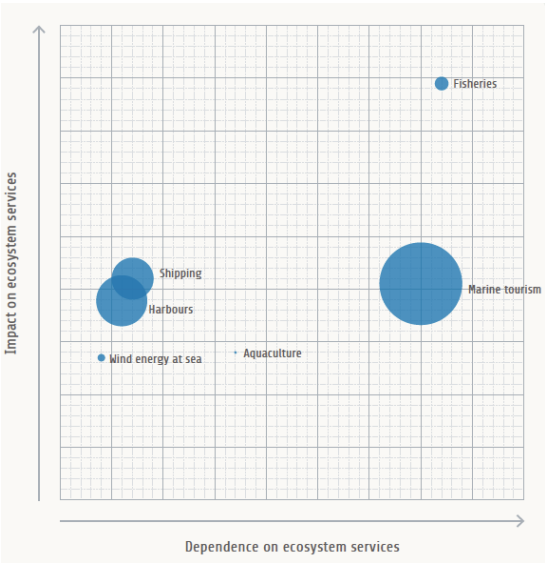


Figure 8.5. Example on how human activities benefit from an impact on the environment. The bubble sizes represent the value added of each activity. The vertical axis represent the total environmental impact of human activities on the ecosystem services, and the horizontal axis represent the activities dependency on the state of ecosystem services. Economically and ecologically sound marine management would shift the location of the bubbles downward and increase the size of the bubbles. The result of this method is expected to vary from country to country (Source: HELCOM 2018).

Table 8.5. Summary of the current state of ecosystem services for use in ecosystem overviews, following the proposed criteria laid down by this workshop.

Item	Description
Client/stakeholder interest	Yes, relevant to understand context of information
Maturity of science	Low
Expertise available in ICES	WGCERP, WGRME and all IEA groups, connections to additional groups may be needed
Data availability	For some sectors. Generally not available on the level of ecoregions but under development e.g. in Baltic Sea (HELCOM)
All ecoregions can be delivered	Y
Doable for ecoregions	Y
Update frequency of underlying data	3-5 years (or more)

HELCOM (2018). State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Baltic Sea Environment Proceedings 155.

Indicators for good ecological status (WGINOR)

Per Arneberg and Gro van der Meeren

A framework for assessing the state of ecosystems are currently being developed in Norway. The primary motivation is to assess the state of ecosystems in Norway in order to follow up a government white paper on conservation of biodiversity and ecosystems in Norway. The framework and resulting assessments can therefore be relevant for EOs.

The framework is based on the following:

- i. Identify ecosystem types that are different enough to warrant separate assessments. For example, in the Barents Sea, the four following ecosystem types have been identified: (1) Arctic shelf ecosystem, (2) Atlantic shelf ecosystem, (3) Arctic slope ecosystem and (4) Atlantic slope ecosystem
- ii. The framework is designed to assess whether ecological state is good or not. The reference condition is set as “intact nature”, which is defined as absence of major anthropogenic impact. Deviation from good ecological state is then defined as an impacted system.
- iii. Ecosystem state is assessed for seven criteria, covering major structures and functions of ecosystems:
 1. Primary productivity
 2. Distribution of biomass among trophic levels
 3. Diversity of functional groups
 4. Abundance of functionally important species
 5. Landscape patterns (size of habitats etc.)
 6. Species and genetic diversity
 7. Abiotic factors
- iv. One or several indicators are developed for each criterion.
- v. For marine ecosystems in Norwegian waters (and we expect this applies for most marine ecosystems), it is not possible to estimate reference values, because we do not have monitoring data for periods when the ecosystems were not significantly impacted by anthropogenic activities and do not have models with the capacity to hindcast what the ecosystems looked like in a previous unimpacted periods.
- vi. The assessments are therefore based on the following steps:
 1. For each indicator, the expected development under current drivers is described using literature. For example, for primary productivity in the Arctic part of the Barents Sea, it is described how this is expected to change under the influence of a changing climate, the driver likely to impact this variable. The uncertainty in this prediction is also assessed (i.e. how uncertain are we on the proposed link between climate change and primary productivity in the Arctic part of the Barents Sea).
 2. It is then assessed whether the expected development of each indicator has occurred, and to which extent.

3. For each of the seven criteria, it is then assessed whether the combined information in all indicators indicate that there are no deviations from good ecological state or whether there are minor or major deviations. This is done with the help of the matrix shown below (Figure 8.5)

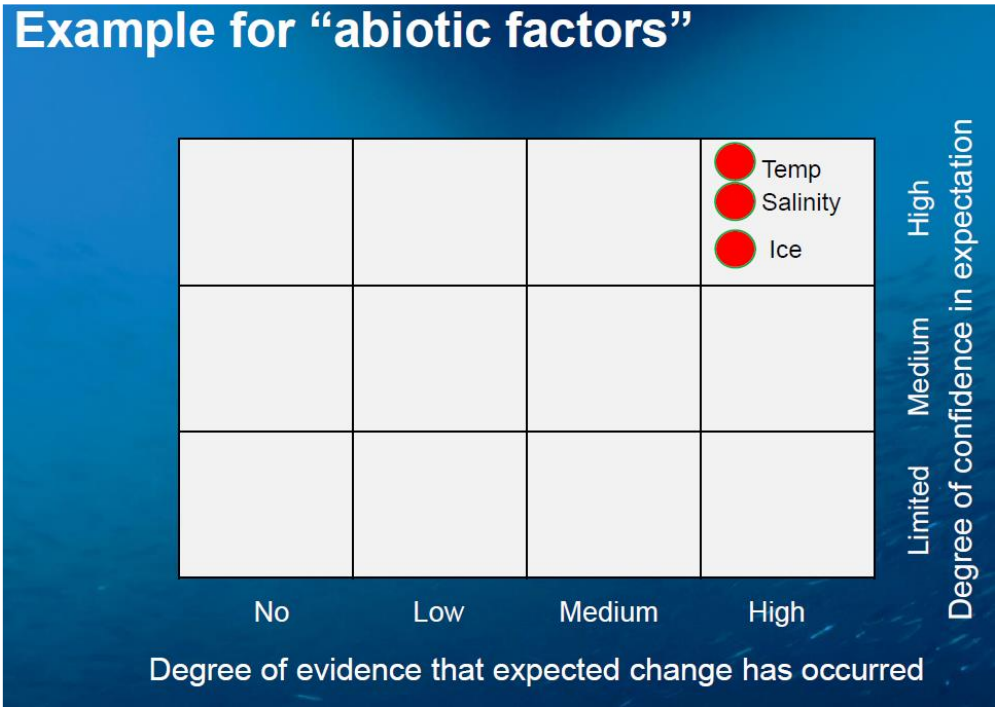


Figure 8.6. Matrix used to assess deviation from good ecological state. On the horizontal axis is given the score for degree of evidence the change expected from current drivers has occurred. On the vertical axis is given the confidence in the expected relationship between drivers and state of the indicator. In the figure, draft evaluation of abiotic indicators from the Arctic shelf part of the Barents Sea are shown. This ecosystem has undergone substantial warming and loss of sea ice and a substantial increase in salinity. In this example, the assessment is that this can be linked to anthropogenic impact on climate with a high degree of confidence (i.e. the points are located on the top row). There is also a high degree of evidence that the expected changes have occurred.

The approach taken with this matrix bears many similarities with IPCC approaches, where independent assessments of degree of climate change (horizontal axis) and degree of confidence in attribution to anthropogenic drivers (vertical axis) are central for overall assessments.

The overall assessment of the state of an ecosystem is here given as a summary of the state for each of the seven criteria. This is accompanied by an evaluation of further need for monitoring and research and, where possible, an assessment of possible future development of the ecosystem.