WORKSHOP ON METHODS AND GUIDELINES TO LINK HUMAN ACTIVITIES, PRESSURES AND STATE OF THE ECOSYSTEM IN ECOSYSTEM OVERVIEWS (WKTRANSPARENT; outputs from 2020 meeting)

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i Executive summary

The Workshop on methods and guidelines to link human activities, pressures and state of the ecosystem in Ecosystem Overviews (WKTRANSPARENT) focused on advancing the interdisciplinary contributions to the ICES Ecosystem Overviews. The Ecosystem Overviews are central to ICES approach to support evidence-based ecosystem-based management across ICES ecoregions and facilitate our capacity to provide integrated ecosystem advice. Experts in natural, economic, and social sciences met to advance the following objectives: i) identify and evaluate approaches for the incorporation of ecosystem processes and functions, ii) review methodological approaches for prioritizing main pressures, and iii) propose updates to technical guidelines.

Two perspectives on the relevance of ecosystem functions and processes were explored: i) extension of the direct effects to ecosystem services, and ii) inclusion of indirect effects to understand how the direct impacts may have knock-on effects on other ecosystem components.

Multiple risk assessment approaches were reviewed to identify candidate methodologies for use in prioritizing the main pressures present in each ecoregion. A downscaled approach using Options for Delivering Ecosystem-based Marine Management (ODEMM) focusing on the risk aspects was selected as the most suitable method. Elements for inclusion in the assessment were agreed, and future developments such as cumulative effects assessments and inclusion of ecosystem services were discussed.

Proposed updates to the technical guidelines included, amongst others, i) a revised structure of the overviews, ii) a proposal for a major revision of the methodology for the human activity-pressure-ecosystem state component network figure, and iii) the addition of several new sections that describe the process of updating and revising, the feedback mechanisms, and the adoption of a pipeline process to incorporate new topics. In addition, glossaries on human activities, pressures and ecosystem state components were provided. The work on technical guidelines will form the basis for updating ICES Technical Guidelines of Ecosystem Overviews.

In order to further advance the Ecosystem Overviews, WKTRANSPARENT recommends (1) arranging a new workshop to identify options to incorporate ecosystem services, (2) seeking further development of ideas for the inclusion of foodweb information, and (3) organising a training event on ecosystem assessment methods.

ii Expert group information

Expert group name	Workshop on methods and guidelines to link human activities, pressures and state of the ecosystem in Ecosystem Overviews (WKTRANSPARENT)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair(s)	Henn Ojaveer, ICES
	Debbi Pedreschi, Ireland
	Gerjan Piet, The Netherlands
Meeting venue(s) and dates	7-9 December 2020, remote meeting (48 participants)

1 Introduction

The ecosystem overviews are central to ICES approach to support evidence-based ecosystem-based management. They provide a description of the ecosystems to identify the main human pressures, and explain how these affect key ecosystem components. The Ecosystem Overviews increase our capacity to provide the integrated ecosystem advice that is required to meet the current and future needs of requesters of advice and stakeholders. Ecosystem Overviews are part of the recurrent advice in the Administrative Agreement signed between the EU and ICES. The overviews are evolving and expanding, and are currently available for ten ICES ecoregions: Azores, Baltic Sea, Barents Sea, Bay of Biscay and the Iberian Coast, Celtic Seas, Greater North Sea, Greenland Sea, Icelandic Waters, Norwegian Sea and Oceanic Northeast Atlantic (an area beyond national jurisdiction, ABNJ).

WKTRANSPARENT was organized as a follow up of the Workshop on the design and scope of the 3rd generation of ICES Ecosystem Overviews (WKEO3) to address a few high-priority issues outlined by WKEO3. The COVID 19 disruption substantially affected the meeting with the scope and topics of the terms of references being adjusted to the online meeting conditions and therefore, WKTRANSPARENT had only a few high-priority ToRs related to further development of EOs. The Terms of Reference for the workshop were to:

a) Explore ways to link the identified high-priority pressures to ecosystem functions and processes;
b) Review relevant approaches and frameworks (risk assessment, mental modeller and others) used by the working groups for assessing and prioritizing the main ecoregion pressures/stressors and human activities with direct impacts to ecosystem components, and propose revisions to the current guidelines;
c) Review and revise technical guidelines for Ecosystem Overviews, including the pipeline process to incorporate new science, the process to update the overviews and outputs from ToR b).

The terms of reference, meeting agenda and the participants list can be found in Annexes 1–3.

Most of the work was done prior to the meeting with engagement of and feedback/input requested from all registered participants. The received input has been summarized and synthesized by WKTRANSPARENT chairs and outcomes were presented and discussed during the meeting. In addition, several individual presentations were invited.

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

2 Explore ways to link the identified high-priority pressures to ecosystem functions and processes

Two perspectives on the relevance of ecosystem functions and processes are explored. These are:

Perspective 1: to supply ecosystem services as these are becoming increasingly important as part of integrated ecosystem assessments and to guide management. In addition, these are required as the means to link the ecological to the social system (i.e. the human dimension). This thus involves an extension of the direct effects to ecosystem services and, in time, possibly into the social system. The proposal is to build on an approach developed by the European Environment Agency (EEA).

Perspective 2: to understand how the direct impacts covered by the methodology that is at the basis of ToR b) may have knock-on effects on other ecosystem components, e.g. through foodweb connections. This thus involves an extension to also include indirect effects. Here we could (should?) also explore the relevance to the MSFD foodweb descriptor in terms of abundance of trophic guilds.

Perspective 1: ecosystem services

Introduction

Since the concept of "ecosystem services" was defined in the Millennium Ecosystem Assessment (MA) as "the benefits people obtain from ecosystems" (MA, 2005), there has been confusion in terms of whether ecosystem services are the actual ecosystem structures, functions or processes; the use of those structures, functions or processes (as services); or the benefits that arise from this use. It has, therefore, been recommended to follow the ecosystem services 'cascade' model (Potschin & Haines-Young, 2011), which has been adopted in several ecosystem service assessment frameworks (e.g. Liquete et al., 2013), and to keep each part of this cascade clearly defined and segregated (Böhnke-Henrichs et al., 2013) (see Figure 2.1).

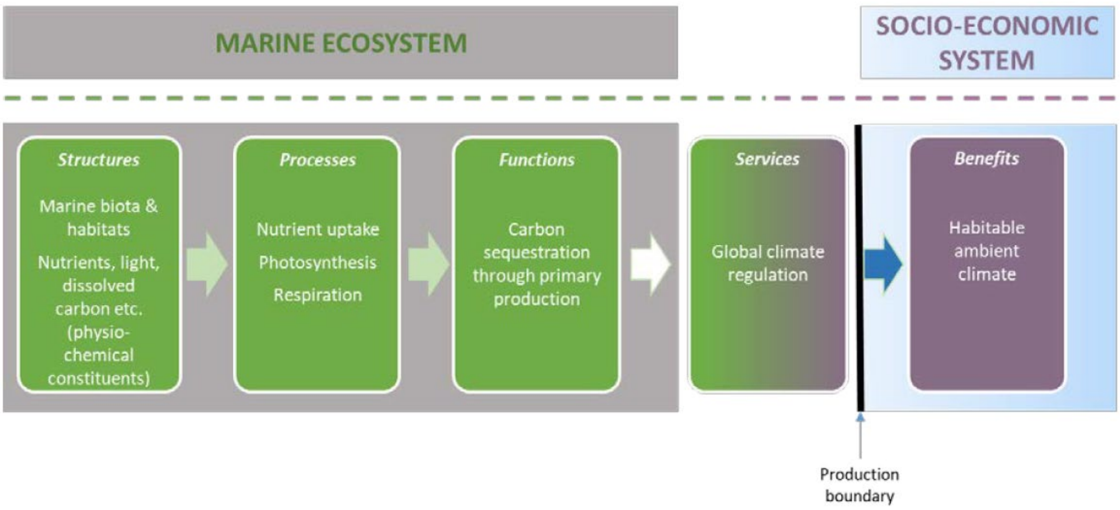


Figure 2.1: Partial marine 'cascade' model, adapted from Potschin & Haines-Young (2011), for the photosynthetic part of the generation of the Global climate regulation service only.

Approach

For the purposes of this study, the capacity of the ecosystem to supply services is assessed based on its state, i.e. taking into account whether the ecosystem is 'healthy' or degraded. This is so we can infer something on the sustainability of marine ecosystem capacity for service supply (Maes et al., 2013, 2014; EEA, 2015). We, thus, define marine ecosystem capacity for service supply here as: 'the effective capacity (potential) of an ecosystem to supply services, which is that based on its state and so linked to its functioning (rather than pure or total capacity, sensu MA (2005), which is linked to just its extent).

We argue that in developing and categorizing marine ecosystem components to link to ecosystem services, it is necessary that all marine biotic groups are explicitly specified and then associated with all marine habitat types they can be found in. The reasons for this are as follows:

1. Different biotic groups present within a given habitat can contribute in different ways to service supply. For the purposes of defining the contribution to this supply, it is important therefore to determine which biotic groups are contributing to a given service. For example, a seabed habitat could deliver the service erosion prevention and sediment retention, which would be contributed to by biogenic reefs of invertebrates, macroalgae, macrophytes and microphytobenthos through stabilization of sediments, accumulation of sediment and attenuation of wave energy. Another service delivered by a seabed habitat would be Seafood from wild animals provisioning, which would be contributed to through benthic invertebrates and macroalgae but not microphytobenthos.

2. Specific associations of biotic groups and habitats will be more important than others in the supply of a service. For example, for the service erosion prevention and sediment retention, macroalgae may contribute more in a given seabed habitat than microphytobenthos. Thus, knowing which aspects of a habitat are the most important for the delivery of a service requires specifying the biotic groups involved in that delivery.

3. The same biotic group in different habitats may not contribute to the same services, e.g. biogenic reefs in shallow sublittoral habitats will contribute to erosion prevention and sediment retention, but biogenic reefs in shelf sublittoral habitats will not as they are too far removed from the area where the erosion is occurring (i.e. do not have the possibility to supply the service from such locations).

Ecosystem component = Biotic group + Habitat type

To define our biotic groups we started from the list of MSFD 'Functional Groups' in the Commission Staff Working Paper on the 'Relationship between the initial assessment of marine waters and the criteria for good environmental status' (EC, 2011). The list was then added to and adapted (as described below) to represent the minimum number of possible groups required to fully cover the differences in ecosystem functioning relevant for the supply of ecosystem services. The three main adaptations we made to develop our final list of biotic groups were based on the:

1. Relevance of certain descriptions or categories in the original list when the functional group would be associated with a particular (physical) habitat type. For example, for coastal fish, the 'coastal' descriptor is unnecessary as this would be accounted for once fish are associated with a specified habitat type.

2. Relevance for the supply of services by the functional group (resulting from its contributions to ecosystem functioning, or from the physical presence or biomass of individual biota).

3. Need to make explicit which are the biotic groups that are not documented in the functional group list, because they are implicitly included (embedded) in the MSFD predominant habitat types (PHTs), but should be specified for the Marine Ecosystem Capacity for Service supply Assessment (MECSA) approach typology of ecosystem components due to their role in the supply of services, e.g. macroalgae.

4. Need to add taxon groups that had not been included in the MSFD's functional groups, nor embedded explicitly in the MSFD's PHTs (bacteria).

Table 2.1 Habitat types ('Level 3a') adapted from the MSFD predominant habitat types and used for the development of marine ecosystem components in the Marine Ecosystem Capacity for Service supply Assessment (MECSA) approach.

Ecological zone/realm	MECSA Habitat Types	Physical Properties of Habitat (1)	
Water column habitats	Variable salinity waters (pelagic parts of land-sea interface features: coastal wetlands(2); coastal lagoons; estuaries; and inlets and embayments (3))	Photic	
	Coastal waters (incl. pelagic parts of land-sea interface features with marine salinity(4), and fully open coastal waters extending up to the shelf)	Photic	
	Shelf waters	Photic/aphotic	
	Oceanic waters	Photic/aphotic	
Ice habitats	Ice-associated habitats	Seasonal sea ice and associated habitats within, on the underside and topside of the ice.	
Seabed habitats	Littoral rock and biogenic reef	Photic	Includes benthic parts of land-sea interface features occurring, in part or in full, across the supralittoral zone (5)(6) and the intertidal/eulittoral zone (7) (e.g. intertidal flats), or equivalent in non-(significantly)tidal seas. Both 'Variable salinity waters' and 'Coastal waters' pelagic types apply in terms of being the relevant overlying water column habitats to the seabed habitats here.
	Littoral sediment		
	Shallow sublittoral rock and biogenic reef		Includes benthic parts of land-sea interface features that are relatively deep and comprised of shallow sublittoral substrates, as well as the benthos of fully open coastal waters extending up to shelf. Both 'Variable salinity waters' and 'Coastal waters' pelagic types apply in terms of being the relevant overlying water column habitats to the seabed habitats here.
	Shallow sublittoral coarse sediment		
	Shallow sublittoral sand		
	Shallow sublittoral mud		
	Shallow sublittoral mixed sediment		
	Shelf sublittoral rock and biogenic reef	Aphotic(8)	Up to shelf end (200 m depth)
	Shelf sublittoral coarse sediment		
	Shelf sublittoral sand		
	Shelf sublittoral mud		
	Shelf sublittoral mixed sediment		
	Upper bathyal rock and biogenic reef		From 200 m – 1450 m depth
	Upper bathyal sediment		
	Lower bathyal rock and biogenic reef		From 1450 m – 2700 m depth
	Lower bathyal sediment		
	Abyssal rock and biogenic reef		> 2700 m depth
	Abyssal sediment		

Table 2.2 The Marine Ecosystem Capacity for Service supply Assessment (MECSA) biotic groups ('Level 4') used for the development of marine ecosystem components in the MECSA approach.

MECSA Biotic Group	Where MECSA biotic groups fit within the MSFD	
	Embedded within the MSFD predominant habitat types	Linked to the MSFD functional groups of highly mobile or widely dispersed species
Birds	-	X
Whales (all cetaceans)	-	X
Seals	-	X
Reptiles	-	X
Fish	-	X
Cephalopods	-	X
Phytoplankton (p)	Water column habitats; Ice-associated habitats	-
Zooplankton	Water column habitats; Ice-associated habitats	-
Epifauna	Seabed habitats	-
Infauna	Seabed habitats	-
Macrophytes (p)	Seabed habitats	-
Macroalgae (p)	Water column habitats; Seabed habitats	-
Microphytobenthos (p)	Seabed habitats	-
Bacteria	Water column habitats; Seabed habitats; Ice-associated habitats	-

The MECSA marine ecosystem components constitute the EU policy-based 'spatial units' holding the capacity to supply marine ecosystem services within the MECSA approach. They are defined as all the possible combinations between habitat types ('Level 3a', Table 2.1) and biotic groups ('Level 4', Table 2.2) where there is a known association of a specific biotic group with the specific habitat type, e.g. fish in oceanic waters or microphytobenthos in the littoral sediment habitat type.

Linking ecosystem components to the capacity to supply services: functioning

Links illustrate a one-way interaction between ecosystem services and the parts of the marine ecosystem (ecosystem components) that hold the capacity to supply those ecosystem services. They are established based on ecological knowledge, in particular an understanding of the (ecosystem) state-service (generation) relationship (see explanation below), and indicate the potential for an ecosystem component to have the capacity to supply, or to contribute to the supply of, that service. Links are confirmed using scientific literature, other information sources, and expert judgement. They are qualitative (i.e. they express the potential presence/absence of an interaction, which is only counted once, rather than a magnitude). Linkages are generic and unrelated to the specifics of any one EU marine region. Links always represent the potential capacity of the ecosystem to supply services. However, the specific meaning of the links (in terms of how the biota contribute, i.e. at the level of ecosystem structures or of ecosystems processes/functions) may differ between services, or between the components that can supply the same service, and this will again be dependent on the (ecosystem) state-service (generation) relationship. For example, the link between fish and the supply of the Seafood from wild animals service is a straight contribution of the component (the fish) to the supply of the service, while the link between epifauna and the Waste and toxicant removal and storage services fulfilled through the process of filtration. Within the cultural services, ecosystem components contribute to the supply of services in a variety of ways, including through their own existence and through animal behaviour (relating to, e.g. recreation and leisure from wildlife watching activities). All of these types of links, regardless of the mechanisms involved, are considered direct links here. The nature of the relationship between the state of relevant ecosystem components and the capacity to supply ecosystem services is explored when moving to the next stage of the approach.

Examples per ecosystem service

Provisioning services include all materials and biota constituting tangible outputs from marine ecosystems; people can exchange or trade these outputs as well as consume them or use them in, e.g. manufacturing. The ecosystem functions leading to the capacity to supply these services include the *growth of populations and individuals, i.e. the accumulation of biomass*, of the relevant marine biota, which is achieved through ecosystem processes such as feeding, respiration and absorption of nutrients. However, the names of Common International Classification of Ecosystem Services (CICES) divisions or groups comprising these services often reflect the 'good' or 'benefit' from the service, e.g. raw materials or nutrition. We, nevertheless, consider that the relevant biota is (also) the service, regardless of whether these biota grow in the wild or through in situ aquaculture. This is because these biota constitute the final ecosystem output (holding the biomass) that is harvested and used, in part or in full, by people because it provides them with the direct benefit (e.g. nutrition).

Regulation and Maintenance services include all the ways in which marine biota and ecosystems control or modify the biotic and abiotic parameters defining the environment of people (i.e. all aspects of the 'ambient' environment). People do not consume these marine ecosystem outputs, but they affect the performance of individuals, communities and populations. These services are mainly used passively by people (e.g. breathing oxygen produced by marine ecosystem components, such as phytoplankton) and include some ex-situ uses. Some could be considered to be used both actively and in-situ (e.g. waste and toxicant treatment via biota – if waste is intentionally released into the sea as a form of treatment, or flood protection – if a saltmarsh is intentionally left undeveloped for this purpose). Many of these services could be understood to be intermediate (rather than final) services under certain contexts (e.g. seed and gamete dispersal, maintaining nursery populations and habitats, gene pool protection, sediment nutrient cycling, etc.) because their possible direct human use (and benefit) is not very obvious. Thus, many of these services do act as supporting services for other (final) services, and their direct human benefit is less obvious than their supporting role. For example, waste and toxicant treatment via biota and disease control support the seafood services (such as for producing safe shellfish), and recreation and leisure (providing a safe/clean environment to carry out activities such as surfing and scuba diving). Nevertheless, in other contexts, these services may be considered as final services, including through the avoidance of a human intervention and related costs (e.g. gene pool protection allows the avoidance of keeping a 'gene bank', or of keeping animals in captivity for genetic insurance). Examples of where services can be intermediate or final are provided for some of the regulation and maintenance services below, but it is considered here that all of the services listed below can be final in at least one context.

Cultural services include all non-material marine ecosystem outputs that have physical, experiential, intellectual, representational, spiritual, emblematic, or other cultural significance, and are always final services. However, demand for them may sometimes be passive and, in those cases, the benefits from the services could, in principle, be free flowing (not requiring human input). These services can be supplied in-situ, or ex-situ, or both. The names of these services tend to reflect the benefits people get from them or the activities via which these benefits are obtained, rather than the services providing those benefits. Considering the kinds of ecosystem structures, processes or functions that cultural services can be underpinned by, these can range from the abundance, distribution and behaviour of animals (e.g. on which wildlife watching is based); the decomposition of microalgae (producing the sea smell people enjoy when being at the seaside); or simply the existence of ecosystem components (for aesthetic benefit, existence, bequest, etc.). Thus, cultural services are, in principle, linked to the state of ecosystem components and the capacity of the ecosystem to supply them, but the way in which they are linked can vary, ranging from a tight link to being fully decoupled in some cases.

A fundamental assumption of this work was that the state of the marine ecosystem can inform us on its capacity to supply marine ecosystem services. We defined marine ecosystem capacity for service supply here as: "the effective capacity (potential) of an ecosystem to supply services, which is that based on its state and so linked to its functioning (rather than pure or total capacity, *sensu* MA (2005), which is linked to just its extent)". Thus, changes to the state of the biotic parts of the ecosystem (e.g. fish, plankton, macroalgae), influenced by their local habitat condition, could lead to a change in the capacity of the ecosystem to supply ecosystem services. This assumption is limited by our understanding of how the ecosystem can supply services and of how ecosystem state relates to its capacity for service supply (first limitation). For each service assessment, therefore, establishing the relationship between the state of the components of the ecosystem holding the capacity to supply a particular ecosystem service and (the state of) the ecosystem capacity to supply that service, i.e. the (ecosystem) state – service (generation) relationship, is a key consideration. It is important to note that other parts of the marine ecosystem may also be involved in this relationship, such as certain physico-chemical attributes (e.g. nutrients). Also, it is not implicitly assumed that a good state of these components, and other parts of the marine ecosystem where relevant, will mean a good capacity of the ecosystem to supply services, although in many cases this will be true (but there are exceptions). Establishing the nature of the (ecosystem) state – service (generation) relationship is fairly straightforward in cases where a clear link between them can be made, such as between the state of phytoplankton and the state of the ecosystem capacity to *assimilate waste nutrients*. However, in many cases, the type of relationship may be more difficult to characterize. Limitations in characterizing this relationship may arise because either there is a lack of knowledge on the relationship, or, where information exists, it suggests that the relationship is multi-faceted, making it difficult to predict how the ecosystem capacity to supply a service will change with a change in relevant aspects (e.g. ecosystem components) of ecosystem state (second limitation):

- On the first limitation mentioned above, the understanding of the relationship between marine ecosystem functioning and how this leads to the supply of some ecosystem services is currently not good enough to allow us to predict how a change in the state of the ecosystem can lead to changes in its capacity to supply (certain) ecosystem services. While understanding of ecosystem functioning and service supply capacity has developed, there are still many gaps in our knowledge. One major gap is for the cultural services. While we intuitively understand that people get many cultural benefits from interacting and experiencing marine ecosystems, we do not always understand the pathways through which the functioning of marine ecosystems specifically lead to those interactions, experiences and benefits.
- On the second limitation mentioned above, there exist a number of examples where the relationship between (ecosystem) state – service (generation) was particularly intricate. For example, how does the ecosystem capacity to supply an aesthetic interaction/ experience and the related benefit (e.g. the enjoyment provided by a pleasant view of a marine landscape) relate to the condition of the marine biota and habitats experienced? In some cases, such as if the habitats were polluted with litter, then both the ecosystem state and its capacity for service supply (the aesthetic service) would be negatively affected. But in another case, reduced biodiversity in habitats (perhaps indicating poor status), may not have much of an impact on the overall view and experience provided when interacting with these habitats, and so service supply capacity may remain unaltered; whilst the state of the habitats themselves might already be recorded as being degraded. It is certainly the case that the MECSA approach should not be applied based on the assumption that there is always a linear, positive relationship between the state of the ecosystem components, and other parts of the

marine ecosystem where relevant, and (the state of) the ecosystem's capacity to supply a specific service.

Perspective 2: indirect effects

Available ecosystem models, e.g. EcoPath, should be explored. The models considered should contain at least the ecosystem components at the highest aggregation level, e.g. fish, benthos, mammals. This should be investigated in more detail and developed in future.

Recommendations forward

Arranging a workshop on identifying options how to incorporate ecosystem services into ecosystem overviews.

Harvesting ideas and identifying ways for inclusion of foodweb information into ecosystem overviews from SCICOM.

3 Review relevant approaches and frameworks (risk assessment, mental modeller and others) used by the working groups for assessing and prioritizing the main ecoregion pressures/stressors and human activities with direct impacts to ecosystem components, and propose revisions to the current guidelines

Ecosystem-based management requires consideration of the whole suite of anthropogenic pressures affecting entire ecosystems (Halpern *et al.*, 2007; Levin *et al.*, 2009; Hilborn, 2011; Borja *et al.*, 2016; Harvey *et al.*, 2017). Policy also requires us to be more holistic in our approaches with the ecosystem approach being mentioned in a wide range of policy directives (e.g. Marine Strategy Framework Directive (European Commission, 2008), Common Fisheries Policy (CFP; (European Union, 2013), Maritime Spatial Planning Directive (MSPD; European Union, 2014), Magnuson-Stevens Fishery Conservation and Management Act, (MSA: *Magnuson-Stevens Fishery Conservation and Management Act.*, 1996), Australia's Oceans Policy (Environment Australia, 1999), Canadian Oceans Act (Department of Fisheries and Oceans, 1996); Oceans Act of 2000 (US Congress, 2000), South African National Water Act (Government of the Republic of South Africa, 1998), etc.). ICES itself is also committed to progressing the ecosystems approach (ICES, 2019a, 2019b, 2019c). However, ecosystems are large and complex, as are the range of anthropogenic activities and pressures that affect them, and the ecosystem processes and services that we benefit from. We also recognize that there are feedback loops between pressures and benefits, such that negative impacts to the marine ecosystem can diminish the benefits it provides and human responses can then mitigate impacts to improve benefits. These human responses often occur through governance institutions (Levin *et al.*, 2009; Belgrano and Villasante, 2020). In order to incorporate ecosystem concerns into management, we need frameworks and tools for organising and assessing the wide range of possible interactions and impacts.

Integrated Ecosystem Assessment

Integrated Ecosystem Assessment (IEA) is a tool for implementing ecosystem-based management. Levin *et al.* (2009) define IEA as an incremental iterative process for 'formal synthesis and quantitative analysis of information on relevant natural and socio-economic factors, in relation to specified ecosystem management objectives'. IEAs are proposed as a framework 'for organizing science in order to inform decisions in marine EBM at multiple scales and across sectors', enhancing the ability of managers to evaluate cumulative impacts and carry out trade-off analyses (Levin *et al.*, 2009). IEAs in their purest form intend to take a comprehensive multi-sectoral, multi-pressure ecosystem view of the entire social-ecological system, involving stakeholders to identify management objectives. Conceptually, IEA is both simple and sensible; however the data, monitoring and modelling requirements of full ecosystem based management are many and daunting (Hilborn, 2011; Hobday *et al.*, 2011; McQuatters-Gollop, 2012; Dickey-Collas, 2014; Borja *et al.*, 2016; Harvey *et al.*, 2017).

Both NOAA and ICES have adopted the 'Levin cycle' as their framework for IEA (ICES, 2012). The cycle outlines 5 stages of IEA: scoping, indicator development, risk analysis, management strategy evaluation, and ecosystem assessment (Levin *et al.*, 2009, 2014; Samhouri *et al.*, 2014). The idea of the loop is useful as it highlights IEA as an iterative process; however, the framework is not prescriptive, instead adapting to regional requirements and various data situations (Levin *et al.*, 2014; Holsman *et al.*, 2017). Despite this, the imagery of the cycle and description of 'steps' can present an obstacle to progress as a lack of progress in one step can hamper development in another. IEA has been described as a process in which a management objective is assessed in an ecosystem context; therefore, an entire IEA process may not be required to inform management measures (Harvey *et al.*, 2017). Instead, it has been proposed that we think of IEA as a toolbox or 'cloud' (Dickey-Collas, 2014) moving towards improved ecosystem understanding by progressing each of the critical elements (while maintaining effective communication).

Ecological Risk Assessment

Ecological (or environmental) risk assessments (ERA), sometimes also referred to as pressure or impact assessments, provide a flexible, problem-solving approach that assesses the effects of human activities on the environment, with the aim of informing and supporting the decision-making needs of environmental managers (Hope, 2006; Hobday *et al.*, 2011; Piet *et al.*, 2017; Hammar *et al.*, 2020). Using such tools facilitates a comparative assessment of all the potential risks affecting the region/ecosystem of interest, placing each risk in context, and enabling prioritization of the top risks and trade-off analyses (Halpern *et al.*, 2007; Piet *et al.*, 2015; Holsman *et al.*, 2017; Pedreschi *et al.*, 2019). These assessments can be qualitative, semi-quantitative or fully quantitative depending on the approach used, the focus of the study (one vs. multiple pressures), the scale of the study/management area, and the availability of data (Hobday *et al.*, 2011; Holsman *et al.*, 2017). Various methodologies exist for carrying out ERAs, but the overall aim is to capture the 'exposure-effect/sensitivity' or 'probability-consequence' relationship between pressures and ecosystem components (sometimes with aspects of vulnerability/recovery included)(Fletcher, 2005; Levin *et al.*, 2009; Samhouri and Levin, 2012; Holsman *et al.*, 2017; Piet *et al.*, 2017). Risk assessments can be carried out in a' business as usual' context to inform ongoing management and risk prioritization, or in a 'risk planning' mode which takes into account rare/catastrophic events (e.g. oil spills). These assessments can then be used to explore management scenarios.

There is no one-size-fits-all solution to risk assessment in EBM (Piet *et al.*, 2017); methodological decisions need to be considered in concert and the preferred methodology is likely to be context dependent. There are two general approaches to risk assessment; quantitative and qualitative. In reality, both are mixed-methods approaches, but for ease of description they are referred to here as quantitative and qualitative approaches.

Quantitative approaches include spatial map-based approaches (including cumulative maps), many of which are based on Halpern *et al.*, (2008) and indicator-based assessments (Halpern *et al.*, 2012; Borja *et al.*, 2016, 2019). Quantitative assessments by necessity rely on available data (or the ability to model or interpolate from existing data), which limits the elements that can be included. Spatial assessments also frequently include qualitative expert judgements to determine the vulnerability, weighting or relative impact of a pressure on a particular component, as data in this realm is usually sparse or non-existent (Halpern *et al.*, 2007, 2008, 2014; Hammar *et al.*, 2020).

Qualitative assessments may be used when quantitative data are of limited availability, allowing fuller consideration of all potential pressures and parts of the ecosystem – although they may be limited by the available knowledge and expertise. Due to the wide range of components under consideration, semi-quantitative analyses necessarily sacrifice nuance and maintain a high-level focus in order to be manageable – too much detail would render it an impossible task (Fletcher, 2005; DePiper *et al.*, 2017). These assessments tend to use data (where available), and/or expert opinions to inform categorical scores and semi-quantitative analyses of the various components under consideration rather than using the data directly. These approaches link identified pressures through to the human activities (sectors) that cause them in order to identify relevant management actions. Some have also been linked further through to drivers, ecosystem responses, ecosystem services, thus advancing towards social-ecological risk assessment and understanding (e.g. Cooper, 2013; Elliott *et al.*, 2017; Bryhn *et al.*, 2020) and aligning closely with the IEA concept. Due to the variable availability of data to underpin these linkages (or 'pressure pathways'), these 'qualitative' methods tend to rely more on expert judgement with different aspects of risk being assessed and scored in each one.

ERA in IEA

Quantitative and qualitative methodologies are entirely complementary, and can be used as different steps in the IEA cycle outlined above, in line with 'IEA toolbox' approach outlined above and advocated for by many IEA experts (Hobday *et al.*, 2011; Dickey-Collas, 2014; Gaichas *et al.*, 2016; Holsman *et al.*, 2017; Muffley *et al.*, 2020). The qualitative methods are ideal for the first 'scoping' phase of analyses to highlight what aspects are of highest concern, and the quantitative methods are then used in following steps (where data are available) to better quantify the risks, and simulate management actions (DePiper *et al.*, 2017). This scoping phase can identify areas of priority concern (highest risk) for further analysis, while also providing a simplified, easily communicable framework and outputs that can provide useful and informative starting points for discussions with stakeholders. Using them together means the entire social-ecological system can be taken into account, and areas of potential high risk but low data can be highlighted for further research and monitoring. Using the methods in concert helps to avoid the pitfalls of either approach, as qualitative approaches provide a relatively low-cost rapid method to include socio-economic complexity whilst enabling researchers to avoid spending the time and resources required to model poorly understood relationships, advancing to more complex tools and methods only where there is an identified need to do so (Hobday *et al.*, 2011; Gaichas *et al.*, 2016; Holsman *et al.*, 2017; Muffley *et al.*, 2020).

Whether using ERA to define the priority areas and working with managers to flesh out socio-economic variables and systems, and questions relating to these priorities (more similar to DPSIR style approaches and Knights *et al.*, 2014; Borgwardt *et al.*, 2019), or using stakeholders (which can include managers) to define the system and limit questions to that system such as in the NOAA/ WKIrish approach, either way the goal is to reduce complexity to concrete concerns and actionable management proposals. The core aspects of scoping with stakeholders and contextual embedding in high-level objectives, assessing risk, assessing state, and evaluating management options are involved in all approaches. The former is deemed most useful in this case for the purposes of informing the EO network diagrams.

Goals of the diagram in the Ecosystem Overviews

The ICES Ecosystem Overviews are **advice products** that provide a description of the ecosystems, identify the main human pressures, and explain how these affect key ecosystem components (in line with EBM and IEA approaches) (ICES, 2013). A key challenge for the Ecosystem Overviews is to distil complexity into digestible information useful to decision-makers. In order to do this, assessments must link through to activities managed by decision-makers and/or their policies. The challenge is to show the causalities between human activities, the pressures they create, and the impacts on ecosystems, ecosystem services, and ultimately ourselves as beneficiaries of those services (Korpinen and Andersen, 2016). Thus ecosystem status assessments (such as the NAFO ecosystem summary sheets (see ToR b)) are not reviewed here, although they can form an important part of an IEA, and can inform the EOs. Current pressures and impacts should be reviewed rather than potential pressures to provide the most relevant information for management action and understanding current context. Furthermore methods must be transparent, with communicable and accessible outputs in order to be effective (Borja *et al.*, 2016). In this way we can move towards implementable EBM that recognizes humans as a dimension in social-ecological systems, rather than separate to it (Levin *et al*., 2016). This is in line with ICES goals (ICES, 2019a, 2019b, 2019c), and helps to progress the ICES Strategic Initiative on the Human Dimension.

Issues with the Current Framework

The existing ICES framework was designed to provide some comparability across ecoregions via a minimally demanding (thus implementable) common methodology. Issues have arisen with its application, as highlighted by WKTRANSPARENT respondents. Many expert groups and chairs have found it difficult to understand what exactly is required/expected of them, and how to implement the guidelines. ICES has been proactive in providing Secretariat support to expert groups (e.g. via Iñigo, Eirini and Julie) and attending expert group meetings. Despite this there has been a range of approaches, and differences in how the guidelines have been applied across groups.

Specific issues highlighted with the methodology (that we are working to address in this workshop) include:

1. The 'Glossary' for the Ecosystem Overviews pressures does not include all pressures now listed in the various Ecosystem Overviews. Further, explanations of the other categories (Sector and State) should also be provided to ensure common understanding.
2. There are definitions on the online interactive diagrams. However, they are often not complete/comprehensive enough to be fully informative. Issues have arisen in particular with attempting to delineate between impacts on habitat and benthos (where do biogenic habitats go?)
3. Two different elements are currently encompassed in the 'state' category – there are ecological components, and there are integrative processes (e.g. 'productivity' and 'foodwebs'). It is exceedingly difficult to assess the **direct** impact of a given sector and pressure on such processes. In the case of foodwebs, anything that affects any part of the ecosystem, and/or habitat has the potential to affect foodwebs, thus making it uninformative.
4. Suggest reconsidering labelling 'states' as, e.g. 'ecological characteristics' or 'ecological components', as this is more reflective of their content. State is reflective of the 'State' section in the Ecosystem Overviews, but this section refers to 'short concise descriptions of the main state of the *ecosystem components'*.
5. It would be useful to clarify the area of interest. If including the entire ecoregion, most spatial scales will be very small and undifferentiated as the ecoregions contain extensive offshore areas where few activities beyond shipping and fishing take place. This can lead to some perception issues with the assessment, as the pressures of concern across the entire ecoregion (e.g. litter) generate larger scores than pressures that are coastally restricted (e.g. coastal discharges), when land-centric views tend to prioritize those coastal issues.
6. Linked to the above can be frustration at the high-level approach that is needed. This can be particularly evident when touching on areas of expertise of the expert group.
7. Guidelines on how to score each of the criteria would be useful (examples of what constitutes a 1,2 or 3 scoring).
8. Guidelines on how to determine the 'strength of link' between the diagram elements (e.g. should it be based on severity? Proportional contribution? Number of linkages?)
9. Should there be a minimum number of participants/experts?
10. Should scoring be done by the group together, or separately and then combined?
11. Should indirect links/impacts be included?

It was also felt that in some categories the EG knowledge could be applied to provide a more informative assessment. For example; 'Fish' could be split into demersal and pelagic fish and elasmobranchs (similar to ODEMM) or/and into commercial and non-commercial (useful for MSFD) to highlight issues of interest such as bycatch and collateral damage. Some groups expressed an interest in creating a near-term future-cast assessment/diagram.

Issues have also been highlighted in relation to the outputs from this methodology. These include:

1. The lack of a common glossary has led to differences in terminology between EOs (e.g. Celtic Seas has 'Urban and Industry run-off', BoB/IW has 'Coastal discharges') – it is unclear what these encompass and whether different sectors such as agriculture, land-based industry and wastewater should be subsumed into one of these categories.
2. Poor communication between EGs and ADGECO has resulted in final published EO diagrams that are different from those submitted from the EGs. Any changes at ADG need to be documented and feedback provided to the EG at a minimum, but preferably, changes should be avoided and instead if there is an issue the query should be referred back to the group to address.

In line with best practice and the ICES Transparent Assessment Framework, the EOs need to progress towards common tractable, citable, published, adaptable and integrative methodologies. Thus, WKTRANSPARENT is working to improve the EO guidelines, and update the methodology employed for creating the EO network diagrams.

Methods Review

In seeking to identify a methodology that is appropriate to use by IEA groups, and for producing the network diagrams for the ecosystem overviews, ICES IEA groups were asked to provide details on the methods they currently use to produce the diagrams (Table 3.1), and any suggestions for frameworks that should be included. Furthermore, a global review by Korpinen and Andersen (2016) of cumulative pressure and impact assessments in marine environments, and an existing framework from the SEERAC project reviewing and comparing ecological risk assessments were examined and adapted to enable comparison between key existing methodologies and provide additional options. To narrow the scope to the goals of the EO diagrams, only assessments taking into account multiple pressures, and factoring in Sectors, Pressures and Ecosystem Components were considered further. In lieu of presenting the many variations of the Halpern *et al.*, (2008) approach detailed in Korpinen and Andersen (2016), we reviewed the original paper, the Ocean Health Index (Halpern *et al.*, 2012), and the Symphony tool (Hammar *et al.*, 2020) as used by ICES WG members. The frameworks were presented for review by WKTRANSPARENT participants.

Eleven methodologies (Annexe 5) were reviewed based on a number of criteria such as: scale, activity/pressures captured, ecosystem component/ indicator assessed, type of measurement, measure of impact, measure of recovery, measure of combined effects, measure of risk, measure of uncertainty, measure of socio-economic factors and management scenario evaluation. Pragmatic factors such as ease of use, adaptability/scalability, and ability to incorporate different levels of knowledge/data availability were considered critical in order to facilitate use and uptake across the IEA groups. Only assessments capable of dealing with multiple activities and pressures were deemed relevant. Compatibility with IEA processes were considered key, along with ability to integrate with other ongoing ICES/IEA group work (e.g. conceptual mapping exercises and cumulative effects assessments).

Table 3.1. Details of ICES groups with responsibility for producing the network diagrams in the ICES Ecosystem Overviews, and the methods used to date.

Acronym	Name	Ecosystem Overview	Method
WGEAWESS	Working Group on Ecosystem Assessment of Western European Shelf Seas	Celtic Seas, and Bay of Biscay/Iberian Coast	adapted ODEMM
WGIAB	ICES/HELCOM Working Group on Integrated Assessment of the Baltic Sea	Baltic	Expert ranking informed by existing HOLAS II assessment. All pressures (0 not important, to 2 very important). Links discussed in plenary.
WGIAZOR	Working Group on Integrated Assessment of the Azores	Azores	ICES guidelines
WGIBAR	Working Group on the Integrated Assessments of the Barents Sea	Barents	no record on process previously used
WGICA	ICES/PICES/PAME Working Group on Integrated Ecosystem Assessment (IEA) for the Central Arctic Ocean	Central Arctic Ocean	ICES/WKTRANSPARENT guidelines.
WGIEAGS	Working Group on Integrated Ecosystem Assessment of the Greenland Sea	Greenland Sea	Expert ranking of sectors/pressures (rank 0 to 5) and magnitude individually, then consensus. Components inspired by existing EOs. Did not score probability (if relevant, included).
WGINOR	Working Group on the Integrated Assessments of the Norwegian Sea	Norwegian Sea	ICES guidelines - ish. Suggest 3-5 most important, then discussed and ranked and scored in plenary with support from literature.
WGINOSE	Working Group on Integrated Assessments of the North Sea	North Sea	WKECOVER - ICES scoring. Intend to use the subregional conceptual diagrams to form a combined overview, but methodology not yet clear/decided. Conceptual diagrams vary in complexity and components (some foodweb, some high level).

Results of the Review

The methodology that appears to be the most relevant to the aims and objectives of the ICES EOs and the network diagram in particular, whilst maintaining manageability/simplicity, is the ODEMM/AQUACROSS methodology. The reasons for this are outlined below.

1. Meets the goals of ICES EOs, in particular to 'describe the distribution of human activities and resultant pressures (in space and time) on the environment and ecosystem'(ICES, 2013);
2. Meets the challenges faced by existing groups by providing an existing (peer-reviewed and citable) framework with definitions and clear scoring criteria;
3. Provides existing assessments that can provide a starting point for ICES EGs (although will need updating/review);

4. Examines all sectors and pressures that occur in the region and scores them independently. Scores then dictate ranking rather than ranking being based on expert opinion of relevant importance (thus minimising bias);
5. Examination of all elements enables identification of areas of potential high risk but with low data/assessment ability;
6. Is relatively adaptable and flexible – can incorporate any sectors/pressures relevant to an area, can be scaled to ecosystem/region of interest, and accommodate all data situations;
7. Can be tailored/adapted to ICES and EG needs (see methodology discussion below);
8. Once built, framework can be easily updated to reflect new knowledge and/or data;
9. Facilitates prioritization of risks which is a core task of the IEA cycle, and directs efforts/highlights areas for further research/quantitative assessment in line with the Holsman *et al*. (2017) approach;
10. Each element can be examined independently to look at specific areas of interest;
11. Facilitates a range of data analysis outputs (see later);
12. Publically available R code has been produced for carrying out analyses (and can be updated specifically for ICES needs/to ensure standardized outputs);
13. Provides opportunities for collaboration across groups on a common linkage support database;
14. Provides a first step to other ERA approaches used by ICES groups/member countries (e.g. Symphony tool (Hammar *et al.*, 2020));
15. Potential to be linked to existing ICES (among other) databases to underpin linkages with existing data;
16. Provides established methodologies that can further link through to cumulative effects assessments and ecosystem services (elaborated later), as well as conceptual mapping exercises that can incorporate ecosystem dynamics (e.g. via foodweb modelling), or socio-economic considerations (e.g. via mind mapping with stakeholders).

Potential to Link with Other Ongoing ICES Science

Conceptual Mapping/ Participatory Modelling

A number of ICES working groups have used mental/conceptual/participatory modelling approaches for a variety of uses (e.g. WGINOSE (ICES, 2020a), WGNARS (DePiper *et al.*, 2017), with knowledge exchange facilitated by WGMARS (ICES, 2017), and WKIrish (ICES, 2020b)). Conceptual mapping is useful tool in number of respects, and has been highlighted as an excellent communication tool for working with stakeholders, to identify common understanding, goals and objectives of complex systems, and in highlighting differences in perspective, values and priorities, e.g. from different stakeholder groups (Levin *et al.*, 2016; DePiper *et al.*, 2017; ICES, 2020a). Crucially, mental models can provide a key transition point between more linear DPSIR-type approaches, and more 'circular' IEA or ecosystem modelling approaches (Levin *et al.*, 2016). There are a number of tools available, with Mental Modeler (Gray *et al.*, 2013) being the most frequently used among ICES groups. Mental Modeler is free, very simple to learn, and easy to use, meaning even complex models can be produced rapidly during a meeting, and scenarios tested immediately providing rapid initial feedback and facilitating shared understanding between stakeholders and scientists. However, outputs from conceptual models are highly dependent on the perspectives/individuals present during the exercise, and while they represent a valid view and capture important knowledge and information, they rarely capture the full range of sectors, pressures and components of interest/concern within a given ecoregion, and when they do, they become so complex and onerous to manipulate as to be almost useless. Furthermore, capturing and integrating the differences between stakeholder knowledge systems is difficult to achieve and may result in combined models becoming overly focused on driving components, thus reducing its usefulness to decision-makers (Gray *et al.*, 2012). For the purposes of the ICES EO network diagrams, it is likely that an ERA framework such as the ODEMM/AQUACROSS framework would still be needed to bring some degree of comparability and standardization, and to constrain analysis to at least some common components.

WGNARS used conceptual modelling to define transdisciplinary representations of the social-ecological system in an EBFM-focused IEA, forming separate submodels of the biological, physical and social components before merging them into a full model (DePiper *et al.*, 2017; Muffley *et al.*, 2020). This ensured each element was fully examined. An example from the Grand Banks included Human Activities, Ecosystem Drivers, Habitats, Human Benefits, and Biota. Support tables were used to allow for common aggregated components across systems (e.g. 'pelagic fish'), with detail providing specific elements that differs between examined regions (i.e. specific spp) and explicitly defining the system linkages. An interactive example of the approach can be viewed here. These models have been used for qualitative management strategy evaluations (MSE) as well as for communication purposes. In 2019 the interactive conceptual model linked above was used to scope questions for an ongoing quantitative MSE for the Mid-Atlantic Fishery Management Council. The interactive conceptual model, with concurrent presentation of linkage definitions, justification for inclusion, informational gap analysis, and available models, greatly facilitated the transition from ERA (Gaichas et al. 2018) to the quantitative MSE by allowing a fully transparent scoping process, conducted in collaboration with fishery managers (Muffley *et al.*, 2020).

WGINOSE, inspired by WGNARS, have been working with Mental Modeler since 2017, with a primary focus on the most relevant ecosystem components to assess and compare with ecological models (e.g. Ecopath with Ecosim) (ICES, 2020a). Through the 4 models built to date, there has been wide variation in the components included, with some focusing mostly on the ecological system, and others focusing primarily on the sectors, pressures, and high-level objectives. WGINOSE is actively investigating how to integrate multiple subregional mental models into a common framework, but this work is ongoing.

WKIrish used the prioritized outputs from an ODEMM analysis (top sectors and pressures) as a starting point for a mental modelling exercise with stakeholders (ICES, 2020b). Participants were asked to elaborate the key social and economic issues relevant to the identified top sectors and pressures. Due to the expertise in the room, the focus was largely on fisheries; however, the outputs provided useful information on social and economic issues of relevance to fisheries stakeholders. These outputs are conceptually similar to those of WGNARS, both of which could be used to help inform groups such as WGSOCIAL, WGECON and wider IEA groups as to stakeholder-identified relevant socio-economic aspects to be taken into account in EOs (e.g. through indicator development). This exercise presents an opportunity to combine two established IEA group methodologies to follow in the footsteps of NOAA (e.g. Levin *et al.*, 2014; Gaichas *et al.*, 2016; DePiper *et al.*, 2017; Holsman *et al.*, 2017; Muffley *et al.*, 2020) by moving from a conceptualisation of humans acting *on* ecosystems, to one of humans *as a part* of the ecosystem (Levin *et al.*, 2016), thus advancing the SIHD, moving towards integrated *social-ecological* assessment, and improving the EOs.

Cumulative Effects Assessment

Traditionally ERA focused on risks independently from one another; however, progress in recent years has evolved ERA to include Cumulative Effects Assessments (CEA) that work to take into account the potential interactions (beyond additive) between risks. A number of the 'quantitative' methods outlined in the 'Network Diagram Methodologies' take this into account (usually in an additive way). However, the ICES Working Group WGCEAM has been working on a methodology for ICES ecoregions which stems from the existing ODEMM/AQUACROSS projects. Thus, adoption of a common methodology across groups can provide multiple benefits by ensuring comparability and transferability of data and complementarity of methods thus facilitating common understanding, and eliminating redundancy in efforts.

Ecosystem Services

The proposed connection to ecosystem services as discussed in ToR a) was first considered in the AQUACROSS project (Culhane et al., 2018, Teixeira et al., 2018) but matured through an initiative by European Environment Agency (Culhane et al., 2020). For more information, see ToR a.

Marine Strategy Framework Directive

ODEMM and AQUACROSS considered links from the risk assessment framework through to the MSFD descriptors. However, initial efforts were comprised of an expert-based qualitative assessment of risk to GES for each Descriptor (Breen *et al.*, 2012). Pedreschi et al. (2019) instead developed a method to directly link the Descriptors to the risk assessment framework, allowing quantification of the risk to each Descriptor from the existing assessment. Further developments have linked the pressures and ecological components directly through to each of the MSFD criteria (draft report in background materials). This enables some linking through to key EU marine objectives and an examination of risk/threat to each of the MSFD Descriptors or GES criteria.

Foodwebs

Foodwebs have been highlighted as a key area priority area of development in the EOs within the next few years (ICES, 2019d). Although there are ongoing developments in relation to this (e.g. WKEWIEA, WKFooWI), there is also scope for incorporating progress on this aspect via conceptual modelling and linking the ERA network diagrams outlined herein to stakeholder-built ecological models (see above relating to WGINOSE/WGNARS/WKIrish). This could enable examination of the impacts of pressures on key elements of foodwebs (including productivity), thus also tackling concerns relating to indirect impacts.

A second contribution to Foodwebs is via the MSFD Descriptor 4 as outlined above.

Forecasting

A number of groups have expressed an ambition to carry out a forecasting risk assessment for the EOs, some in the context of climate change (longer term), others in the context of rapidly changing systems. While that has not yet been done (to our knowledge), it is envisioned that this would be possible, and a useful future development pathway that could be applied across IEA groups and informed by the climate change section of the EOs and work of the SICCME.

Ecosystem Status Reporting

While this is a key aspect of the IEA cycle, it is not directly related to the network diagrams of the EO, and thus has not been further elaborated here. However, it is informative and critical to other aspects of the EOs, and so is included under ToR a.

Integration of Traditional and Local Ecological Knowledge

Interview, oral history, and focus group data may provide a rich source for evaluating the nuances of beliefs and opinions, as well as investigating topics such as local or traditional ecological knowledge. Such methods are likely to provide complementary data and information that can contribute to the ERAs and inform conceptual mapping exercises. Furthermore, statistical analyses of code frequencies in coded textual data can provide deeper insight through improved understanding of traditionally held knowledge. This knowledge can then be used to inform baselines for assessment and the use and choice of assessment indicators.

The NOAA Alaska IEA Team is testing the use of focus groups to choose key indicators (including ecological indicators) and ground-truth measurement methods that are appropriate in local areas. This effort was intended to tie community well-being to fisheries beyond just commercial participation and economic welfare and to contextualize other components of well-being tied to fisheries uses in localized value systems (Szymkowiak and Kasperski 2021). This effort showcases "a methodology of applying the well-being framework to develop locally relevant quantitative indicators that can be used to track how fishery shocks may reverberate through social systems and affect fishing communities" (ibid., p. 108). Mapping social and ecological indicators at the same scales can lead to more sustainable environmental governance (re. Leslie et al., 2015). With more participation by Alaska Natives, Szymkowiak and Kasperski hope in the future to bring in traditional ecological knowledge of Native Alaskan groups, some of whom have been fishing the same areas for thousands (or even tens of thousands) of years (Huntington, 2000; Stephen Kasperski, pers. comm.). In the Northeast, similar efforts have been proposed to trial interviews with long-time and retired fishers to gather knowledge of how habitat has changed in their lifetimes (Patricia M. Clay, upubl.). The fishers would have niche-level knowledge that could complement larger-scale data collected by NOAA. These examples highlight how oral histories, interviews, and focus groups can be used to gather ecological as well as social, cultural, and economic data and/or create indicators for each of these domains.

Details of the Proposed Method

The ODEMM project provides an assessment methodology tracing sector–pressure–component pressure pathways (also known as 'linkage chains'; e.g. fishing-abrasion-benthic habitat or renewable energy-noise-marine mammals, Figure 3.1). The AQUACROSS built on ODEMM, expanding upon the established methodologies and applying it in new ecosystems. The ODEMM project carried out assessments for each of Europe's regional seas. In 2019, WGEAWESS used the ODEMM 'North-East Atlantic' (NEA) assessment as a starting point for the BoB-IC EO network diagram update (ICES, 2019e). In this assessment the ODEMM methodology was adapted to create a hybrid ODEMM-ICES methodology that provides the general structure and framework of the ODEMM approach, along with the simplicity and ease of use of the ICES guidelines. This hybrid methodology attempts to bridge the issues identified above in relation to the ICES methodology, whilst maintaining simplicity to facilitate uptake and use by ICES EGs with limited time and resources. This modification of the methodology focused on assessing three of the five ODEMM criteria that form the 'Impact Risk' score, omitting (at least in this first step) scores relating to 'Recovery' potential (resilience and persistence). The reasons for this were twofold. Firstly, primary consideration in the context of the EOs is given to 'Impact Risk' scores as the aim is to highlight key areas for management aspect, and secondly, for pragmatic reasons. However, should time/interest permit, the 'Recovery' aspects can be retained (or added at a later date) to facilitate additional analyses, depending on the needs/interests of the relevant IEA EG. These 'Recovery' aspects are also less variable (they depend only on the characteristics of the ecosystem component under consideration), meaning this is an aspect that can potentially be addressed in a collaborative cross-IEA group exercise.

In 2020, the approach was also applied for the Celtic Sea EO update, but a more recent analysis focused on the Irish EEZ (which makes up the majority of the Celtic Seas Ecoregion) was used as the starting point for this analysis (see Pedreschi *et al.* 2019).

Figure 3.1 Illustration of a 'linkage chain' or 'pressure pathway'. Each one consists of a sector that creates a pressure that affects a specific ecological characteristic/component

- **Note:** only **current status** and **direct effects** are considered. Within the overviews there is space to discuss potential future risks, but this assessment focuses on the **current situation.**

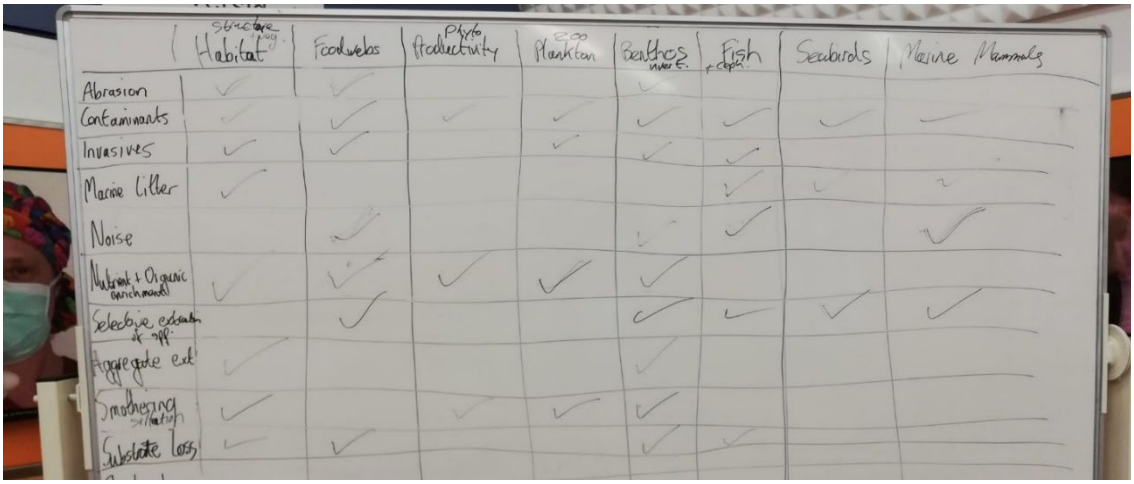
- **Note:** Climate Change is considered a driver in this context. Climate change interacts with too many pressures in diverse and indirect ways for it to be considered in a framework such as this. Instead, climate change is discussed in the climate change section of the EO. However, there are regions in which climate change relates to rapidly evolving pressures (e.g. melting ice) and so these EGs have specified a need to include this as a pressure. WKTRANSPARENT may consider adding a 'Sector' of 'Exogenous Activities' referring to pressures manifesting from outside the management area.

Methodology:

STEP 1 – LINKAGE FRAMEWORK

- The first step in the assessment is to produce the 'linkage framework'. This is a relatively simple interactive exercise where a matrix is produced outlining which pressures affect which states/ecosystem components (from the provided ICES list). This exercise can be carried out informally, with all members of the group from the ecoregion contributing to the discussion, and providing examples/justification from their expert knowledge. At this point, there is no scoring of attributes, only establishing a link through X's in boxes.
- In the WGEAWESS work, the ODEMM North-East Atlantic (NEA) assessment was amended to merge with the ICES EO categories. Since WKTRANSPARENT, linkage framework templates with agreed categories of ecological components, along with definitions of each (see ToR C), have been provided for EGs to fill out. These templates are now hosted on the [Ecosystem Overview Sharepoint]().

Figure 3.2 The Pressure-State linkage framework produced for the BoB/IC during WGEAWESS 2019.



- If working from an existing framework (e.g. original ODEMM analyses), this linkage framework can be used to inform tailoring of the ODEMM assessment to the EG EO area. As a first step, the categories needed to be made comparable. Examples of this process can be found at (ICES, 2019e).

STEP 2 – RISK ASSESSMENT

- ODEMM assessments consist of five scores that are assigned for each of the individual sector-pressure-ecological component linkage chains (outlined in Figure 3.3). For this assessment, it was agreed that the top risks are what should be outlined in the ICES ecosystem overview diagrams, and therefore, analysis continued considering the first 3 scores only; spatial extent (or 'overlap'), frequency of occurrence, and the Degree of Impact (a.k.a. severity/magnitude) which are combined to produce the 'Impact Risk' score. These scores reflect the scoring in the EO guidelines which contain scores for magnitude and probability of occurrence (a product of the spatio-temporal overlap of pressures and ecological components). Scores for 'Persistence' and 'Resilience' which together give an estimate of the time to recovery (Recovery Lag) are omitted.

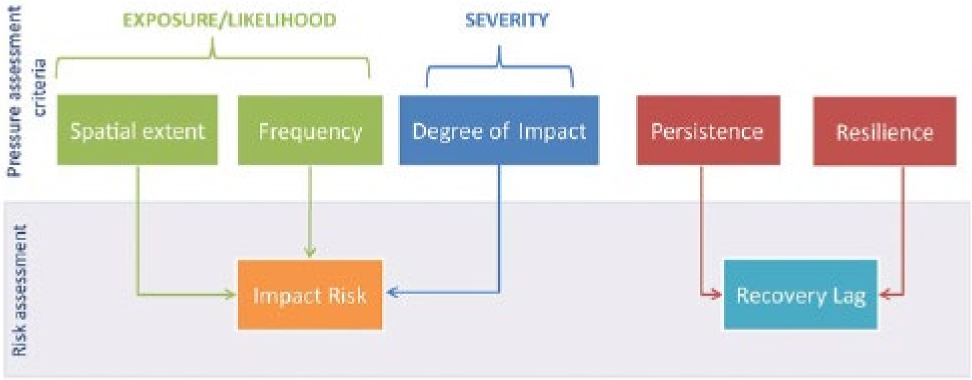


Figure 3.3 Pressure assessment criteria, illustrating how they are grouped to calculate the I*mpact Risk* and *Recovery Lag* scores for the risk assessment (taken from Robinson *et al.* 2014. Fig 5.2). WKTRANSPARENT focused on the Impact Risk Elements.

- For each linkage chain in the linkage framework, scores must be assigned for each of the elements; Spatial Extent, Frequency, and Degree of Impact. A template for this spreadsheet has been provided on the Ecosystem Overview Sharepoint. EGs must use the linkage framework to assign which elements are not of concern in their EO of interest, by marking them as 'NO' (No Overlap) in the 'Spatial Extent' column.
- The panel must then review/assign scores for each of the identified linkage chains. The first time this is carried out it will be a time-consuming process – particularly if starting from scratch. However, many ecoregions have existing 'state of the environment' reports from national agencies, or from their own EGs that can help to inform this. Data such as maps, where available, should be used to inform scores (and documented).
- As a pragmatic approach, 'bundling' can be used in order to speed up the process, or to provide a first pass for review by EG colleagues (it is often easier to react to and change scores than to try to produce them *de novo*). For instance, Spatial Extent values can be assigned to a Sector and Ecosystem Component, and applied across all pressures. **It is essential that these scores are then reviewed and adjusted.**
- The first scoring category 'Extent' refers to the spatial overlap between the sector (or pressure if known) and the ecosystem components. This requires broad scale knowledge of the activities taking place in an ecoregion. Categories are relatively broad, and were defined as follows:
    - **Exogenous** (activity occurs outside of the area occupied by the ecosystem component, the pressures would reach the ecosystem component through dispersal)
    - **Site** (>0-5% overlap)
    - **Local** (5-50%)
    - **Widespread patchy** (>50%)
    - **Widespread even** (>50%)

Similarly, scores can be assigned at the sector level and (cautiously) applied to all of its pressures (unless there was a specific reason to change this). For instance, 'Aggregate extraction' is known to be a very site-specific activity, therefore the spatial extent will never be higher than 'Site'.

- Next is 'Frequency of Occurrence' of the pressure from a specific sector. Scores are based on the frequency of the impacting activity (in an average year) and informed by the nature of the pressure in a similar fashion to the 'extent' scores. Categories for Frequency are:
  - **Rare** (e.g. occurs in one month per year)
  - **Occasional** (e.g. occurs in 4 months per year)
  - **Common** (e.g. occurs in 8 months per year)
  - **Persistent** (e.g. occurs in every month of the year)

  For example, Fishing and Shipping are known to occur throughout the year in the ecoregion, however the introduction of 'Non-native invasive species' (and establishment) is considered to happen only rarely.
- Degree of Impact/Magnitude scores. In a diversion from the ODEMM methodology, but in keeping with ICES methodology, scores were assigned from 1 (low) to 3 (high). As outlined in the 'Issues' section above, it was unclear how to assign these scores, so scores were interpreted using the ODEMM guidelines.
  - **Low** is assigned to a pressure not considered to (currently) produce population level/functional group effects
  - **Chronic** is assigned to pressures which may have a population level/functional effect if it has a high enough spatial and or temporal occurrence (i.e. chronic nature)
  - **Acute** is assigned where acute (immediate) impacts are expected/known to occur.

In keeping with ODEMM methodology, each score is assigned ***independently*** of the other scores. For instance, degree of impact of a specific pressure on an ecosystem component is not expected to change depending on the sector causing the pressure; i.e. 'Abrasion' affecting 'Habitats' will have the same effect on them whether it is caused by 'Fishing' or by 'Navigational Dredging'. This feature means that once the score is agreed for the effect of abrasion on habitats, it can be applied for all sectors causing this pressure to affect the habitat. This speeds up the review process.

NOTE: For groups with capacity/interest in carrying out a full assessment, full scoring criteria are provided in the supporting documents on the Sharepoint. Scores for Resistence and Resilience allow calculation of Recovery Lag. Scoring 'Dispersal' (see later) and apportioning 'Pressure Load' across sectors facilitates integration with WGCEAM's cumulative effects analysis. These represent optional next steps for groups that adopt this approach.

Analysis:

- Impact risk scores per linkage chain are calculated as the product of the assigned three scores (i.e. spatial extent x frequency of occurrence x degree of impact scores).
- There are a number of options for how to analyse and present the resulting data. The analysis was carried out following the guidelines provided in the ODEMM guidance documents and published papers (for full methodological details see: Robinson and Knights, 2011; Knights *et al.*, 2013, 2014; Robinson *et al.*, 2013, 2014; White *et al.*, 2013; Piet *et al.*, 2015).
- 'Proportional Connectance', and 'Impact Risk' (product of the 'overlap', 'frequency' and 'degree of impact' scores) boxplots and estimates can be produced in R as per Pedreschi *et al.* (2019). The code used to produce these estimates is publically available for use at (http://github.com/PaulBouch/ODEMM_Celtic_Sea). The modified/updated script for

this analysis is on the WKTRANSPARENT sharepoint. The results are shown in Figure 3.4.

- The 'top' risks can be calculated in a number of ways
  - The sum of impact risk scores of all linkage changes belonging to a category
  - The mean of impact risk scores of all linkage changes belonging to a category
  - The top scoring individual linkage chains

Both the sum and the mean are influenced by the number of impact chains present although 'summation' is less sensitive to such fluctuations. For this reason, both are illustrated in Figure 3.4, alongside proportional connectance values, which indicate centrality in the network (e.g. for sectors it indicates how many connections they have to the pressures and ecological components in the network, but with no indication as to the magnitude of the risks/impact). Presenting these metrics together helps to avoid the bias possible using one method alone.

- As the goal of these diagrams in the EO is to provide information on the 'top' or most important pressures in the ecoregion, the relative contribution of each sector and pressure to the overall risk score is calculated and used to identify the top sectors and pressures that should be illustrated in the diagram and elaborated in the text. To do this, each impact risk score is calculated as a percentage of the total risk (=sum of all chains) in the ecosystem, and those contributing more than 1% to the total risk score are identified as top risks relevant for management action (Piet et al. 2015). This results in highlighting the highest-impacting (highest Impact Risk score) individual linkage chains to identify foci for action to decision-makers (Piet et al. 2015). The components contributing to these chains in the BoB-IC are highlighted in Table 3.2.
- When the filtration exercise results in fewer than 5 top sectors/pressures, the next highest risk contributing sectors were also added to Table 3.2 to provide the top 5 Sectors and Pressures. With their addition, Table 3.2 now represents the top 34 linkage chains that account for 51% of the risk in the example system.

Table 3.2. The components contributing to the highest impacting linkage chains, and the percentage of impact risk in *the whole BOB-IC system* associated with them (in brackets). Sectors in grey do not appear in the 'top risks' filtering exercise but are included in the top 5 sectors for the EOs.

Sector	Pressure	Ecological Component
Fishing (43%)	Species Extraction (15%)	Benthos (29%)
Shipping (19%)	Abrasion (14%)	Habitat (23%)
Tourism/Recreation (18%)	NP/Organic input (13%)	Fish (14%)
Land-based Industry (8%)	Siltation/Smothering (11%)	Plankton (12%)
Agriculture (6%)	Sealing/Substrate Loss (4%)	Mammals (12%)
		Seabirds (10%)

Figure 3.4 Proportional Connectance, Impact Risk, and Impact Rank Boxplots. Each component assessed is listed in order of its average Total Risk Rank. The thick black vertical lines on the boxplots indicate the median values, with the box lengths representing the 25% quartiles and the whiskers representing 1.5 times the interquartile range. Outliers are shown as black dots. The small Impact Risk scores have been log-transformed ('Impact Rank') to allow visual comparison

between the assessed components. Components are ordered on the y-axis in order of the sum of their Impact Risk (top=high, bottom=low) to aid interpretation. For instance, Fishing has the highest risk scores regardless of the metric used (sum or mean), and has a high proportional connectance, but not as high as that from Aquaculture. In contrast, looking at the pressures we can see that if using Sum as the metric for ranking, Contaminants come out on top, whereas when using the Mean Species Extraction comes out as the highest risk – this is due to the differences in their connectance values (contaminants has many low scoring linkage chains (low mean) but that when summed add to a high value (high sum)).

- There are a number of options for how to illustrate the above information when producing the EO network diagram.
    - Firstly, the components can be ordered according to:
        1. The sum or mean of impact risk (or total risk) scores of *the top linkage chains* belonging to a component
        2. The sum or mean of impact risk (or total risk) scores of *all linkage chains* belonging to a component

Both the sum and the mean are influenced by the number of impact chains present although 'summation' is less sensitive to such fluctuations. Reviewing these metrics together helps to avoid the bias possible using one method alone. In general, it has been recommended that EGs order according to the summed impact risk across all linkage chains (see Technical Guidelines ToR C).

- A second concern is the 'thickness' of the connecting lines. Discussion, reflection within the group, and feedback from ADGECO indicate that thickness of the lines appears to convey magnitude rather than number of connections, and so the thickness should be related to the risk scores, as this is easier and more intuitive to understand. Thus, the thickness of the lines have now been determined based on the sum of the Impact Risk scores of the elements illustrated in the diagram divided into 3 bins (dependent on assessment scores) to reflect the ICES guidelines.

While the approach outlined above is not as simple as the existing framework, it does work to tackle some of the issues put forward in relation to its implementation. It also facilitates further analyses informative for IEAs and is less susceptible to influence and/or bias.

Outstanding issues for consideration

WGEAWESS received feedback that some reviewers felt that connections were missing from the diagram. This is no doubt due to the fact that not all elements are illustrated in the diagram, only those relating to the top pressures/linkage chains as requested by ICES in an effort not to overload the diagrams and facilitate communication. However, WGEAWESS did put forward a proposal for consideration by WKTRANSPARENT that would enable inclusion of all connections relevant to the illustrated elements, but with those not in the top risks in grey (e.g. Figure 3.5). This suggestion was accepted by WKTRANSPARENT, and is included in the Technical Guidelines (ToR C).

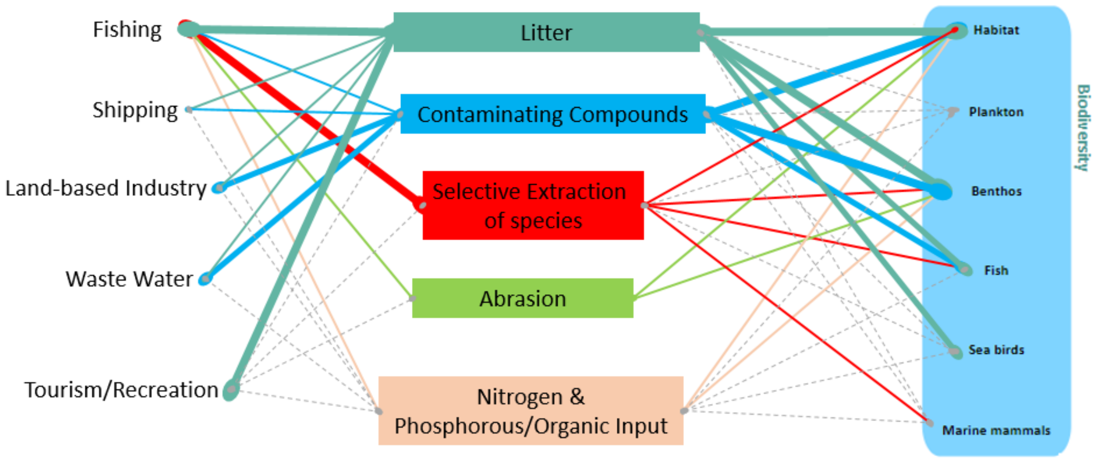


Figure 3.5 Mock-up diagram illustrating the full suite of linkages, with those not in the 'top risks' as identified by relative contribution values illustrated with grey dashed lines. This would help to illustrate that all connections have been evaluated, but only the highest risk ones are presented for further analysis/discussion.

- Further suggestions were made for ways in which to combine the two diagrams from WGEAWESS 2020 (Celtic Seas EO) in order to highlight the pressures with both the highest summed risk score, and the highest average risk scores, by simply editing text sizes (Figure 3.6). This was deemed to be too complex and thus confusing rather than clarifying the message, and as such was not adopted by WKTRANSPARENT.

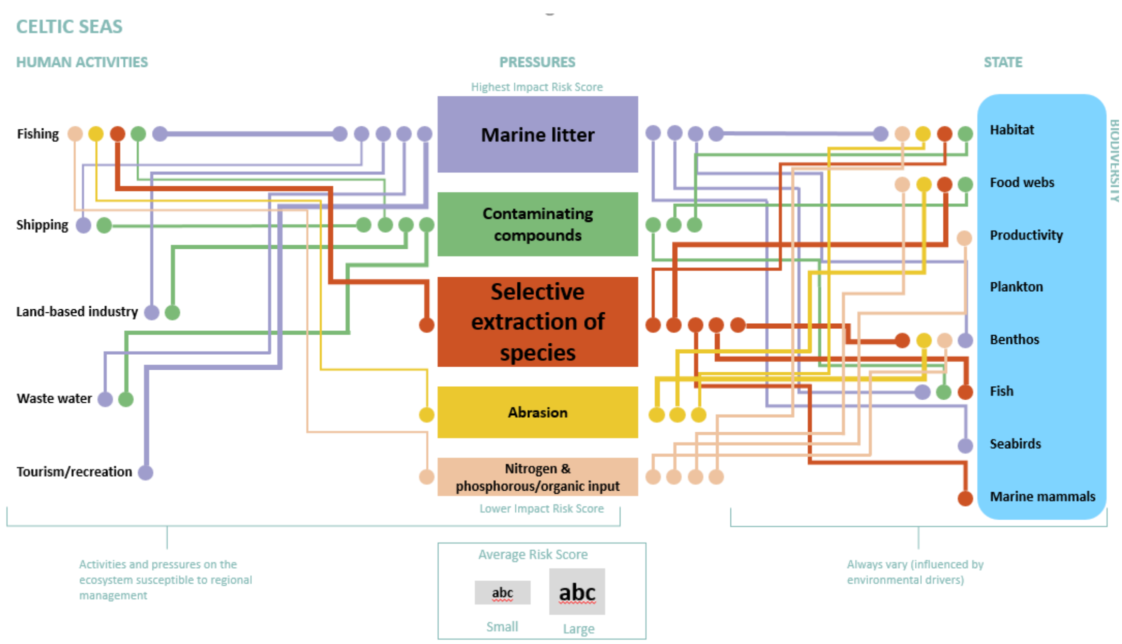


Figure 3.6 Proposal for including summed impact risk AND average impact risk data into the EO diagram.

- In the AQUACROSS project, Borgwardt *et al.* (2019) suggest replacing the simple 'product' calculation for Impact Risk used here with Euclidian distance from the origin on a consequence-severity plot (a standard PSA approach used by a number of CEAs). However Battista *et al.* (2017) advocates for the retention of the product stating that 'resulting risk scores more accurately represent the potential impact of a given threat on a system, making them more appropriate for comparison with risk scores from other threats, or at other sites as it results in similar risk scores for threats with different intensity and impact characteristics, but that would result in the same potential consequences'. Retaining the product approach is not only simple, but also facilitates cross-EO comparisons of absolute risk (through a common dimensionless score and relative risk comparison). This recommendation was accepted.

- It was recognized that some regional variation in the detail of assessment that is useful within the EGs may be present. As such it was suggested that the agreed upon ecological components required for the Ecosystem Overviews may be determined from a more detailed analyses, however there should be a common hierarchy for these components. An example hierarchy is presented in Annexe 5.

Recommendations forward:

- The number of individuals and the expertise that take part in the assessment should be documented (e.g. in the WG report)
- Strawmen should be useed when available – they provide extremely useful starting points for discussion
- Removing Productivity and Foodwebs from the diagram is generally accepted, however it is important that these issues/topics are addressed elsewhere in the EOs
- This exercise provides an opportunity to improve cross-group expertise and collaboration, and should be used to do so – it also provides an opportunity for wider critical evaluation – however, remember engagement needs to be managed in order to ensure the workshops/assessment are run in a consistent manner
- Capacity is a concern for running more in-depth assessments – however the hierarchical approach was agreed as an effective way to allow groups to engage at their level, while keeping outputs high-level and useful for advice recipients
- There were important discussions on how the approach can be expanded in relation to Ecosystem Services, but also to take account of processes which may provide an additional useful avenue for including Foodwebs and Productivity.
- The framework may provide a common language across IEA (and other) groups in which to examine various aspects including ecological processes, impacts, cumulative effects, ecosystem services, benefits, and even objectives
- Although there is much potential to allow the system to become very complex, it must remain an operational approach that can be applied across all ecoregions
- It is important to document evidence/information underpinning decisions. At a minimum this can reflect confidence (1 = qualitative judgement, 2 = literature support, 3 = data support) – in the case of the latter 2, the source should be documented.
- A training event for IEA Chairs may be hosted by the IEASG Chair to help kick-start the process (after Technical Guideline approval by ACOM).
- Questions were raised as to how to include stakeholder knowledge in such an approach. An iterative approach of developing initial assessments with scientists before engaging with stakeholders/managers to amend/review/provide input has worked well in NOAA and WKIrish contexts (see comment above in relation to strawmen), and may provide a suitable template for IEA groups. It was also highlighted that the scale of ecoregions that the EOs operate at may not be conducive to such knowledge, as stakeholder knowledge can often be more locally-specific. Finally, a workshop on working with stakeholders to develop conceptual models has been proposed for late 2021.

The recommendations and outcomes from ToR B were included in the development of the Technical Guidelines under ToR C.

4 Technical guidelines for ecosystem overviews

The currently existing technical guidelines for ecosystem overviews were published in 2018. While developing updated document, WKTRANSPARENT took into account comments received on the currently existing guidelines from individual experts contributing to ecosystem overviews as well as from ADGECO (2019 and 2020) meetings. Most of the preparatory work was carried out in advance of the meeting, and only outstanding issues were discussed during WKTARNSPARENT meeting. A very few outstanding issues were also solved after the meeting. The following sections (with six Annexes A-F) contain updated technical guidelines for ecosystem overviews, also including: i) proposed revised sections list, ii) the update and revision process, iii) the feedback mechanisms, iv) pipeline process to incorporate new topics, and v) proposal for major revision in the methodology for the human activity-pressure-ecosystem state component network figure.

Introduction

The Ecosystem Overviews (EOs) are key products in the ICES approach to support Ecosystem Based Management (EBM). The EOs complement other types of advice, providing supporting context and allowing users to understand the implications of sectoral decisions and impacts in an ecosystem context. The overviews are not meant to be a catalogue of all available information on the ecoregion. EOs aim to provide quantitatively supported science-based statements (where possible) complimented by qualitative expert assessment where data are poor or lacking in key areas, that are of use to ICES advice requesters, stakeholders, and regional managers. The overviews are intended to progress the delivery of integrated advice taking account of the effects of multiple human pressures on the environment, accounting for the effects of the most influential environmental and ecosystem processes, and considering multiple objectives.

The EOs are developed through a set of workshops and are based on information provided by ICES integrated ecosystem assessment groups and other expert groups that specialize in state descriptors and using automated data products and GIS layers from accepted legitimate sources. The ecosystem overviews are completed by an advice drafting group and approved by ICES Advisory Committee, ACOM.

The EOs are included in a number of ICES cooperative agreements with national agencies and international organizations and commissions, and also reach a broader audience of the scientific community, including the ICES network. Given this broad audience, the overviews evolve by both top–down processes (advisory requests and ICES decisions about strategic direction) and bottom–up processes (information streams highlighting “new” science products from the ICES network).

Figure 4.1 ICES ecoregions.

Purpose and structure

As one of ICES advice products, the purposes of the ecosystem overviews are to:
1) identify key signals inside and outside the ecoregion which need to be taken into account for EBM;
2) describe the:

a) location, scale, and the management and assessment boundaries of the ecoregion;
b) main regional pressures (in space and time) and associated human activities on the environment and ecosystem;
c) state of the ecosystem components (in space and time) and assess pressures, including climate change, accounting for changes in state;
d) relevant social-economic aspects to the extent possible, including ecosystem services, benefits and values to the society.

The overviews describe regionally manageable anthropogenic pressures and outline the implications of key global drivers, such as climate change. They summarize the trends in the predominant pressures and human impacts that affect living resources, and outline the implications of variability in the system. The information is based on the best available evidence, and highlight areas in which data are lacking/needed.

The overviews are structured around seven sections:

1. Contents list;
2. Key messages – summarize key signals (external and internal) in the ecoregion which need to be taken into account for EBM;
3. Ecoregion description – maps and text showing boundaries of ecosystem and depth contours, relevant subregions, management and assessment regions, human usage, catchment areas, and designated areas (i.e. Natura 2000 areas);

4. Management – describe the management frameworks and legislative instruments within each ecoregion;
5. Pressures - identify regional priorities, listing the predominant pressures in the ecoregion, with an indicative list of activities;
6. Ecosystem state - short concise descriptions of the main state of the ecosystem components within each ecoregion, linking the selected pressures to the state of the ecosystem;
7. Climate change impact – describe and if possible, quantify climate change effects affecting the ecoregion.

Technical guidelines

The guidelines below apply to the production of ecosystem overviews:

- Non-changing elements such as geography should not be described in detail, nor should key attributes of systems that are very well known to the expected readership;
- Though systems are complex in reality, simplification is a necessity. Only top pressures should be identified for further analysis. The approach taken should be made explicit in the EO;
- All ecosystem state elements are displayed in the pressure-state diagram, independent of whether direct links to pressures were identified or not. If no links are identified, this will be clear as no connecting lines will be present;
- EOs are ecoregionally specific and written for the region as a whole; any important differences within the region can be reflected in a few brief subregion bullets;
- The text should be assertive and use specific language, without too many qualifications, stating what are facts and what are not (i.e. where information is uncertain or data are lacking);
- Visual tools should be used (where possible), simplified to a degree so that results are intelligible and useful;
- Information/details on the spatial scale, uncertainty/confidence and any aggregation of time-series, and time series length should be provided;
- Where data from an area is partial, e.g. if three out of four countries are providing data for a region, a pragmatic approach assessing whether the available data may be considered to give a reliable impression of trends/pressures, etc., across that region will be taken;
- Data and knowledge sources must be fully cited. Unpublished or not validated sources should not be used;
- Where possible, production should be automated using GIS methods, open databases and methodologies;
- In general, abbreviations should be spelled in full when first mentioned. For organizations (e.g. OSPAR) and technical abbreviations (such as B_{lim}), hyperlinks to websites and/or relevant documents should be made.

Update, expansion and revision

The process involves the three following categories:

1. Update: annual updates of limited information such as fisheries figures and the correction of mistakes. The updates are coordinated by both the Secretariat and the IEA groups. This is achievable during annual expert group meetings;

2. Revision: includes complete review and revision of the EO, the process recommended around every 5 years. To follow the methodology, presence of a wide range of expertise is critical. Requires substantial intersessional work and is therefore not achievable during the routine EG meeting. The following guidelines apply for the revision process:
   - Review activities-pressures-states diagram and propose modifications, as appropriate;
   - Make all changes in the currently published EO visible (i.e. track changes) and supply with additional references;
   - References should be included in the working document;
   - Before starting the revision process, contact ICES secretariat to identify new products and layout that can/should be applied to your ecoregion https://www.ices.dk/advice/advisory-process/Pages/Ecosystem-overviews.aspx;
   - The updated EO is then subject to the established advisory process (see here).

3. Expansion: addition of new items from the pipeline (details below). Requires intersessional work with input from one or more expert groups and involvement of ACOM and secretariat in the process.

Incorporation of new topics through the Pipeline process

To purpose of the pipeline is to secure the further development of EOs through:

- encouraging more EGs to engage in thinking about the potential contribution of their work to EOs;
- providing a more formalized development and testing ground for products that may become part of EOs;
- familiarizing scientists in the ICES network with the good practice and quality criteria for inclusion of products into the advisory evidence-base;
- providing EGs with regular feedback, review and steering to assist them in developing products for the EOs.

Five-step process:

Step I – Initial scoping and defining of a new topic.

The proposed new topic should ideally meet all eight criteria (see below). The new topic should generally be proposed either by the ICES community or stakeholders and address a specific management objective.

Step II – Quality assured data and knowledge development.

This step involves mostly ICES expert group development of the new product, including knowledge development, synthesis, and assurance of data quality and transparency. These activities may take place in existing working group meetings or dedicated workshops.

Step III – Peer review.

Peer review of the science output (from Step II) by the independent external reviewers and also by ACOM. This stage should strictly follow ICES guidelines of advice. Feedback is then provided to the experts, which may include a request to clarify issues and/or revisions to the product.

Step IV – Drafting the advice and transfer to TAF.

Drafting the advice by Advice Drafting Group (ADG). Transfer of the product methods, data and outputs to Transparent Assessment Framework (TAF). This stage should strictly follow ICES guidelines of advice. During the drafting step, the ADG may ask experts to clarify issues.

Step V – Approval of the advice and publishing.

Approval of the advice by ACOM and inclusion of the product in the EOs.

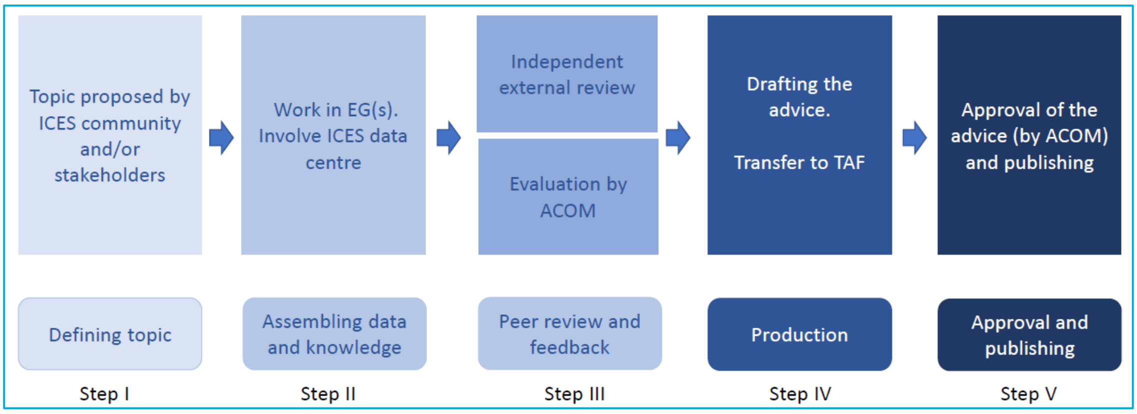


Figure 4.2 The five-step process of EOs for inclusion of new topics. In all steps lead experts will be supported by ICES Secretariat and followed by ACOM leadership.

Inclusion criteria:

Ideally, the proposed new product should:

1. Support the role of Ecosystem Overviews as previously outlined by WKECOVER;
2. Be identified as high-priority topic by WKEO3;
3. Be of interest of an ICES client commission(s) and/or stakeholder(s);
4. Be based on mature and peer-reviewed science;
5. Be supported by capacity of experts to periodically update the product; i.e. availability of experts with the required skills, and resources (incl. time) for providing and analysing data, and delivering text/contributions;
6. Be applicable for all (most) ICES ecoregions;
7. Be based on quality-assured data which follow the FAIR (Findable, Accessible, Interoperable, Re-usable;) data principles;
8. Follow the Transparent Assessment Framework (TAF).

To initiate the process for the inclusion of a new topic:

Please provide maximum 1-page (see Annex D) by defining your topic (brief title) and addressing the inclusion criteria as outlined above. Please send your proposal to Inigo Martinez (Inigo@ices.dk). It will be reviewed by ACOM leadership and ACOM.

Feedbacks

Feedback from experts

Purpose: to correct factual errors in the ecosystem overview and provide review of text with appropriate justification:

i) Identify the problem;
ii) Provide suggested text (and display material, if needed);
iii) Provide references (unpublished or not validated sources should not be used);
iv) In case of concerns on the activities-pressure-state figure, clearly state the issue with justification.

Feedback from the Advice Drafting Group

Purpose: to ensure feedback loop from the advisory process to experts

i) Provide the list on the changes made in the substance of the draft text, together with justification;
ii) Provide reasoning and necessity for the technical changes made;
iii) Provide information on any key discussions held during the advisory process relevant for further improvement of the EO.

Methodology to develop pressure – ecosystem state relationships (the network diagram)

The core of the EOs are network diagrams that illustrate the **current** main regional pressures with (a) the main human activities that cause these pressures, and (b) the ecosystem state components most impacted by these pressures (Figure 1, an example from the Celtic Seas ecoregion EO). These network diagrams are informed by a Driver-Pressure-State approach using a linkage framework and pressure assessment process that examines and scores all **direct** pressures and human activities relevant to a given ecoregion. The assessment is semi-quantitative, informed by both quantitative (where available) and qualitative (e.g. expert judgement) information where little or no quantitative information is available. The number of individuals and their expertise should be noted in the relevant expert group reports. The steps are as follows:

STEP 1 – LINKAGE FRAMEWORK

- Identify all relevant pressures and human activities present in the ecoregion (see Annexes A-B).
- Produce two matrices (xls file format) indicating: i) which human activities create which pressures, and ii) which pressures affect which ecosystem state components (see Annexes A-C, E). This exercise can be carried out at expert groups meetings, with all members of the group from the ecoregion contributing to the discussion, and providing examples/justification from data sources and their expert knowledge. At this point, there is no scoring of attributes, only establishment of links. The templates are available on the Ecosystem Overviews Sharepoint Site here.

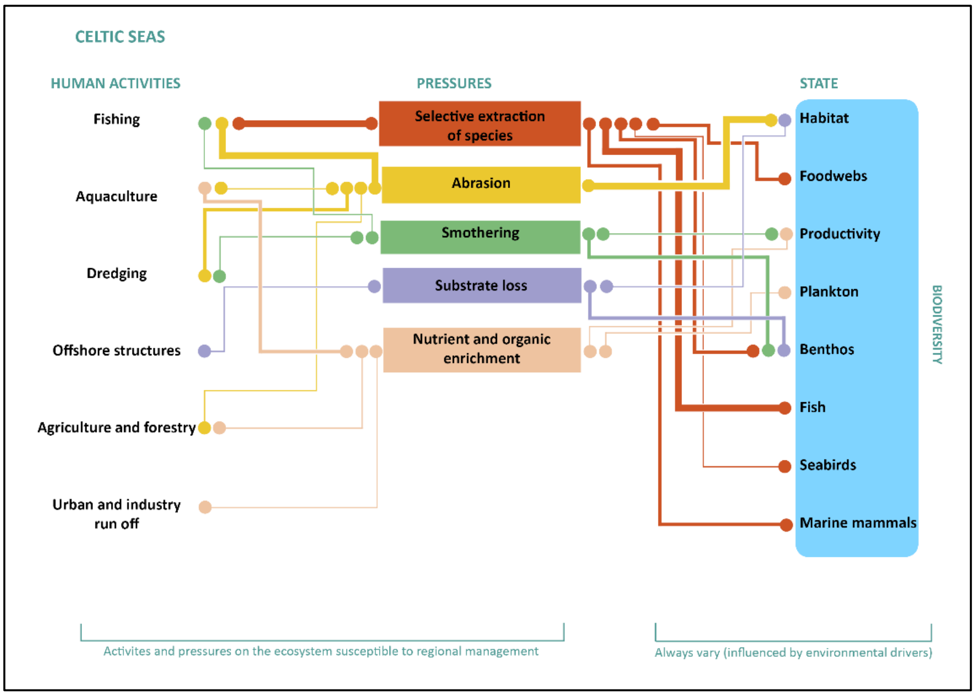


Figure 4.3 Main regional pressures. An example from the Celtic Seas ecoregion EO.

STEP 2 – RISK ASSESSMENT

- Categorical scores are assigned for each of the identified linkage chains (human activity-pressure-ecosystem state component), for each of the elements: i) spatial extent, ii) frequency of occurrence, and iii) degree of impact. Data should be used to inform scores (and documented) where available. Existing 'state of the environment' reports from national agencies can also be used to inform assessment.
- **'Spatial extent'** refers to the spatial overlap between the pressure and the ecosystem state components. The spatial distribution of the pressure may be inferred from that of the activity but, depending on the pressure, may differ due to e.g. dispersal. This requires broad scale knowledge of the human activities and their pressures taking place in an ecoregion. Categories are relatively broad, and are defined as follows:
  - **Exogenous** (activity occurs outside of the area occupied by the ecosystem state component, the pressures would reach the ecosystem component through dispersal)
  - **Site** (>0-5% overlap)
  - **Local** (5-50%)
  - **Widespread, patchy** (>50%)
  - **Widespread, even** (>50%)
- **'Frequency of occurrence'** of the pressure from a specific human activity. Scores are based on the frequency of encounter between the pressure and ecosystem component (in an average year) in the area of overlap. This is pressure-specific. Categories for frequency are:
  - **Rare** (e.g. occurs in one month per year)
  - **Occasional** (e.g. occurs in 4 months per year)
  - **Common** (e.g. occurs in 8 months per year)
  - **Persistent** (e.g. occurs in every month of the year)

- **Degree of impact** is the severity (or likely degree of impact) of any pressure when it encounters an ecosystem component. The following scores apply.
    - **Low** is not considered to (currently) produce population level/functional group effects
    - **Chronic** pressures may have a population level/functional effect if it has a high enough spatial and or temporal occurrence (i.e. chronic nature)
    - **Acute** (immediate) impacts are expected/known to occur.
- Each score is assigned ***independently*** of the other scores. For instance, degree of impact of a specific pressure on an ecosystem state component is not expected to change depending on the human activity causing the pressure; i.e. 'Abrasion' affecting 'Habitats' will have the same effect on them whether it is caused by 'Fishing' or by 'Navigational Dredging'.
- Evidence/information used to underpin each decision/scoring should be documented. At a minimum this can reflect confidence (1 = qualitative judgement, 2 = literature support, 3 = data support), however sources should be provided where possible.
- For the example template of risk assessment, see Annex F. The full templates are available on the Ecosystem Overviews Sharepoint Site here.

Table 4.1 Definitions for categorical scores in Step 2, and their corresponding quantitative scores for Step 3.

Spatial extent	Frequency of occurrence	Degree of impact
Spatial overlap of each activity-pressure combination with an ecosystem state component	Temporal overlap of each activity-pressure combination with an ecosystem state component	the severity (in terms of likely degree of impact) of any human activity/pressure interaction with the ecological component
No Overlap 0 No overlap between human activity and ecosystem state component	If there is no overlap, the pressure is linkage chain is not considered further in the framework	
Exogenous 0.01 The activity occurs outside of the area occupied by the ecosystem state component, but one or more of its pressures would reach the ecosystem state component through dispersal		
Site 0.03 Human activity overlaps with an ecosystem state component, but less than 5%	**Rare** 0.08 A pressure is introduced up to 1 months of the year	**Low** 0.05 Never causes high levels of mortality or habitat loss/ never causes a noticeable effect for the ecosystem state component of interest in the area of interaction
Local 0.33 Human activity overlaps with an ecosystem state component by more than 5% but less than 50%	**Occasional** 0.33 A pressure is introduced up to 4 months of the year	**Chronic** 0.2 An impact that could have detrimental consequences if it occurs often enough or at high enough levels
Widespread Patchy 0.67	**Common** 0.67	

Human activity overlaps with an ecosystem state component by 50% or more with a patchy distribution	A pressure is introduced up to 8 months of the year	
Widespread Even 1 Human activity overlaps with an ecosystem state component by 50% or more with an even distribution	**Persistent** 1 A pressure is introduced throughout the year	**Acute** 1 A severe impact over a short duration. An interaction that kills a large proportion of individuals and causes an immediate change in the ecosystem state component

STEP 3– ANALYSIS/DIAGRAM

- Categorical scores are converted to numerical scores according to Table 1. Impact risk scores per linkage chain are calculated as the product of the three scores assigned in Step 2 (i.e. spatial extent x frequency of occurrence x degree of impact scores). Each impact risk score is then calculated as a percentage of the total risk (=sum of all chains) in the ecosystem, and those contributing more than 1% to the total risk score are identified as top risks relevant for management action.
- The 'top' risks illustrated in the EO diagrams represent the linkage chains that contribute the most (≥1%) to the overall risk score, and the top five pressures in a given ecoregion are those with the highest summed impact risk scores per pressure. The percentage of risk illustrated in the diagram is provided in the figure heading.
- Human activities and ecosystem state components are ordered in relation to their summed impact risk score (largest contributors on top, lower contributors on bottom). Linkages that exist but do not contribute to the top risks are illustrated using grey dashed lines.
- In the case that the top risks (≥1% contribution to total impact risk score) identify fewer than 5 human activities or pressures, summed impact risk scores per human activity/pressure can be used to identify the next highest ranking human activities and/or pressures. If this is the case, this should be noted in the figure title.
- Thickness of the connecting lines are determined based on the sum of the impact risk scores of the elements illustrated in the diagram divided into 3 size-class bins (thus thickness reflects magnitude).
- Further comprehensive analyses are available via R script here, with outputs included in integrated ecosystem assessment expert groups reports.

Climate change impact

Climate change is incorporated in the EOs as a distinct pressure/driver which is not manageable at the ecoregional scale (and as such not included in the top five pressures). Climate change affects the environmental context and may operate across all human activities and ecosystem state components. A separate climate change section follows the pressure section and should include and distinguish:

- Evidence of **ongoing effects** of climate change on relevant environmental variables, ecosystem state components and/or human activities, based on **past and present observations** (e.g. time-series of sea surface temperature, atmospheric forcing, or upwelling strength; and temporal variations in plankton species composition, fish spatial distribution, or marine traffic distribution, in response to one or more environmental drivers).

- Evidence of **anticipated effects** of climate change on relevant environmental variables, ecosystem state components, or human activities, based on **future projections** (e.g. forecasted anomalies in sea surface temperature, projected species distribution in response to future thermal regimes, projected spatial distribution of fishing effort with shifting productivity, etc.)
- A description of **possible effects** on **strengths of relationships** between the top five pressures and human activity and/or ecosystem state components (e.g. ice cover reduction will open new routes for maritime transport that can increase the introduction of contaminating compounds and negatively impact the state of marine mammals).
- A brief paragraph listing the **key knowledge gaps** for assessing climate change impacts on the ecoregion.

For ongoing (observed) effects, evidence of climate change should consist of directional trends and/or persistent changes in the mean or variance. For ecosystem state components and human activities, trends should be expressed over time and in association with one or more environmental drivers.

For anticipated effects and model-based projections, downscaled (or regional) models should be used whenever possible. If regional models are not available, global ensemble models may be used, but the uncertainty layer associated with the projection should be presented.

Where climate change has been shown to affect a component in the state sections of the ecosystem overviews, a succinct sentence or two describing these effects will be appropriate.

Annex A: ICES glossary of principal human activities in ICES ecoregions

Human activity	Explanation and examples
aggregate extraction	Inorganic mine and particulate waste, maerl, rock/minerals (coastal quarrying), sand/gravel (aggregates).
agriculture run off	Agricultural wastes, coastal farming, coastal forestry, land/waterfront run-off.
aquaculture	Finfish, shellfish, macroalgae
coastal development	Artificial reefs, barrage, beach replenishment, communication infrastructure on the shoreline, construction phase, culverting lagoons, dock/port facilities, groynes, land claim, marinas, oil and gas infrastructure found on the coast rather in the marine environment (e.g. shore pipelines), urban dwellings (i.e. housing and other buildings).
desalinization	Removal of salt and other minerals from the seawater.
fishing	Benthic trawls and dredging, netting (e.g. fixed nets), pelagic trawls, potting/creeling, suction (hydraulic dredging).
harvesting/collecting	Bait digging, seaweed and saltmarsh vegetation harvesting, bird egg collecting, shellfish hand collecting, peels, curios.
land-based industry	Industrial effluent discharge, industrial/urban emissions (air), particulate waste.
military	Military (ships, munitions).
navigation dredging	Capital dredging, maintenance dredging, removal of substrate, spoil dumping.
Nuclear power	Nuclear power stations, water abstraction and thermal discharge
oil and gas and hydro	Oil and gas power stations, thermal discharge (cooling water), water resources (abstraction).
renewable energy	Renewable (tide/wave/wind) power stations.
research	Animal sanctuaries, marine archaeology, activities undertaken as part of marine research (e.g. survey cruises, grab sampling, trawls etc).
shipping	Litter and debris, mooring/beaching/launching, shipping, shipping wastes.
telecommunications	Communication cables.
tourism and recreation	Angling, boating/yachting, diving/dive site, litter and debris, public beach, tourist resort, water sports.
wastewater treatment	Sewage discharge, thermal discharge.

Annex B: ICES glossary of principal pressures in ICES ecoregions

Pressure	Explanation and examples
Abrasion	Abrasion pressures relate to disturbance of the substrate at or below the surface of the seabed; aggregate and other mineral extraction is not covered by this pressure. Abrasion pressure is associated with bottom-contacting mobile and set fishing activities, in particular otter trawling, dredging for shellfish, and navigation and beam trawling. Other activities with a limited spatial footprint also cause abrasion.
Climate change	Climate change is a directional and non-random process that affects both the mean and the variance in environmental parameters and ecosystem state components, as well as human activities and resultant pressures. The human component of climate change is caused by the release of CO_2 and other gases. This release also has other effects such as acidification of marine waters.
Introduction of contaminating compounds	Examples of this pressure include discharges from ships, from hydrocarbon exploration and production, atmospheric deposition, and riverine inputs. Compounds of concern include: • For marine sediments the main transition elements and compounds of concern include arsenic, cadmium, chromium, copper, mercury, nickel, lead, and zinc. • Organometallic compounds such as tributyltin (TBT) and its derivatives can be highly persistent and even low levels of exposure can cause chronic toxicity. • Hydrocarbons, including polyaromatic hydrocarbons (PAH). • Priority substances listed in Annex II of Directive 2008/105/EC1. • Synthetic compounds, including pesticides, antifoulants, and pharmaceuticals.
Introduction of non-indigenous species (NIS)	The direct or indirect introduction of NIS, e.g. Chinese mitten crab *Eriochier sinensis*, slipper limpet *Crepidula fornicata*, Pacific oyster *Crassostrea gigas* and their subsequent spreading and out-competing of native species. Ballast water and hull fouling can facilitate the spread of NIS. This pressure is also associated with aquaculture, translocation of organisms, or from accidental releases.
Marine litter	Marine litter is any persistent, manufactured, or processed solid material that is discarded, disposed of, or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded or unintentionally lost into the sea and on beaches, including such materials transported into the marine environment from land by rivers, draining, or sewage systems, or by winds. For example, marine litter consists of: plastics, wood, metals, glass, rubber, clothing, paper, etc. Land-based sources of marine litter include tourism, sewage, and illegal or poorly managed landfills. Sea-based sources include shipping and fishing.
Noise	Ocean noise refers to sounds made by human activities that can temporarily or permanently interfere with, or impair the ability of marine animals to hear natural sounds in the ocean. Noise may also cause physiological or behavioural effects. Human activities that cause ocean noise include marine traffic (shipping), recreational boating, fishing vessels, energy exploration, military sonar, and inshore and offshore infrastructures (construction and operations).
Nutrient and organic enrichment	Increased levels of nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations. Anthropogenic sources include wastewater, terrestrial/agricultural run-off, sewage discharges, aquaculture, and atmospheric deposition. Nutrient enrichment may lead to eutrophication (see also organic enrichment).
Selective extraction of species	The commercial exploitation of fish and shellfish stocks, including smaller scale harvesting, recreational fishing, and scientific sampling. Ecological consequences include the sustainability of stocks, impacting energy flows through foodwebs, and the size and age composition within fish stocks. This pressure includes bycatch associated with fishing activities.

1 DIRECTIVE 2008/105/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council. Official Journal of the European Union, L 348: 84–97.

Pressure	Explanation and examples
Selective extraction of non-living resources from the seabed and subsoil	This pressure relates to marine aggregate extraction and mining. Some removal of benthic organisms and alteration of seabed topography may also occur.
Smothering	Smothering pressures relate to siltation or sedimentation on the surface of the seabed. Activities associated with this pressure type include marine and coastal construction, aquaculture, land claim/reclamation, navigation dredging, disposal at sea, marine mineral extraction, fishing, cable and pipeline laying, and various construction activities.
Substrate loss	This pressure type includes both: the permanent loss of coastal habitats (associated with activities such as land claim, new coastal defences); and the permanent change of one marine habitat type to another through a change in substratum, including artificial substrates (e.g. concrete). Associated activities include the installation of infrastructures such as hydrocarbon production facilities, wind farm foundations, marinas, pipelines, cables, and scour protection.

Annex C: ICES Glossary of core ecosystem state components

A more detailed sub-level approach is employed by some ecoregions, with the results and details presented in their WG reports. A common hierarchical framework has been developed to facilitate cross-comparison and is available on the Ecosystem Overviews SharePoint Site here.

Ecosystem component	Explanation and examples
Fish	Limbless cold-blooded vertebrate animals with gills and fins living wholly in water. This includes both bony fish and elasmobranchs.
Cephalopods	Any member of the class Cephalopoda, such as a squid, octopus, cuttlefish, or nautilus; characterized by bilateral body symmetry, a prominent head, and a set of arms or tentacle.
Reptiles	Cold-blooded air-breathing vertebrates which have epidermal scales covering part or all of their body. Includes marine turtles.
Seabirds	Birds that are adapted to life within the marine environment, spending most of their time at sea and sourcing all or most of their food from the marine environment.
Marine mammals	A mammal that lives in marine, or in some cases, an aquatic environment and obtains all or most of its food there.
Benthic habitat (and associated biota)	An ecological or environmental area inhabited by one or more living species. The ecosystem component also includes all benthos - the flora and fauna found on the bottom, or in the bottom sediments, of the sea not listed separately above.
Pelagic habitat (and associated biota)	An ecological or environmental area inhabited by one or more living species. The ecosystem component also includes plankton – small organisms that float or drift in great numbers in bodies of salt or freshwater. Includes zooplankton (including jellyfish) and phytoplankton, but does not include species groups listed separately above.
Ice habitat (and associated biota)	Habitat associated with ice. The ecosystem component also includes closely associated biota, both invertebrates and vertebrates other than those listed separately above.

Annex D: Template for application of a new topic to be included into ecosystem overviews (step I of the pipeline process)

Title of the proposed topic:

Proposed by: Name(s)

Expert Group(s) involved:

Brief explanation of the topic, proposed scope/content, expected length/word count and any display material (max 1/2 page):

Delivery plan (which ecoregions and when [year]):

Information on meeting the inclusion criteria:

Criterion	Response
Support the role of Ecosystem Overviews as previously outlined by WKECOVER	
Identified as high-priority topic by WKEO3	
Interest of ICES client commissions and/or stakeholders	
Based on mature and peer-reviewed science	
Capacity of experts to periodically update the product	
Based on quality-assured data, follow FAIR principles	
Follow Transparent Assessment Framework (TAF)	
Applicable for most (if not all) ICES ecoregions	

In case of inclusion of the proposed topic, is there a need to update the Technical Guidelines? If yes, please specify which section(s).

Annex E: Example of a table for identifying which human activities create which pressures

Human activity/ pressure	Abrasion	Introduction of contaminating compounds	Introduction of non-indigenous species (NIS)	Marine litter	…
Aggregate extraction					
Agriculture run off		X	X		
Aquaculture					
Coastal development				X	
Desalinization					
…					
…					

Templates for identifying which human activities create which pressures, and which pressures affect which ecosystem state components are available on the Ecosystem Overviews SharePoint Site here.

Annex F: Example of a table for risk assessment

Sector	Pressure	Ecosystem state component	Spatial extent	Confi-dence	Source
Fishing	Selective extraction of species	Fish	Local	1	Expert name
Fishing	Selective extraction of species	Cephalopods	Widespread, patchy	2	Reference to a publication
Fishing	Selective extraction of species	Reptiles	Widespread, even	3	Reference to a dataset
Fishing	Abrasion	…			
Fishing	Introduction of contaminating compounds	…			
Land-based Industry	Introduction of contaminating compounds				
…	…				

Templates for risk assessment (including scoring conversion) are available on the Ecosystem Overviews SharePoint Site here.

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Annex 2: Resolutions

WKTRANSPARENT - Workshop on methods and guidelines to link human activities, pressures and state of the ecosystem in Ecosystem Overviews

2020/WK/IEASG07 Workshop on methods and guidelines to link human activities, pressures and state of the ecosystem in Ecosystem Overviews (WKTRANSPARENT) chaired by Henn Ojaveer*, ICES, Debbi Pedreschi*, Ireland, and Gerjan Piet*, Netherlands, will be established and will meet by correspondence for three days (7-9) in December 2020 to:

a) Explore ways to link the identified high-priority pressures to ecosystem functions and processes;

a) Review relevant approaches and frameworks (risk assessment, mental modeller and others) used by the working groups for assessing and prioritizing the main ecoregion pressures/stressors and human activities with direct impacts to ecosystem components, and propose revisions to the current guidelines;

b) Review and revise technical guidelines for ecosystem overviews, including the pipeline process to incorporate new science, the process to update the Overviews and outputs from ToR b).

WKTRANSPARENT will report by 18th of December for the attention of the ACOM/SCICOM.

Supporting information

Priority	High priority. Ecosystem overviews are part of the recurrent advice in the Administrative Agreement signed between the EU and ICES, and key mechanism for ICES to deliver its advice on ecosystem based management.
Scientific justification	This is a direct follow-up from WKEO3 to further advance and develop ecosystem overviews, which includes both conceptual/guidance developments as well as consider incorporating ecosystem functions/processes.
Resource requirements	The national research programmes and ICES EGs which provide the main input to this group are already underway, and resources are already committed.
Participants	The WK will be attended by experts covering the areas of knowledge related to the ToRs, with a wide range of area coverage.
Secretariat facilities	Setting up webex calls.
Financial	No financial implications.
Linkages to advisory committees	Direct link to ACOM.
Linkages to other committees or groups	WGCEAM, WGICA, WGINOSE, WGINOR, WGIBAR, WGEAWESS, WGCOMEDA, WGIAB, WGIEAGS, WGIAZOR, WGITMO, WGMME, WGZE, WGSAM, BEWG, JWGBIRD, WGSFD, WKCONSERVE, WKINTRA2, WGECO.
Linkages to other organizations	OSPAR, HELCOM, NEAFC, PICES, etc.

Annex 3: Meeting agenda

Workshop on methods and guidelines to link human activities, pressures and state of the ecosystem in Ecosystem Overviews (WKTRANSPARENT)

Chairs: Henn Ojaveer (ICES), Debbi Pedreschi (Ireland) and Gejan Piet (Netherlands)

7-9 December 2020, remote meeting

7 December

13:00	Welcome and General introduction to the workshop (Henn)

Tor b): Review relevant approaches and frameworks (risk assessment, mental modeller and others) used by the working groups for assessing and prioritizing the main ecoregion pressures/stressors and human activities with direct impacts to ecosystem components, and propose revisions to the current guidelines (Lead: Debbi)

13:15	Presentation: Approaches used by current groups, issues arising, outcome of review (Debbi)
13:35	Erik Olsen – Conceptual Mapping (WGINOSE)
	Gerjan Piet – Cumulative Effects Assessment (WGCEAM)
13.55	Discussion
14:15	BREAK
14.30	Presentation: Details of approach - need for common elements (Debbi)
14.50	Discussion
16.00	BREAK
16.10	Wrap up, re-cap, and action points.
17.00	END OF DAY 1

8 December

ToR a) Explore ways to link the identified high-priority pressures to ecosystem functions and processes (Lead: Gerjan)

13:00	Introduction
13:10	Session 1: Ecosystem services as component of integrated ecosystem assessments (presentations and discussion)
15:00	BREAK
15:15	Session 2: Methodology of evaluating direct effects and relevance of indirect effects (presentations and discussions)
17:00	END DAY2

9 December

ToR c) Review and revise technical guidelines for ecosystem overviews, including the pipeline process to incorporate new science, the process to update the Overviews and outputs from ToR b) (Lead: Henn)

13:00	Introduction
13:10	Update of technical guidelines (work with the file on the SharePoint Site)
14:30	BREAK
14:45	Finalize updates of technical guidelines
16:00	BREAK
16:10	General discussion and future steps
17:00	END OF THE MEETING

Annex 4: Reviewed Methodologies

List of the eleven methodologies that were reviewed in detail for use in Ecosystem Overviews and integration with IEA processes.

Name of Method	Paper
ODEMM/ AQUACROSS	Knights et al. 2013; Knights et al. 2015, Piet et al. 2015; Goodsir et al. 2015; Pedreschi et al. 2019; Pedreschi et al. 2018 unpublished; Borgwardt et al. 2019
Mental Modeller	Gray et al. 2013
	Halpern et al. 2007
Cumulative Pressure Maps	Halpern et al. 2008, 2015
Ocean Health Index	Halpern et al. 2012, 2015, 2017
Symphony Tool	Hammar et al. 2020
Swedish ES approach	Bryhn et al. 2020
Pan Baltic Scope project	Ruskule et al. 2019
	Bergström et al. 2019
	Gaichas et al. 2018
CARE	Battista et al. 2017
NOAA	Samhouri and Levin 2012
	Samhouri et al. 2019

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Annex 5: Ecosystem component hierarchy

An example of how a more detailed assessment can be used to inform the Agreed ICES EO categories.

Agreed ICES Categories	Example further detail	Example 2 further detail
Fish	Fish	Demersal Fish
		Pelagic Fish
		Deep Sea Fish
	Elasmobranchs	Demersal Elasmobranchs
		Pelagic Elasmobranchs
		Deep Sea Elasmobranchs
Cephalopods	Cephalopods	Cephalopods
Reptiles	Reptiles	Reptiles
Marine Birds	Marine Birds	Marine Birds
Marine Mammals	Cetaceans	Baleen Whales
		Toothed Whales
	Seals	Seals
Pelagic habitats and associated biota		Variable Salinity Waters
	Coastal Pelagic	Coastal Waters
	Shelf Pelagic	Shelf Waters
	Oceanic Pelagic	Oceanic Waters
Ice habitats and associated biota	Ice habitats	Ice habitats
Benthic habitats and associated biota	Littoral Rock and biogenic Reef	Littoral Rock and biogenic Reef
	Littoral Sediment	Littoral Sediment
	Shallow sublittoral rock and biogenic reef	Shallow sublittoral rock and biogenic reef
	Shallow sublittoral sediment	Shallow sublittoral coarse sediment
		Shallow sublittoral sand
		Shallow sublittoral mud
		Shallow sublittoral mixed sediment

	Shelf rock and biogenic reef	Shelf rock and biogenic reef
	Shelf sublittoral sediment	Shelf sublittoral coarse sediment
		Shelf sublittoral sand
		Shelf sublittoral mud
		Shallow sublittoral mixed sediment
	Slope Rock and biogenic Reef	
	Slope Sediment	
	Deep Sea Rock and Reef	Lower bathyal rock and biogenic reef
		Upper bathyal rock and biogenic reef
		Abyssal rock and biogenic reef
	Deep Sea Sediment	Lower bathyal sediment
		Upper bathyal sediment
		Abyssal sediment