WORKING GROUP ON CUMULATIVE EFFECTS ASSESSMENT APPROACHES IN MANAGEMENT (WGCEAM)

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Editors

Roland Cormier • Gerjan Piet • Vanessa Stelzenmüller

Authors

Robert Aps • Silvana Birchenough • Melanie Boivin • Alicia Cassidy • Kelly Code • Roland Cormier • Sophie Cormier • Brad Firth • Niel Fisher • Carole Godin • Matthew Gubbins • Adrian Judd • Alain Mallet • Terry Melanson • Darcy Pickard • Gerjan Piet • Stacey Rehel • Christine Sabean • Fernand Savoie • Mette Skern-Mauritzen • Vanessa Stelzenmüller • Tyler Tunney • Hilary White • Daniel Wood

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Contents

i Executive summary

The goal of the Working Group on Cumulative Effects Assessment Approaches in Management (WGCEAM) is the development of a common and consolidated CEA framework to implement such assessments in different planning and regulatory context considering the different settings regarding data, knowledge, and decision-processes. Case studies are used to further develop the framework. This work is expected to provide guidance on data and knowledge needs to apply such a common CEA framework in different planning and regulatory settings.

Throughout the first meeting of the working group, a cumulative effects assessment framework for management was developed and two case studies (i.e. North Sea and the Gulf of St Lawrence) were identified as the proof of concept to be reviewed at the next WGCEAM meeting.

The CEA framework allows identifying and prioritizing the pressures that would need to be addressed by management measures based on the vulnerability of the ecosystem components to those pressures. The rationale and setting of the framework differs clearly from a typical ecosystem status assessment where the responses of indicators are assessed to quantify the effects of human pressures. Hence, while the framework can provide information on which ecosystem components are potentially mostly at risk, i.e. through the overall quantification of the cumulative effects across all pressures, the focus is on the effect potential for each pressure-ecosystem component relationship as this is key to guide management. Effects per se are not readily actionable in a management and, in particular in regulatory, context because observed or predicted effects are the result of multiple factors that are influenced by the variability of the spatial and temporal distribution of the pressures, the ecosystem response including various natural processes. Furthermore, it is also not intended to guide in detail regulatory management on a sector by sector basis as it is intended to provide more strategic advice aimed at identifying from the collective pressures and related human activities which sectors primarily require management regulations.

The framework assesses the vulnerabilities of ecosystem components to cumulative or collected pressures for a given ecosystem and management context. Following standard risk-based assessment practices, vulnerability is determined from the exposure (both spatial and temporal) of a specific ecosystem component to the different pressures and the effect potential based on the pressure load and the resistance and recovery potential of that ecosystem component.

In 2020, the WG focused on the development of the case studies. This helped to identify general issues around the application of the framework. Such issues comprised the identification of spatial and temporal boundaries, a common understanding of the evaluation elements such as resistance and recovery, or the application of standardised criteria to assess vulnerabilities. Finally, the group discussed the future use of the framework in the ICES advisory process. The development of a guidance of the framework and the embedding in the advisory process will be addressed at the next meeting.

ii Expert group information

Expert group name	Working Group on Cumulative Effects Assessment Approaches in Management (WGCEAM)
Expert group cycle	Multiannual
Year cycle started	2019
Reporting year in cycle	2/3
Chair(s)	Vanessa Stelzenmüller, Germany
	Roland Cormier, Germany
	Gerjan Piet, The Netherlands
Meeting venue(s) and dates	21-25 September 2020, Virtual meeting, 24 participants

1 Introduction

As a follow-up to ToR b), this meeting reviewed the results of North Sea and Canadian case studies that were built from the conceptual framework (Figure 1) that was developed at the last meeting of the WGCEAM in October 2019 (ICES 2019). The glossary of terms from that meeting was also discussed and added to this report (Annex 3).

The framework is designed to assess the vulnerabilities of ecosystem components to cumulative pressures generated by human activities in a given ecosystem and management context. The vulnerabilities of each ecosystem component to potential effects is identified through causal pathways (or impact chains) with prevailing pressures (Upper left box of Figure 1). Vulnerability is subsequently established as a function of exposure that combines the spatial and temporal overlap of the pressure and the ecosystem component including the effects potential that combines the load of the pressure, resistance and recovery potential of the ecosystem component (Upper right box of Figure 1). Graphically, this information is then integrated into a vulnerability profile representing a cumulative or ranked representation of all vulnerabilities of all pressure/ecosystem component combinations occurring in that ecosystem such that these can guide management (Lower right box of Figure 1). Providing a strategic setting for marine spatial planning and regulatory processes, the intent of the profile is to show which combination has the most potential of causing effects to inform management priorities for sector-specific activities (Lower left box of Figure 1).

The meeting examined the findings of the case studies in terms the knowledge gaps and/or data challenges to calculate the exposure and effects potential of the framework (Upper right box of Figure 1). Some first attempts to provide informative graphs for the vulnerability profile were also produced within the case studies.

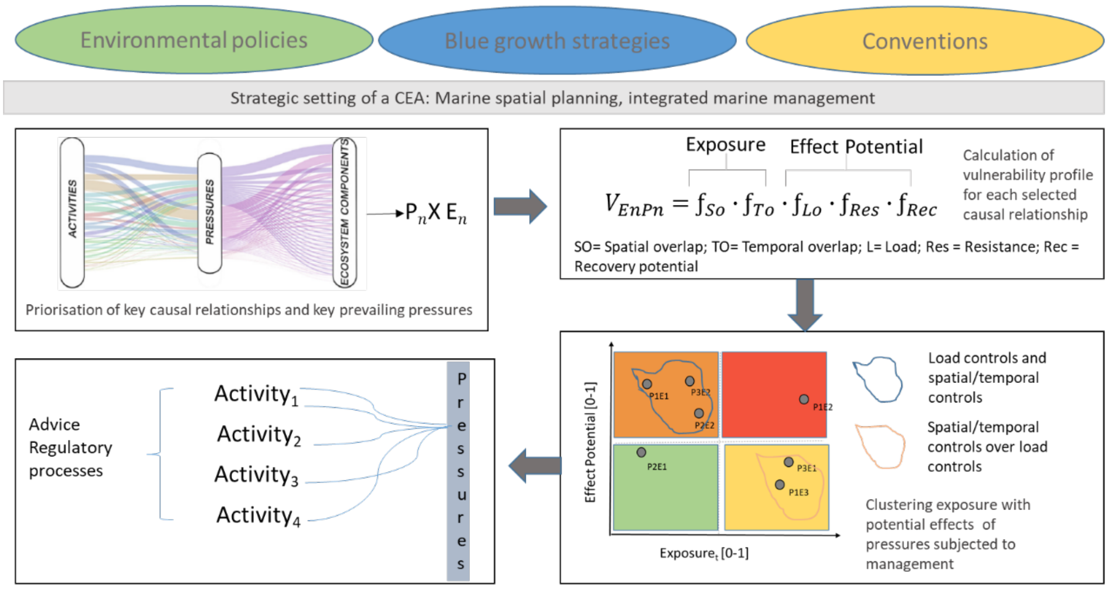

Figure 1. Conceptual CEA framework for management.

The intention is a flexible application of the framework where different data, evidence and knowledge availabilities can be accommodated that spans qualitative, to semi-quantitative, to fully quantitative approaches depending on the available data for each of the causal pathways in such assessments. A qualitative approach would rely on expert solicitation that would depend on the current knowledge of causal pathways that could also consider evidence from other similar situations. Semi-quantitative approaches would use pre-established criteria and tabulation techniques, initially developed through expert solicitation that would be applicable to the specific area or species. A quantitative approach would primarily be a data driven process to generate the evidence of the effect potential based on the spatial and temporal distribution of the pressures.

Table 1. Characterisation of qualitative, semi-quantitative, and quantitative CEA assessments depending on the availability of data (in relation to the exposure of an ecosystem component to a pressure), evidence (in relation to sensitivity and recovery of an ecosystem component from the disturbance by a given pressure) and knowledge (in relation to the severity of the identified pathways of risk).

	Data	Evidence	Knowledge
Qualitative	✗	✗	✓
Semi-quantitative	✗	✓	✓
Quantitative	✓	✓	✓

2 Case studies findings

The case studies examined during the meeting were from North Sea (Europe) and the Gulf of St Lawrence (Canada). The North Sea case study calculated exposure and effect potential for a comprehensive range of pressures and ecosystem components using both data and risk criteria from previous EU-funded projects (i.e. ODEMM and AQUACROSS). The Canadian study calculated the exposure and effect potential from data on landscape, freshwater and marine pressures and ecosystem components.

2.1 Canadian case study

The Canadian case study was situated in the Magdalen Shallows of the Gulf of St Lawrence and its respective watersheds (Figure 2). Although the intent case studies for this meeting were to examine the application of the framework in a marine environment, this case study also included landscape and watercourse pressures and their respective activities. This exercise provided an opportunity to apply the framework to these systems given the current need to assess cumulative effects across landscape, freshwater and marine environment in Canada. Exposure and effect potential used the framework equation and the definitions for the variables as outlined in ICES 2019 (Figure 1). Where *So* is the spatial overlap, *To* the temporal overlap, *Lo* the load, *Res* the resistance and *Rec* the recovery potential.

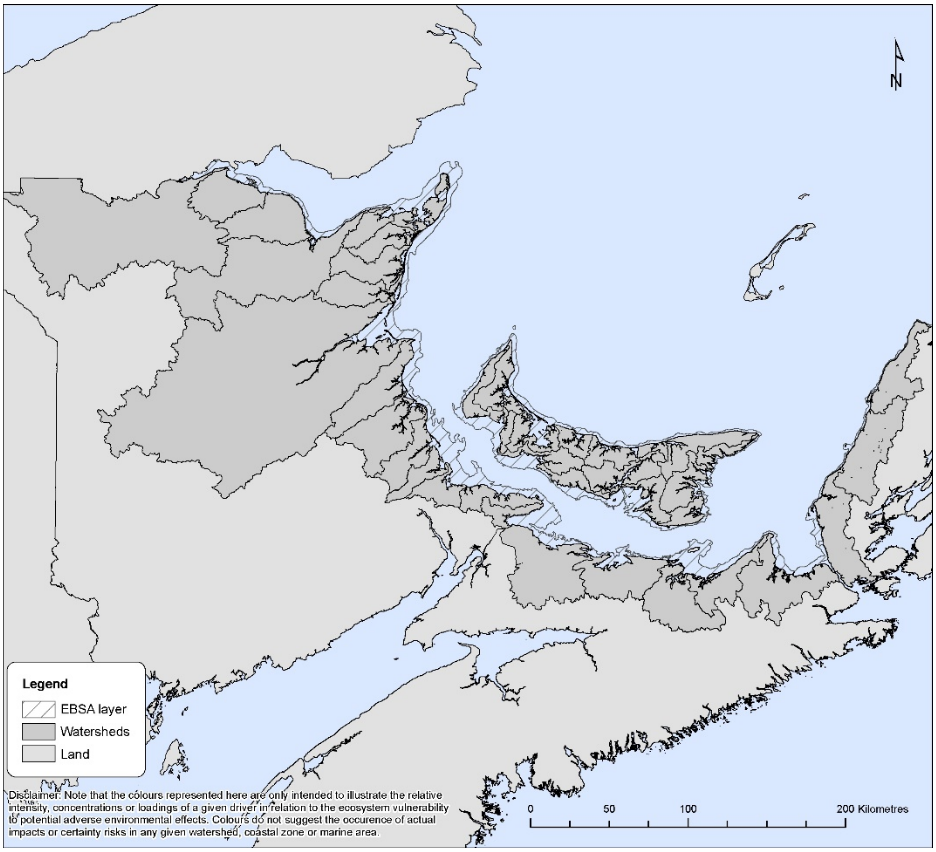

Figure 2. Canadian case study area.

Ecosystem components were delineated spatially to calculate the spatial overlap of the pressures to reflect the different species assemblage support by the component and the pathways of the pressure-effect potential.

- The boundaries of a watershed is used to delineate the spatial extent of the landscape pressures.
- The total length of streams within a watershed boundary is used to delineate the linear extend of the watercourse pressure.
- The bathymetry line of <5 m depth is used to delineate the spatial extent of marine estuaries and shorelines.
- The bathymetry line of < 30 m depth is used to delineate the spatial extent of the coastal zone.
- The bathymetry line of >30 m depths to the edge of the Magdalen shallows is used to delineate the spatial extent of the marine zone.

The delineations scoped the spatial and temporal extent of the activity/pressure/ecosystems components pathways to analyse and establish a vulnerability profile. The temporal overlap was calculated on a 12 month duration of a pressure on the receiving ecosystem component because some pressure only occur a few months of the year. The load was calculated from the amount of a pressure per spatial unit per day in a year. Resistance values were derived from literature or expert knowledge and reflect the point where the ecosystem component cannot resists or rapidly compensate in the face of the perturbation from a pressure to maintain the ecosystem function it supports (DFO, 2015). The recovery potential is calculated in terms of the time it takes for the ecosystem component to be reinstated in months.

The calculations for each activity/pressure/ecosystem component combination was used generate a vulnerability profile (Figure 3). The colour scheme follow the framework definitions of Figure 1.

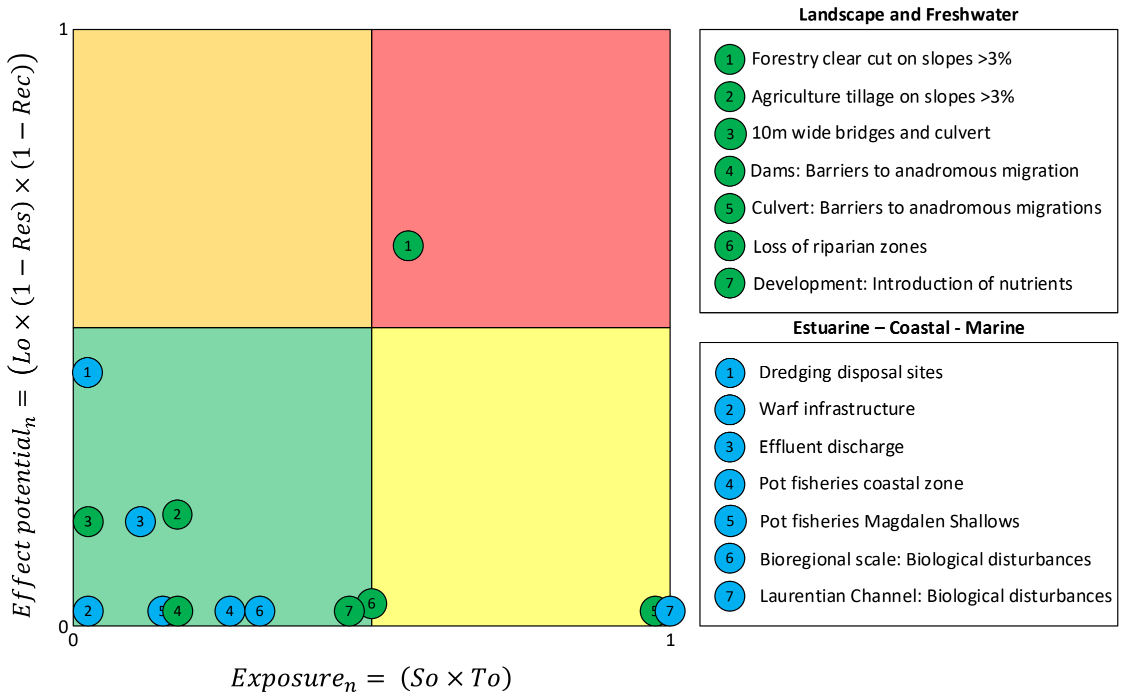

Figure 3. Vulnerability profile for the Canadian case study.

This case study highlights the importance of the boundaries used to delineate the ecosystem component exposed to pressure in order to scope the relevant activity/pressure pathways that have the potential of causing effects on the component. Such boundaries also have a significant influence on the spatial and temporal overlap calculations for exposure. For consistency across the pressures analysed in the vulnerability profile, there is a need for common denominators across the 5 variables used in the framework.

2.2 North Sea

For the North Sea CS we explored two avenues for the application of CEA framework:

- One comprehensive but semi-quantitative using the risk categories from previous EU-funded projects ODEMM (see e.g. Knights *et al.* (2015)) and AQUACROSS (see Borgwardt *et al.* (2018)) but with new risk scores that better fit the WGCEAM framework.
- The other fully quantitative but only covering a limited number of impact chains. The knowledge and experience gained from this approach were applied to guide the development of the semi-quantitative approach.

As the semi-quantitative approach is expected to be more likely to become operational in the relatively short term and can also be applied in the most data-poor areas the WGCEAM decided to focus on this approach. Thus in order to calculate vulnerability we worked from the formula

$$V_{EnPn} = \overbrace{f_{So} \cdot f_{To}}^{\text{Exposure}} \cdot \overbrace{f_{Lo} \cdot f_{Res}}^{\text{Effect Potential}} \cdot f_{Rec}$$

Effect Potential comprises Pressure Load (Pload) and Ecosystem Component Sensitivity (ECSens). We defined risk categories and distributed scores ranging between 0 and 1 for Exposure, PLoad and ECSens. This enables a multiplication of these scores to calculate vulnerability ranging also between 0-1. Below we further elaborate how we allocated the scores for the North Sea CS.

Exposure

Exposure is determined by the spatial overlap of the pressure and the ecosystem component. In a data poor situation where no data are available regarding the spatial and temporal distribution of a pressure the fall-back option is to use expert judgement (as is available for each of the EU regional seas). To that end we combined the two aspects of risk, spatial overlap and dispersal with new scores into an Exposure score which is now between 0-1 (but for readability expressed as % in the table below).

Table 2. Example of scoring the exposure of an ecosystem component to a given pressure in data poor situations.

Spatial Overlap		Dispersal		
		None	Moderate	High
Extent		1	10	20
No overlap	0	0	10	30
Ex	1	1	11	31
Site	3	3	13	32
Local	37	37	43	56
Widespread Patchy	67	67	70	77
Widespread Even	100	100	100	100

In cases where for several impact chains maps of spatial distributions of a pressure exists exposure can be calculated. An example is given in Figure 4. Should there be any temporal changes in the spatial overlap because there are seasonal patterns in either the pressure or the ecosystem component then several maps should be used each weighted with the proportion of the year that it applies.

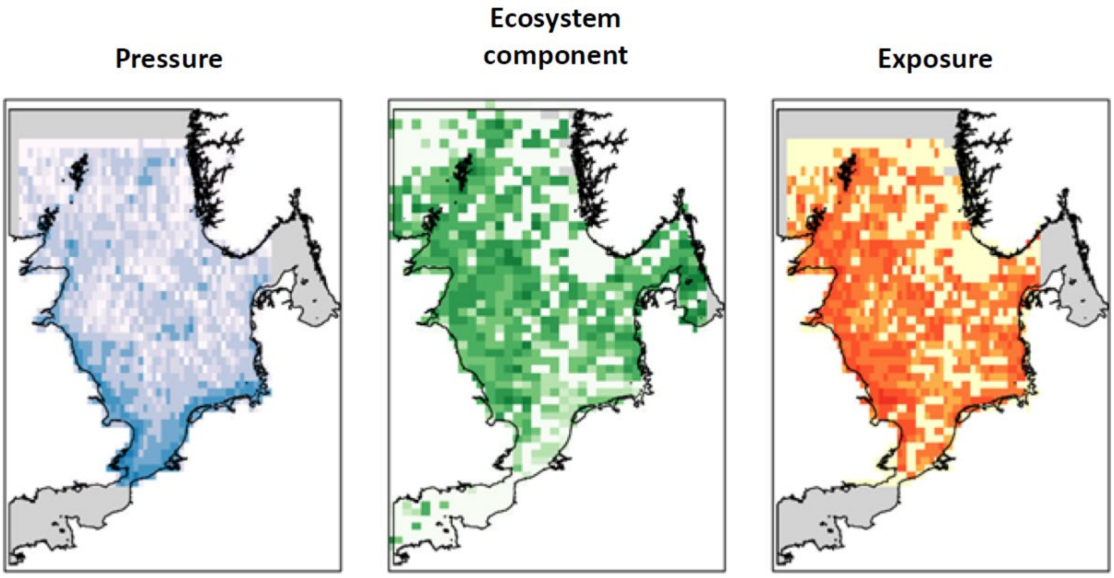

Figure 4. Example maps showing the spatial distribution of a pressure, ecosystem component and the calculated overlap (ranging between 0-1).

Pressure Load

In representing the magnitude of the pressure, the concept of Load is possibly a more tangible concept from a management perspective than the Intensity in the environment which actually determines the effect on the ecosystem component (depending on its Sensitivity to that pressure). A major issue with notably the crude severity scores from the current North Sea "Impact Risk" database was that because pressure intensity was not explicitly considered it hampered the CEA application to guide management which is usually sector-specific. We resolved that by introducing an estimated sector-specific contribution to the pressure load. To that end we first identified those activities that can be assumed to contribute >40% to the overall load. Often this applies to activities where the pressure is the primary purpose for this activity to take place (e.g. biological extraction in case of fishing).

Table 3. Pressure load scores.

Pressure Load (assumed % relative contribution)	Score
0.1	0.1
1	1
5	5 Unless there is no >30% activity category. In that case the balanced distribution applies to these activities
>30	Balanced distribution of the remaining load after all minor activities have been scored (Scores≠0.1, 1, 5). This should add up to a total of 100% for the pressure

This resulted in a matrix of all the activities contributing to each pressure, where Pload is represented by the proportion (hence a value 0-1 or 0-100%) of that activity to the existing magnitude of the pressure. Together all activities per pressure add up to 100%.

Ecosystem Component Sensitivity (ECS)

In the North Sea CS we combined the risk aspects of resistance and resilience with that of population dynamics. Resistance is here considered to represent the annual depletion or mortality caused by the pressure on the ecosystem component, resilience represents the recovery potential.

The Figure 3 explains how the concepts or resistance and recovery were considered to determine the Effect Potential and Vulnerability.

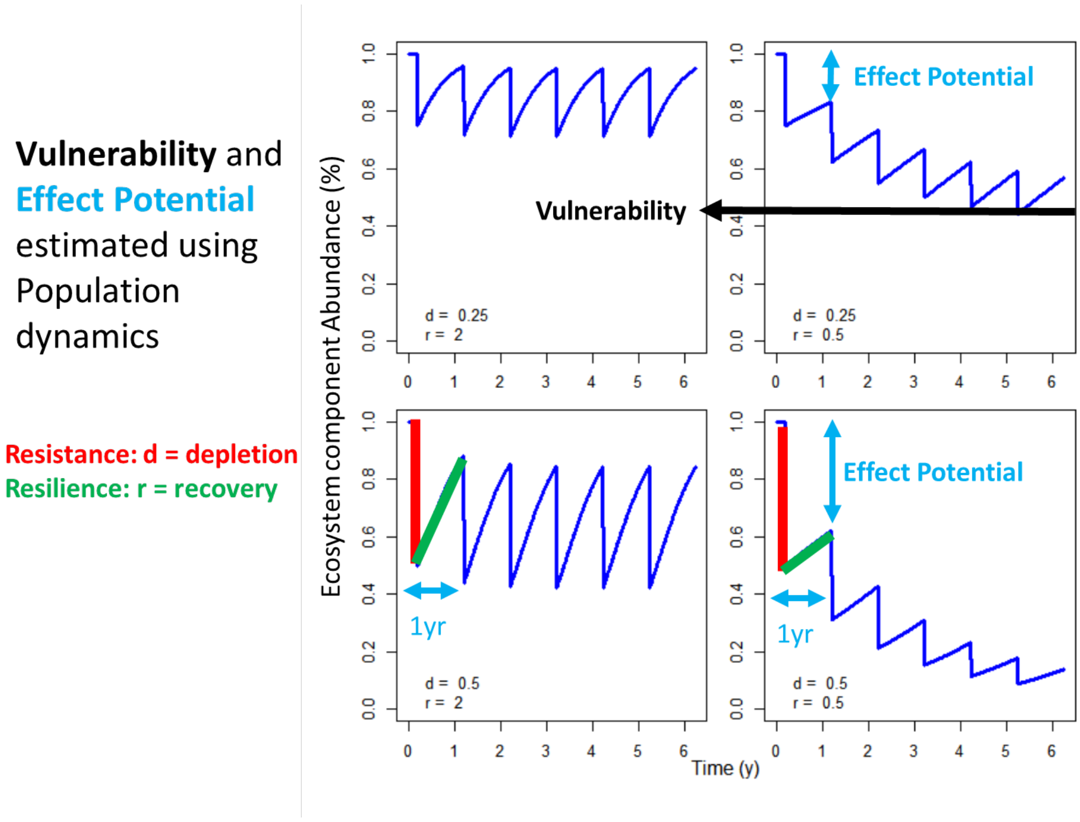

Figure 3. Illustration of how different sensitivities, based on resistance (=depletion) and resilience (=recovery potential) determine the Effect Potential and Vulnerability. In a data-poor situation resistance can be approximated using the aspects of Frequency and Severity and is expressed as the proportion of the initial abundance removed or killed by the frequency and severity of the pressure. To calculate resistance we used the standard formula {Pitcher, 2017 #8395} that calculates what remains of an ecosystem component relative to an undisturbed situation:

$$\textit{Resistance} = 100*(1- (1\textit{-Severity})^\wedge \textit{Frequency})$$

Depending on the (now modified) scores this will give you different resistance values (see table 4).

Table 4. Resistance scores based on existing Frequency and Severity categories with adopted or slightly modified scores.

	Severity	Low	Chronic	Acute
Frequency		0.01	0.1	1
R	0.3	0.00	0.0	0
O	1	0.01	0.1	1
F	3	0.03	0.3	3
VF	6	0.06	0.6	6
C	12	0.12	1.2	11

	Severity	Low	Chronic	Acute
Frequency		0.05	0.5	5
R	0.3	0.02	0.2	2
O	1	0.05	0.5	5
F	3	0.15	1.5	14
VF	6	0.30	3.0	26
C	12	0.60	5.8	46

	Severity	Low	Chronic	Acute
Frequency		0.1	1	10
R	0.3	0.03	0.3	3
O	1	0.10	1.0	10
F	3	0.30	3.0	27
VF	6	0.60	5.9	47
C	12	1.19	11.4	72

For the recovery we can apply the resilience scores from Knights *et al.* (2015).

Table 5. Recovery scores for the North-East Atlantic (NEA) from Knights *et al.* (2015). These scores are supposed to reflect the time in years it takes to recover from an impact.

Ecosystem component	Recovery	Recovery score
Littoral rock and other hard substrata	High	1
Littoral sediment		1
Pelagic water column		1
Circalittoral rock and other hard substrata	Moderate	6
Infralittoral rock and other hard substrata		6
Sublittoral sediment		6
Birds	Low	55
Deep-sea bed		55
Fish & Cephalopods		55
Mammals		55
Reptiles		55
	None	100

Vulnerability

Ultimately for each causal relationship, i.e. impact chain, the vulnerability of an ecosystem component to the pressure caused by a specific activity needs to be estimated. The aggregated vulnerability across all causal chains is then the basis to guide ecosystem-based management and Blue growth strategies.

Vulnerability is now calculated as Exposure* Pload * ECS which is considered to capture best the translation of how each of the vulnerability aspects contribute to the overall concept. With Exposure, Pload and ECS each with values between 0–1 this will give a Vulnerability value between 0-1 (or 0–100%).

- For Exposure this then reflects the proportion (%) of the ecosystem component that is potentially perturbed by the pressure. In case of quantitative information on a spatial grid it is the proportion surface area of the spatial grid cells in which both the pressure and ecosystem component occur.
- For the Effect Potential this represents the by the relative contribution of a specific activity to the overall pressure impacting the ecosystem component thereby reducing a proportion (%) of the ecosystem component to a level where its contribution to ecosystem integrity and functioning is compromised. For each grid cell where both the ecosystem component and pressure occur this is the % abundance (numbers, biomass) of that ecosystem component relative to undisturbed.

For each impact chain combination, this should then always result in a vulnerability value 0-100%. However, when aggregating across all impact chains in order to perform a CEA an overall vulnerability >100% may occur (but depending on the resistance scores). While this initially appears to be impossible this is in fact the consequence of treating the entire Greater North Sea as a single entity. In reality, this may only occur in locally. If a more sophisticated method is applied using spatial distributions and performing the above calculations in small grid cells this may only (potentially) result in the local extirpation of this ecosystem component but not necessarily the overall extirpation as this is the result of several pressures that differ in their actual spatial overlap with the ecosystem component.

Conclusion

This North Sea CS provides a robust model on how to assess vulnerability in a qualitative and semi-quantitative manner. The development of the method has benefitted from experience applying actual data to estimate vulnerability of a limited number of impact chains. The advantages of this approach compared to previous approaches are:

- As opposed to the previously assessed concept of "impact risk", the concept of "vulnerability" can be understood and explained to managers/decision-makers in real-world terms, i.e. the proportion abundance relative to undisturbed of an ecosystem component that is lost due to the activity-pressure.
- Each of the vulnerability aspects for which now categories and scores are used can be replaced by actual data should this become available without creating any bias. This allows a gradual (one vulnerability aspect per impact chain at the time) improvement of the CEA.

3 Constraints and challenges regarding the application of the CEA framework

The application of the CEA framework in the two cases studies steered some discussion regarding a general and context independent issues:

a) Criteria to determine spatial and temporal boundaries

In a risk-based CEA assessment management objectives reg. risk of cumulative effects (e.g. MSFD, MSP, SEA) should guide the delineation of spatial and temporal boundaries (Stelzenmüller *et al.* 2018, 2020) to address the variability in species assemblages at the location of the assessment. However, there are not only the management boundaries and the respective applicability of policies and regulation. The distribution of the ecosystem components, functions and processes at risk could determine the assessment context. From the discussions, it became clear that the temporal boundaries could be defined in relation to management scenarios or in relation to the pressure load (frequency of occurrence).

b) Defining the components of vulnerability (exposure, resistance and recovery)

The group acknowledged the importance of terminology and recommended the use of the glossary (Annex 3) when the framework is being applied. Still specifically the phrases of resistance and recovery needed to be explained in more detail. The North Sea CS illustrates those concepts in Tables 4 and 5. In a semi-quantitative application the overall vulnerability represents the multiplication of the scores associated to the components of exposure, pressure load and effect potential of each ecosystem component and pressure pairing. Regardless of the actual scores a clear definition of the scoring criteria is a prerequisite for standardised assessments.

c) Evaluation of the vulnerability profile and the lack of benchmarks

The vulnerability profile of a given case study allows identifying pressure-ecosystem component pairings which contribute the most to the overall risk of cumulative effects. Thus, the vulnerability profile is a tool which allows an evaluation of (a whole programme of measures consisting of) potential sectoral management measures, i.e. strategic management strategy evaluation. For instance an example of the outcome of such an evaluation on the vulnerability profile can be found in Figure 5. Working from the basis that the intrinsic characteristics of such as recovery potential from a certain pressure exposure and load will remain the same (e.g. Table 5) the sector specific regulations will affect the resistance, load and exposure. Therefore, potential sector specific regulations could be simulated by a adapting the scoring and the resulting change of the vulnerability profile could be examined. Figure 5 illustrates a potential simulation of the implementation of regulations and a resulting hypothetical change to the vulnerability profile. There will be most likely no clear benchmark on accepted levels of risk for cumulative effects or combined vulnerabilities. However, an overall lower vulnerability profile would indicate a reduced risk of cumulative effects.

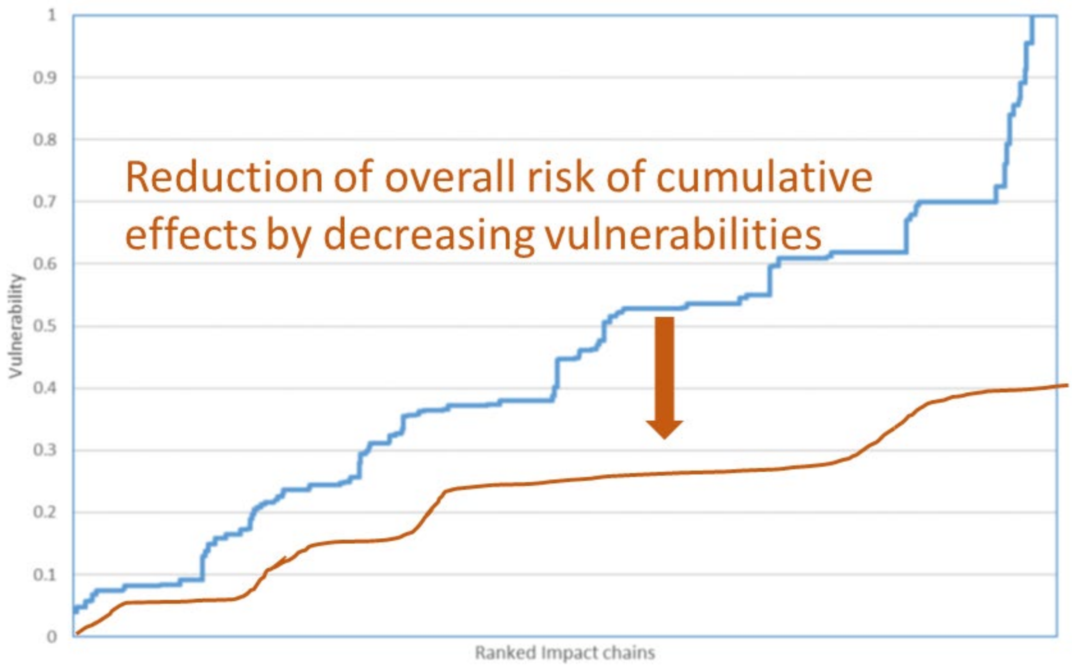

Figure 5. Example of how a vulnerability profile (based on ranked impact chains) may be improved (from Blue to Brown) through management. In fact the change in area below the profile reflects the achieved mitigation of impact of a specific management scenario.

d) From pressures to the regulation of activities

As outlined above the vulnerability profile can guide the priorisation of pressure-ecosystem component pairings that are key in a given assessment case study. Once the pressures are identified the respective sectoral contributions to the overall exposure and load of a pressure have to be examined. If the example of Table 3 would be followed than the sectors contributing the most could be easily identified. Hence, this would be the information that would feed into a regulatory process informing sectoral management.

4 Concluding remarks and next steps

Intersessional meetings will be used to further develop the Canadian case study in collaboration with the participants that generated the North Sea case study.

The case studies demonstrated that data is necessary but is not essential. Semi-quantitative analysis can be conducted using expert knowledge in the absence of the data and evidence that would be needed for a fully quantitative approach. As in any analysis of this type, semi-qualitative analyses can still produce results that are usable in a management and, more so, in a regulatory context. The quality and robustness of these analysis is expected to increase as more data becomes available and knowledge is generated overtime. The framework does shed light on the type of data and information that should be collected overtime to improve the results produced by the framework. The framework can also be used to evaluate data repositories to identify data gaps or data sources that could be provided by other organizations, and support needed from the ICES Data Center. Central to the next meeting is the development of guidance on the use of the CEA framework and the embedding of such analysis in ICES ecosystem advisory processes. Several ongoing ICES processes provide the context for this development; the risk assessment framework of the Ecosystem Overviews; the ICES Advice Framework, newly expanded to be fit for purpose also for ecosystem advice; the ACOM/SCICOM Benchmark Oversight Group (BOG) that oversees the development of benchmarks for approaches used for ecosystem advice; and finally, the ongoing discussion in ACOM and SCICOM on establishing an EBM Oversight Group, to support the development of ICES science and advice for Ecosystem Based Management.

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Annex 1: List of participants

Name	Institute	Country	Email
Vanessa Stelzenmüller	TI Institute of Sea Fisheries	Germany	Vanessa.Stelzenmueller@thuenen.de
Roland Cormier	Helmholtz-Zentrum, Geesthacht	Germany	Roland.Cormier@hgz.de
Gerjan Piet	Wageningen Marine Research	The Netherlands	Gerjan.Piet@wur.nl
Adrian Judd	Centre for Environment Fisheries & Aquaculture Science	United Kingdom	Adrian.Judd@cefas.co.uk
Alain Mallet	Fisheries and Oceans Canada	Canada	Alain.Mallet@dfo-mpo.gc.ca
Alicia Cassidy	Fisheries and Oceans Canada	Canada	Alicia.Cassidy@dfo-mpo.gc.ca
Brad Firth	Fisheries and Oceans Canada	Canada	Brad.Firth@dfo-mpo.gc.ca
Carole Godin	Fisheries and Oceans Canada	Canada	Carole.Godin@dfo-mpo.gc.ca
Christine Sabean	Fisheries and Oceans Canada	Canada	Christine.Sabean@dfo-mpo.gc.ca
Daniel Wood	Centre for Environment Fisheries & Aquaculture Science	United Kingdom	Daniel.Wood@cefas.co.uk
Darcy Pickard	ESSA	Canada	DPickard@essa.com
Fernand Savoie	Fisheries and Oceans Canada	Canada	Fernand.Savoie@dfo-mpo.gc.ca
Hilary White	Fisheries and Oceans Canada	Canada	Hilary.White@dfo-mpo.gc.ca
Kelly Code	Fisheries and Oceans Canada	Canada	Kelly.Code@dfo-mpo.gc.ca
Melanie Boivin	Fisheries and Oceans Canada	Canada	Melanie.Boivin@dfo-mpo.gc.ca
Matthew Gubbins	Marine Scotland	United Kingdom	Matthew.Gubbins@gov.scot
Mette Skern-Mauritzen	Institute of Marine Research	Norway	mette.skern-mauritzen@hi.no
Niel Fisher	Fisheries and Oceans Canada	Canada	Niel.Fisher@dfo-mpo.gc.ca
Robert Aps	Estonian Marine Institute	Estonia	Robert.Aps@ut.ee
Silvana Birchenough	Centre for Environment Fisheries & Aquaculture Science	United Kingdom	Silvana.Birchenough@cefas.co.uk
Sophie Cormier	Fisheries and Oceans Canada	Canada	Sophie.Cormier@dfo-mpo.gc.ca
Stacey Rehel	Fisheries and Oceans Canada	Canada	Stacey.Rehel@dfo-mpo.gc.ca
Terry Melanson	Fisheries and Oceans Canada	Canada	Terry.Melanson@dfo-mpo.gc.ca
Tyler Tunney	Fisheries and Oceans Canada	Canada	Tyler.Tunney@dfo-mpo.gc.ca

Annex 2: WGCEAM resolution

The **Working Group on Cumulative Effects Assessment Approaches in Management (WGCEAM)**, chaired by Vanessa Stelzenmüller, Germany, Roland Cormier, Germany, and Gerjan Piet, the Netherlands, will be established and will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	28 October – 1 November	ICES HQ, Copenhagen, Denmark		
Year 2020	21–25 September	by corresp/ webex		physical meeting cancelled - remote work
Year 2021	TBD October	TBC	Report by DATE to SCICOM	

ToR descriptors

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
a	Develop a cumulative effects assessment (CEA) framework suited to guide science advice on the development and implementation of ecosystem-based management	While the need for CEAs is widely accepted, their actual implementation in marine planning and management processes is yet to be seen. A common framework requires a review of the differences in the factors (data, knowledge, decision-process) being considered regarding cumulative effects assessment (CEA) in relation to environmental policies, an ecosystem approach to marine spatial planning (MSP) and regulatory processes. The framework should clearly outline: a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	6.1, 6.2, 6.6,	Year 1	CEA framework suited to guide science advice on the development and implementation of ecosystem-based management.
b	Demonstrate the application of the CEA framework in one or more regional case studies	To advance the development of a generic CEA methodology and identify real research gaps one or more case studies will be used as a proof of concept. The initial focus should be on the North Sea and a Canadian bioregion where the CEA is conducted	6.1,6.2	Years 2	Scientific paper describing the application of the CEA framework in one or more regional case studies.

		with the available knowledge base.			
c	Produce generic guidance on data and knowledge needs for CEA's including: using qualitative and quantitative data, accommodating uncertainty, identifying information gaps based on the application of the framework in the above case studies	The application of the framework in case studies allows to i) indicate useful tool(s) for each step, ii) show the indicative datasets and types of data required in carrying out a CEA, iii) develop straight forward visualization tools for pressures, and iv) demonstrate end products and engage with potential clients. The latter point is essential to scope the potential usefulness of CEAs as part of ecosystem advice provided by ICES	6.1, 6.2,	Year 3	Generic guidance on data and knowledge needs for CEA's.
d	Liaise with other fora or expert groups both within ICES (i.e. Secretariat, Data Centre or expert groups) as well as outside ICES (e.g. OSPAR, EEA, HELCOM, JPI Oceans, CEAF, DFO, TC, ECCC) to work towards and consolidate a common CEA framework	The consolidation of a common CEA framework requires a continuous collaboration and exchange of expertise with other groups and fora working on CEAs	6.2, 6.4, 6.5	Year1-Year 3 (ongoing)	Consolidated common CEA framework.

Summary of the Work Plan

Year 1	During the first year the linkages to other groups working on CEAs have to be identified and established. The main goal is the development of a common and consolidated CEA framework allowing to implement CEA in different settings regarding data, knowledge, and decision-processes.
Year 2	In the second year the work will focus on the application of the CEA framework in case study areas. The North Sea and a Canadian bioregion will be the first case studies since data availability and relevant scientific knowledge is most advanced.
Year 3	Emphasis will be on the provision of guidance on data and knowledge needs when applying the common framework. This guidance will lead into a final recommendation on the usefulness of CEAs as part of ecosystem advice provided by ICES.

Supporting information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem effects of all marine human activities including fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 20–25 members and guests.

Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There is a very close working relationship with all the groups under HAPISG. It is also very relevant to WGINOSE.
Linkages to other organizations	There are strong linkages to the OSPAR and HELCOM work on CEAs.

Annex 3: Cumulative Effects Assessment Terminology and definitions

Pathways to impact

Cumulative (or 'collective' cf MSFD) pressures – the net result of multiple residual pressures acting together on an ecosystem or ecosystem component

Cumulative / in combination – The residual or additive result of pressures or effects acting together

Cumulative effects – The net effect of cumulative pressures

Cumulative Effects Assessment (CEA) – Cumulative effect assessments (CEAs) are defined as holistic evaluations of the combined effects of human activities and natural processes on the environment, and constitute a specific form of environmental impact assessments (EIAs)

Cumulative impacts – The net impact of cumulative effects

Direct and indirect effects – Direct effects are measurable changes on receptors caused by identifiable pressures. Indirect effects act through intermediary processes, are hard to measure or identify a clear cause: effect mechanism.

Ecosystem component / Receptor / valued component – Terms used interchangeably under different jurisdictional processes to mean identifiable parts of marine ecosystems potentially subject to pressures. These are usually habitats [structural abiotic and biotic components with an ecosystem function or service] or species (or taxonomic group / life cycle stage / trait specific grouping), often of conservation importance. (NB ecosystem functioning and ecosystem services themselves can be relevant receptors for the purposes of CEA application).

Effect – The change in an ecosystem receptor resulting from the application of a pressure

Effects-footprint – The spatial and temporal extent of the effects of pressures arising from an activity. Sometimes implies the magnitude of these effects within the footprint.

Environmental Impact Assessment (EIA) – A project level assessment of impacts, with legal requirements for CEA at the outcome level

Exogenic and endogenic pressures - Pressures which act from outside (or within) the footprint of a receptor or ecosystem component. It is often difficult to manage the causes of exogenic pressures (e.g. climate change) requiring greater focus on mitigation in management.

Exposure – An ecosystem component experiencing a specific pressure (based on frequency, duration, concentration, intensity etc). This is the spatial and temporal overlap of pressure and a component/receptor multiplied by the pressure load / magnitude.

Impact – The negative effects on ecosystems or ecosystem components resulting from the effect of pressures. In socioeconomic systems described as "Welfare"

Intensity - The magnitude of a pressure or resulting effect or impact

Magnitude (or load) – The size or scale of a pressure acting on a component / receptor. Can also be a frequency.

Marine / Maritime (EU) Spatial Planning (MSP) - A process of allocating space to achieve specific objectives. An Objective level process requiring CEA outputs.

Pressure – The mechanism by which activities and developments exert effects on ecosystem components

Processes, tools and methodology

Capacity – The ability of an ecosystem or ecosystem component to accommodate pressures before reaching thresholds or tipping points. NB often relates to carrying or assimilative capacity. (NB different to biological carrying capacity).

Effectiveness (of measures) – Likelihood of measures to produce the expected pressure reduction to avoid an undesired effect.

Input control – A management measure required to achieve a target. ISO terminology. In MSFD terminology these are management measures that influence the amount of a human activity that is permitted.

Output control – A threshold term used in ISO terminology as the trigger for management action. MSFD definition is a management measure that influences the degree of perturbation of an ecosystem component that is permitted.

Recovery – The ability or rate of an ecosystem component to return to pre-disturbed state after cessation of a specific pressure

Residual pressure – The net pressure arising from the interaction of multiple activities and developments, taking account of the management measures ('prevention control' cf bow tie terminology) in place.

Resilience – The ability of an ecosystem component to recover after application of a stressor. Can also be interpreted as representing the recovery capacity in a population dynamics context

Resistance – The ability of an ecosystem component to withstand a specific pressure without effect. Can also be interpreted as representing the pressure-induced annual mortality in a population dynamics context.

Sensitivity – The extent to which an ecosystem component is likely to be negatively affected if exposed to a specific pressure. A function of resistance and resilience or pressure-induced mortality and recovery potential.

Severity – The size or scale of the effect of a pressure on a component / receptor

Strategic Environmental Assessment (SEA) - An EU member state terminology. A strategic level assessment of the impacts of sectors or plans. An Objective level process requiring CEA outputs.

Stressor – A combination of activity/development and pressure acting in a potentially negative manner on an ecosystem component. Often used interchangeably for pressure

Susceptibility – Whether an ecosystem component / receptor is sensitive to a pressure or not

Target terminology relevant to CEA

Thresholds – Acceptable limits determined by society, applied to pressures, effects or impacts and used as a trigger for management measures. Can relate to quality standards, capacities, tipping points.

Top event – Terminology used in bow tie analysis to describe an adverse outcome marine managers would wish to avoid. Often relates to impacts resulting from exceedance of thresholds or tipping points.

Vision, Goal, Objective, Outcome – A hierarchical set of targets relevant for different levels of marine management: Political, strategic / cross sectoral, Project specific / application of measures

Vulnerability – The risk of negative impact on an ecosystem component as a function of its sensitivity and exposure to a specific pressure of known magnitude. Equivalent to 'impact risk'.