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Structuring cumulative effects assessments to support regional and local marine management and planning obligations

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ABSTRACT

Cumulative effects assessments are a legal requirement in many jurisdictions and are key to informing marine policy. However, practice does not yet deliver fit-for-purpose assessments relative to sustainable development and environmental protection obligations. The complexity of cumulative effect questions, which are embedded in complex social-ecological systems, makes multiple, methodologically diverse assessments a necessity. Using the expansion of marine renewable energy developments in European Union waters as a case study, this paper explores how social-ecological systems thinking and cumulative effects assessment theory can combine to structure CEAs that better support the management and regulation of maritime activities at regional scales. A general perspective for cumulative effects assessment is proposed to remove ambiguity of intent and to orient assessments towards a common objective. Candidate principles for practice are presented for consideration. These principles are integrated into a stepped assessment approach that seeks to improve cumulative effects assessments of localised activities relative to the information needs of decision-makers implementing the ecosystem approach.

1. Introduction

The magnitude and extent of human activities in the 21st Century are a driving force shaping the dynamics and resilience of ecosystems [1]. These activities strongly influence the continuance or loss of ecosystem services and the resources that support societies and economies [2]. How resilient services and resources are to further disturbance, extraction or other use is influenced by the cumulative effects load (see Table 1) carried by those services and resources. Hence, there is growing interest in cumulative effects assessment.

Cumulative effects assessments or cumulative impact assessments (hereafter CEA; see Table 1) are a specific form of environmental assessment designed to provide information about how the effects of human activities contribute to environmental change [3]. The term CEA covers many forms of assessment over many temporal and spatial scales, but relative to environmental management, CEAs are often associated with formal environmental assessments [4]. Shortcomings of such CEAs are well cited and improved practice is urgently required to fulfil legal obligations and to support marine management and planning where degraded ecosystems support vital human activities and where future development is needed to support blue growth objectives [5].

Challenges to improved CEA are multidimensional, including bureaucratic (how to include CEAs in decision-making; [6], practical (better linking CEA theory and practice; e.g. [7], and scientific (e.g. how stressors cumulate; [8]; and which stressors matter most [9]). Ambiguity about the intent of CEA (though not of the driving legislation [10]) further hinders efforts to improve practice [10]. This paper seeks to remove ambiguity about the intent of CEA and to link procedural and scientific progress to advance CEA practice. This is also a multifaceted challenge, as unravelling a cumulative effect question, such as investigating the cumulative effect of one spatially localised development quickly points to a range of variables and scales becoming relevant (Fig. 1). Further, the resilience (see Table 1) of ecosystem components (receptors) to additional stressors is dynamic, as the resilience of the receptor at the time is influenced by a spatially and temporally variable spectrum of stressors and processes [11,12].

The receptor-led perspective [13] brings into consideration connectivity and varied temporal and spatial scales of pertinent processes, patterns and human activities. Varied ecological scales are involved and numerous scientific approaches are relevant, from laboratory studies to ecosystem models (see Hodgson and Halpern [14] for a review of academic CEA approaches addressing ecological scale). The spectrum of

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Table 1
Glossary of concepts and terms.

Concept/Term	Definition
Cumulative effects load	The range of effects experienced by receptors that contribute to the overall health of a receptor
Sustainability	Meeting "human needs now and in the future by continuously improving and balancing environmental integrity, economic vitality, and social equity" (Wu [2]; pg 1012)
Ecosystem Approach	Recognising the connection between ecosystems and social systems, the Ecosystem Approach requires management that protects and maintains ecological characteristics while delivering the services and benefits required by society [16]
Social-ecological systems	Coupled systems of people and nature embedded in the biosphere, recognising humans as an intrinsic part of nature [17]
Cumulative Effects Assessment (CEA)	A systematic procedure for identifying and evaluating the significance of human activities on the resilience of social-ecological system components (receptors).
Strategic Cumulative Effects Assessment (SCEA)	An ongoing process to which coherent, tractable CEAs contribute data and knowledge about the effects of human activities on the persistence of relationships between components of social-ecological systems to support adaptive management and governance.
Resilience	A dynamic concept that refers to the persistence of relationships within a system, the capacity of systems to absorb disturbance and reorganise while undergoing change, i.e. to retain the same functions, structure and feedbacks to sustain identity [17,18]

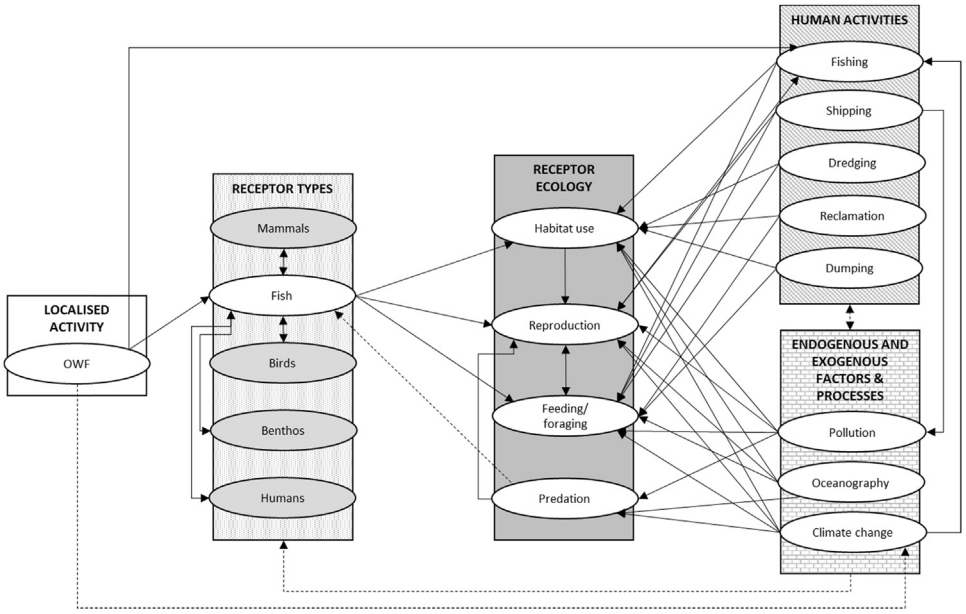

Fig. 1. A non-exhaustive set of direct relationships identified when unpacking a cumulative effect question, such as what is the cumulative effect of one offshore wind farm (OWF) on one receptor type (fishes) within a social-ecological system representative of the Southern North Sea. Dashed arrows indicate feedbacks, such as endogenous and exogenous processes feeding back to influence receptors.

stressors acting on receptors tends to reflect a multitude of human activities, highlighting that cumulative effect questions are situated in coupled social-ecological systems (see Table 1). Human social components determine the effectiveness, or not, of management interventions [12] and are thus relevant to CEA. Investigating the interactions between such a range of components inevitably points to multiple interdisciplinary assessments employing multiple scales of inquiry. However, for such assessments to support marine management and planning requires CEAs that investigate the multitude of interactions and are structured so that knowledge from discrete assessments can cumulate.

This paper uses the development and expansion of marine renewable energy (MRE) in European Union waters as a case study to examine why legislated obligations to assess cumulative effects of individual developments and of strategic plans pose complex scientific questions. Addressing these questions requires a balance between flexibility, structure and rigour to aid decision-making in an uncertain environment. Faced with climate change and the imperative to transition to sustainability (see Table 1), MRE can meaningfully contribute to a low carbon energy generation sector [15]. However, there is no consensus about how significant the environmental impacts of MRE are, leading to substantial uncertainties that delay development. Nevertheless, the spatial and temporal footprints of MRE are increasing as technologies scale up for commercial testing and as proven technologies are industrialised [5]. MRE developments overlap with existing marine users and introduce additional stressors and effects into marine ecosystems (Fig. 1), ecosystems that have changed under a legacy of past human activities and continue to change under existing effects loads. Considering how MRE environmental effects change the resilience of marine ecosystems thus draws attention to critical components of cumulative effect questions, including scale, multiple variables and baselines.

Here, a case is presented for structuring CEAs intended to meet legislated obligations within a social-ecological system framework and to orient CEAs to support one overall Strategic CEA, (shortened to SCEA), an ongoing regional environmental assessment process that reflects current knowledge about receptors and receptor resilience. The SCEA is intended to support local and regional decision-making processes by integrating information from CEAs, which may be stimulated by the need to fulfil project or strategic assessment obligations, guided by a common vocabulary and principles. Commonalities between diverse assessments are identified and a general perspective of CEA is proposed to remove ambiguity about the intent of assessments while maintaining flexibility of approach. Building on conventions proposed by Judd et al. [10], principles are advanced for consideration by regulators, scientists and practitioners, to support progress towards harmonised regional practice. In conclusion, a novel CEA approach is presented that intends to address shortcomings of Environmental Impact Assessment-led CEA.

2. Specifying coherence for cumulative effects assessment

First, the interpretation of coherence as applied to CEA is dealt with. CEAs originated from Environmental Impact Assessment (EIA)