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Issues and challenges in spatio-temporal application of an ecosystem services framework to UK seas

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ABSTRACT

The concepts of ecosystem services and human welfare provide strong integrative frameworks that can be used to inform marine policy and management decisions that support sustainable development. A theoretical framework has been developed and applied to create a model for UK seas to measure changes in final ecosystem services, in terms of human welfare. The model that has been developed is explicitly spatial and temporal to facilitate its use in supporting marine planning decisions. The development and application of this framework to UK seas necessarily requires many assumptions to be made. The paper describes the development and population of the framework and discusses the practical limitations and challenges in seeking to develop and apply such models. Significant differences in long-term values of different services were identified under the different scenarios. All scenarios highlight the projected decline in oil and gas revenues which provide particular intense values at sites of extraction. These values are partially replaced by revenues from offshore renewables in some of the scenarios. Values associated with carbon sequestration, maritime transport, tourism and pollution assimilation are also very significant but more spatially diffuse. The study has demonstrated that it is possible to develop spatio-temporal models to evaluate changes in final ecosystem service benefits using existing data, although the approach necessarily requires many assumptions to be made.

1. Introduction

The evolution of classification systems and analytical frameworks for the application of ecosystem services approaches has been quite rapid over the past 5 years or so. The Millennium Ecosystem Assessment set out a basic classification for ecosystem services [1]. This classification has been developed to support resource accounting and to address issues of potential double counting [2,3]. It is presented within the context of an overall ecosystem services management framework [4]. In particular, the distinction between intermediate services (ecosystem processes), final services and benefits mirrors the measurement of inputs and outputs of resources in economic data on markets, and so is helpful when seeking to make use of ecosystem information in resource accounting [5]. The economics of ecosystems and biodiversity (TEEB) project [6] has helped to document categories of intermediate and final services and their relationship to benefits and standard rules for categorization are beginning to emerge [7].

Where ecosystem services frameworks have been developed and applied, the scope of such frameworks may vary, for example, to focus on purely ecological (biotic) services [1,8] while others take account of both biotic and abiotic services [9,10]. Some studies have also focused on specific requirements for frameworks relevant to marine areas [9].

In this study, a framework based on benefits associated with final ecosystem services and incorporating abiotic services has been used to develop a spatio-temporal model for UK seas [11,12]. This article explores some of the challenges encountered in seeking to develop such a model for UK seas and seeks to identify key areas in which progress needs to be made to improve such models as decision-making tools.

2. Methods

An ecosystem services framework was established focused on final benefits, which incorporated both biotic and abiotic services (Fig. 1) [11,12]. This framework builds on the framework developed by the TEEB project [6]. The framework also seeks to capture all use and non-use benefits and incorporates a small number of regulating services, where these benefits are not captured elsewhere.

A baseline valuation for these benefit categories was developed drawing on published information where available, in particular,

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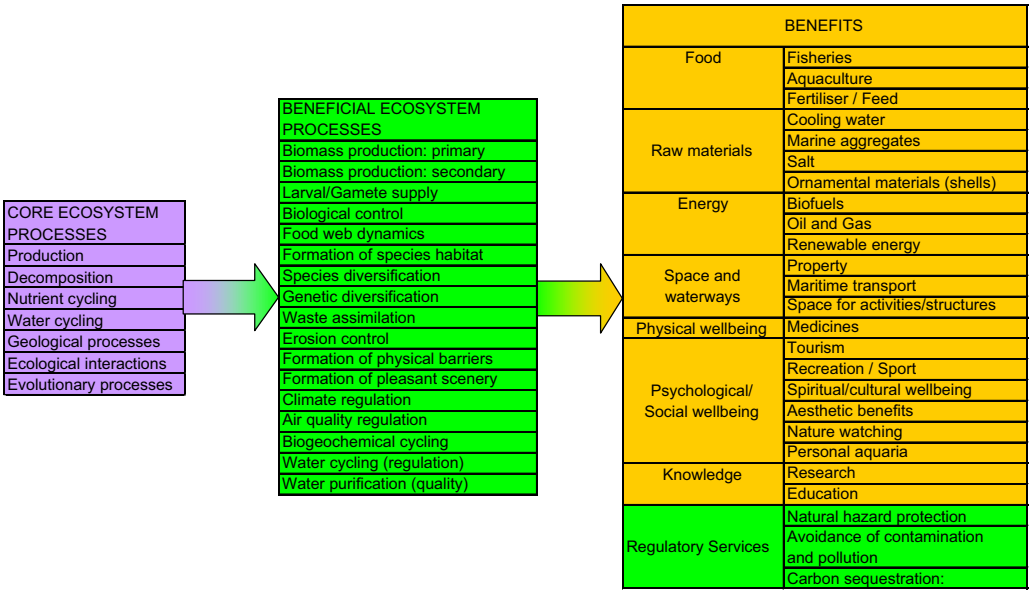

Fig. 1. Ecosystem services framework focused on final benefits. Description: figure linking core ecosystem processes, beneficial ecosystem processes and final ecosystem service.

Table 1
Indicative baseline values of selected final ecosystem services (from [13] unless stated).

Benefits		Estimated baseline value
Food	Fisheries	£52m GVA 2008
	Aquaculture	£147m GVA 2008
Raw materials	Fertiliser/feed	£90m turnover 2008
	Cooling water	£100m replacement cost 2008
	Marine aggregates	£31m GVA 2008
	Salt	Insignificant value
	Ornamental materials (shells)	Insignificant value
Energy	Oil and gas	£37000m GVA 2008
	Renewable energy	£62m Avoidance cost of CO_2 2008
	Biofuels	Estimated investment in research £10m 2008[a]
Sea space and sea bed	Maritime transport	£7100m GVA 2008
	Naval defence	£300m GVA 2008
	Pipelines	Not valued
	Gas storage	Not valued
	Carbon capture and storage	Nil in 2008
	Telecom cables	Not valued
	Power cables	Not valued
Physical wellbeing	Medicines	Not assessed
Psychological/social wellbeing	Tourism, recreation and visitors' aesthetic values	£3790m GVA 2008[a]
	Residents' aesthetic benefits	Not valued
	Spiritual/cultural wellbeing	Partial estimate of the order of £1000m GVA 2008[b]
	Aquaria	Insignificant value
Knowledge	Research and education	£162m investment 2008[c]
Regulatory services	Natural hazard protection	Not valued
	Avoidance of contamination and pollution	£1000m Avoidance cost 2008[d]
	Carbon sequestration	£4319m Avoidance cost of CO_2 2008[a]

[a] [12].
[b] [21].
[c] [22].
[d] [23].

recent estimates developed as part of the UK State of the Seas Report 'Charting Progress 2' [13] (Table 1). For some benefits categories, new valuations were estimated as part of this study. For tourism, recreation and leisure, a new estimate was derived drawing on information from Pugh 2008 for tourism [14], from UK Marine Monitoring and Assessment Strategy (UKMMAS) for boating [13] and from Drew Associates and Radford et al. for recreational angling [15,16]. For carbon sequestration, a valuation estimate was derived, drawing on the work of Thomas et al. in relation to the North Sea carbon pump and shallow water sequestration [17], Nellemann et al. for deep ocean sequestration [18] and International Union for Conservation of Nature (IUCN) for saltmarsh sequestration [19] and using the Department of Energy and Climate Change (DECC) guideline value for non-traded carbon [20].

The majority of values are expressed as Gross Value Added (GVA) (a measure of the increase in value of goods and services produced by an activity), although some estimates are provided