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The value of information: Realising the economic benefits of mapping seagrass meadows in the British Virgin Islands

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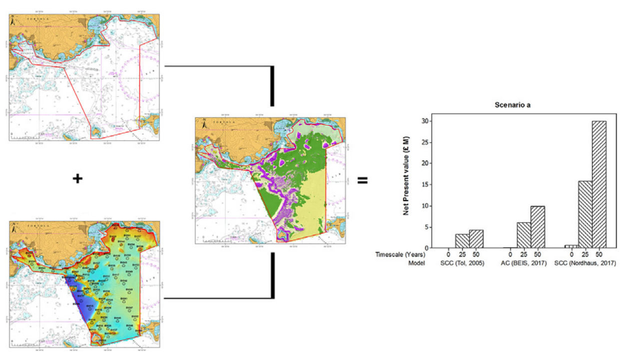
HIGHLIGHTS

- An 800% increase in known seagrass resource was found in a 36 km^2 area.
- Newly mapped seagrasses appear to be resilient in the event of hurricanes occurring.
- Carbon sequestration benefits are valued through avoided cost methods Net Present Values for the 50-year period are 3% of the country' GDP.
- Net Present Values for the 50-year period are 3% of the country' GDP.
- Costs of mapping and monitoring of seagrasses decrease NPVs only marginally.

GRAPHICAL ABSTRACT



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ABSTRACT

Carbon capturing coastal and marine habitats around the world are decreasing in extent every year, habitats found in abundance in Small Island Developing States' territories. However, these habitats are under threat by increased levels of economic activities and extreme weather events. Consequently, as those ecosystems become scarce their value is expected to increase. In this paper the "value of information", the increase in knowledge that renders a system or a function more valuable, from marine habitat mapping is presented through the (monetary) valuation of one regulating service provided by the newly mapped habitats. Mapping a section of a channel with a multibeam echosounder revealed more seagrass resources than in previous studies. Using values for both the Social Cost of Carbon and Abatement Cost methods, from the literature we estimate the value of the carbon sequestration and storage service these seagrass meadows provide. The impacts of hurricanes in the newly mapped seagrasses were also investigated. Despite the costs of mapping, monitoring and of projected losses of ecosystem services provision due to hurricanes, net benefits over a time period of 50 years were considerably larger. The new information provided highlights carbon capturing habitats as more important, enabling the "value of information" to inform policymaking.

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1. Introduction

Small Island Developing States (SIDS) (57 countries mainly in the Atlantic and Pacific regions qualify as such, according to the United Nations) face a difficult challenge as they attempt to boost economic growth whilst preventing overexploitation of their natural resources. These resources offer several services to societies through their contribution to economic activities, either directly by providing food and materials, or indirectly by stabilising the climate and offering health and aesthetic benefits. One of these benefits provided by terrestrial and coastal and marine ecosystems is carbon sequestration. In the coastal

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and marine environment, this process is usually referred to as "blue carbon" sequestration and storage.

Blue carbon refers to carbon in coastal ecosystems defined as tidal marshes, mangroves and seagrass meadows that is either stored, sequestered, or released (Herr et al., 2012). For example, blue carbon is estimated to account for the capture of up to half of the CO_2 emissions of the world's transport sector in a year (Nellemann and Corcoran, 2009). In this work we focus on seagrass meadows and consider them as a marine resource and is referred to as such hereafter.

In particular, seagrass meadows contribute significantly to the removal of carbon from the atmosphere, capturing 10% of the global organic carbon emissions per year, despite being estimated to occupy 0.2% of the area of the world's oceans (Fourqurean et al., 2012). However, different seagrass species present quite varying rates of carbon sequestration and storage (Lavery et al., 2013), and are under the threat of human activities that either degrade or destroy them, leading in turn to a non-uptake of carbon (Crooks et al., 2011). For example, seagrass extent in the world's oceans has declined by approximately 29% since the beginning of the 20th century (Fourqurean et al., 2012). Carbon burial rates (i.e. carbon stored in sediments, after the denitrification process, which renders nitrate into atmospheric gaseous nitrogen) in seagrass meadows provides a mechanism for valuation of carbon sequestration and storage.

For the majority of SIDS though, natural resources are the only way to boost economic growth as they are a catalyst for increasing tourism-related activities, with this growth been demonstrated as having implications for conservation (UNWTO and UNEP, 2008). SIDS are presented with complex decisions when it comes to prioritising conservation over utilisation of their natural resources. This is of particular importance when their vulnerability to natural disasters and the scarcity of natural resources they face, which is accentuated by climate change-related consequences (e.g. increase sea level rise and storm occurrence), reduces the ability to carry out effective long-term planning. Ensuring sustainable decision-making requires a complete and often complicated set of information, in terms of economic analyses of the value of the ecosystem services provided by the natural environment, financial projections of future market demand as well as information on legal, administrative and technological restrictions and opportunities.

Our case study aims to demonstrate how improved knowledge on the distribution of key habitats can improve the accuracy of economic valuation exercises to provide local decision makers with better management capability. In the marine environment, the knowledge of resources is limited due to the relatively hostile nature of the marine environment. Currently, <10% of our ocean floors have been mapped in detail and this proportion is only slightly improved in shallow seas (Fourqurean et al., 2012).

Coupling information on the extent of the seagrasses with an economic estimate of the organic carbon storage potential of the mapped seagrasses against the cost of detailed survey assesses the impact of such activities over a predetermined time period. We also examine the plausibility for policy and decision makers of incentivising the conservation of coastal and marine natural capital through mechanisms such as Payment for Ecosystem Services (PES) schemes (e.g. debt swap).

2. Materials and methods

2.1. Environmental evaluation in a changing climate

Evaluation of environmental projects (projects that involve either directly or indirectly environmental assets) and the related policy decision-making process usually are informed by a Cost-Benefit Analysis (CBA). CBA creates consistent basis for evaluation of decisions when compared to their outcomes (Drèze and Stern, 1987). CBA is a tool used by regional organisations in the US and Europe (Pearce et al., 2006) as well as the World Bank and other international organisations (Dietz and Hepburn, 2010). CBA presents the benefits and the costs of a project compared to alternative options, over a specific time horizon, to determine whether benefits outweigh the costs (Greenhalgh et al., 2017). However, CBA is challenging in its application when public goods such as the benefits from ecosystem services are considered, as these benefits are often difficult to quantify, and the CBA outputs can be misrepresented (Drèze and Stern, 1987) or contested (Turner, 2007). However, the development of new survey technologies enables the acquisition of data that can be used to more effectively quantify resource distribution and better support valuation of economic benefits, therefore ensuring a more appropriate baseline for CBA.

Benefits from environmental projects can be directly quantified (e.g. measuring the possible increase in fish productivity after seasonal restrictions are imposed in a fishing area) or indirectly (e.g. assessing the benefits of a beach cleanup by increased aesthetic benefits for visitors). Benefits from carbon sequestration and storage refer to avoided health costs (as carbon is not released in the atmosphere, causing health damages to humans) and coastal and marine ecosystems offer a large variety of these services. These services, provided by natural ecosystems and classified by the services provided to humans are referred to as "ecosystem services" (Barbier et al., 2011). The term "ecosystem services" is used here to identify the ecological functions and processes of ecosystems that provide human welfare benefits (Fisher et al., 2009) after complementary human assets valued by society have been added (Turner and Schaafsma, 2015) and this paper follows the Millennium Ecosystem Assessment (2005) classification of services.

Most scientific research on the tropical coastal environment and the ecosystem services they provide has focussed on mangroves and coral reefs (Wells and Ravilious, 2006). When it comes to the seagrass ecosystems, evidence of their economic importance becomes limited. If society is to continue to benefit from the ecosystem services that seagrasses provide, implementing management measures to support conservation of these threatened ecosystems is vital.

The Caribbean Development Report (CDR) of the United Nations on the Economics of Climate Change in the Caribbean (UN, 2011) identified several pressures on the coastal and marine environments of Caribbean SIDS which are potentially driven by climate change. These include sea level rise, inundation, erosion and volatile weather (Patil et al., 2016). The ecology and status of Caribbean seagrasses and the particular pressures they face, are not well documented (Ruiz-Frau et al., 2017). The Economic Commission for Latin America and the Caribbean (ECLAC) states that Latin American and Caribbean regions are expected to face climate change adaptation costs of about 20% of their regional GDP to protect their coastal areas against extreme weather events (UN, 2014). Overall, following a peak during the period between 2005 and 2006, Caribbean islands faced fewer threats and lower damages from hurricane and climate change events between 2010 and 2014 (Acevedo, 2016). Extreme weather events as well as human disturbances and microbial priming (a process which affects the decomposition rate of organic matter due to excessive levels of nutrients found in fertilizers and plant litter, among others) can also present a threat to seagrass ecosystems although the impact is variable as effects range from negligible to severe (Short and Wyllie-Echeverria, 1996; Thorhaug et al., 2017; Trevathan-Tackett et al., 2018). However, the effects of hurricanes on seagrasses vary, with studies reporting losses in extent of seagrass cover in shallow areas (Fourqurean and Rutten, 2004), or no losses at all (Steward et al., 2006; Byron and Heck, 2006).

2.2. Case study area

The British Virgin Islands (BVI) are an overseas territory of the U.K. The territory comprises >60 islands, the largest of which is Tortola. As part of a Darwin Initiative project (Vanstaen et al., 2016), a high-resolution seabed survey was carried out in Sir Frances Drake Channel, south of Tortola, which is the main transit route to Road Town harbour for marine traffic (Fig. 1).The area was selected in conjunction with local stakeholders because it contains the BVI's first marine park, the Rhone

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