Marine Pollution Bulletin 71 (2013) 101–106

Contents lists available at SciVerse ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Valuing the European ‘coastal blue carbon’ storage benefit

T. Luisetti [a,b,*], E.L. Jackson [c,d], R.K. Turner [a]

[a] Centre for Social and Economic Research on the Global Environment (CSERGE), School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, Norfolk NR4 7TJ, UK
[b] Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
[c] Marine Institute, Plymouth University, Drake Circus, Plymouth PL4 8AA, UK
[d] Central Queensland University, School of Medical and Applied Sciences, Bryan Jordan Drive, PO Box 1319, Gladstone QLD 4680, Australia

ARTICLE INFO

Keywords:
Coastal blue carbon
Posidonia oceanica
Saltmarsh
Accounting stock value
Ecosystem services

ABSTRACT

‘Blue’ carbon ecosystems are important carbon storage providers that are currently not protected by any international mechanism, such as REDD. This study aims to contribute to raising awareness in the political domain about the ‘blue’ carbon issue. This analysis also provides guidance in terms of how to value stock and flows of ecosystem services adding to the debate begun by the Costanza et al. (1997) paper in Nature. Through scenario analysis we assess how human welfare benefits will be affected by changes in the European coastal blue carbon stock provision. The current extent of European coastal blue carbon has an accounting stock value of about US$180 million. If EU Environmental Protection Directives continue to be implemented and effectively enforced, society will gain an appreciating asset over time. However, a future policy reversal resulting in extensive ecosystem loss could mean economic value losses as high as US$1 billion by 2060.

1. Introduction

Coastal ecosystem stocks of natural capital (the ecosystem structure and processes and links to the abiotic environment) possess high biological productivity and provide a diverse set of habitats and species, with a cosequent flow of ecosystem services (such as carbon storage) of significant benefit (value) to society (Fisher et al., 2009). Coastal ‘blue’ carbon service providing ecosystems cover just 0.5% of marine areas (da Silva Copertino, 2011), yet represent more than 55% of ‘green’ carbon (carbon removed by photosynthesis and stored by natural ecosystems) (Nellemann et al., 2009). This important ecosystem service is protected in terms of its terrestrial carbon storage providers by international mechanisms such as REDD and REDD+; but similar international mechanisms are currently not available for coastal and marine ecosystems (da Silva Copertino, 2011; Fourqurean et al., 2012; Pendleton et al., 2012; Siikamäki et al., 2012). This study contributes to raising awareness about the ‘blue’ carbon issue and provides guidance in terms of how to value stock and flows of ecosystem services.

Efforts aimed at meeting the challenges of environmental change have increasingly focused on the principle of integrated and holistic ecosystem modelling and management, but while the ecosystem approach seeks to be comprehensive, the links to social and economic welfare impacts and policy responses are less developed. The ecosystem services framework is designed to fill this gap by incorporating the benefits society derives from the continued functioning of ‘healthy’ ecosystems into the management calculus. In order to make the real value of ecosystems more ‘visible’ within governance, the ecosystem services framework highlights nature’s worth in monetary terms. The sums involved are significant and often support increased conservation efforts (Turner et al., 2003). The future for carbon sequestration provision in coastal and marine areas will depend on the rate, extent and characteristics of future economic growth and climate change impacts. Through futures scenario analysis we assess how human welfare benefits will be affected by changes in the European ‘blue’ carbon stock provision. Following the most recent scientific published results estimating future loss trends for European seagrasses (especially *Posidonia oceanica*) and saltmarshes (Airoldi and Beck, 2007; Jones et al., 2011), we consider three possible future scenarios: the first based on the continued successful application of current ecosystem conservation policies, and the others on the risk of future benefit losses due to the lack of protection for coastal blue carbon ecosystems.

The results of our valuation analysis highlight the practical economic importance of the ‘blue’ carbon sequestration/storage service, thereby raising the blue carbon ‘political’ profile to support blue carbon related policy negotiations. The paper is developed

---

* Corresponding author at: Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK. Tel.: +44 (0) 1502527716.

E-mail address: tiziana.luisetti@cefas.co.uk (T. Luisetti).

0025-326X/$ - see front matter Crown Copyright © 2013 Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.marpolbul.2013.03.029

as follows: Section 2 explains the methodology used in this analysis; Section 3 presents and discusses the results; Section 4 offers some conclusions.

2. Methodology

2.1. Background information

The European coastal blue carbon sink encompasses saltmarshes and seagrass beds, which represents the globally most important coastal blue carbon storage sink and service benefit in both living and organic-reach soils (Fourqurean et al., 2012). Blue carbon ecosystems release negligible amounts of greenhouse gases and can store more carbon per unit area when compared to fresh water marsh areas (Chmura et al., 2003). In saltmarshes, carbon (C) is stored but methane (CH_4) (considered negligible) and nitrous oxide (N_2O) (considered significant) are emitted. The estimate of net C storage in European saltmarshes used in this study takes account of this net effect (Adams et al., 2012). International initiatives such as REDD+ have been protecting terrestrial green carbon storage through forest conservation. Similar international mechanisms are currently not available for blue carbon (da Silva Copertino, 2011; Fourqurean et al., 2012). According to the Global Land Cover 2000 database the coverage of forest in Europe is approximately 562 million ha compared to our estimate of seagrass and saltmarsh coverage of only 3 million ha. We estimate that saltmarsh and seagrass carbon storage in Europe represents about 1.5–4% of existing global ‘blue’ carbon from coastal vegetated habitats (Nellemann et al., 2009).

There are four species of seagrass found within European seas: Neptune grass (*Posidonia oceanica*), seahorse grass (*Cymodocea nodosa*), eelgrass (*Zostera marina*) and dwarf eelgrass (*Zostera noltii*). Accretion rates of carbon vary from site to site due to currents, growth rates and wave exposure. Carbon burial rates also vary between species of seagrass and the dominant species of seagrass is different in each European sea region. In the Mediterranean the endemic *P. oceanica* is not only the most abundant and widespread, but also the species that is able to best capture CO_2 from the atmosphere (Kennedy and Björk, 2009). In other European seas the most dominant seagrass is the eelgrass, *Z. marina*. Despite its recognised importance there have been few studies assessing the carbon burial rates, and knowledge of the sequestration capacity of *Z. marina* beds is rudimentary. Seagrasses have a number of characteristics which result in high carbon burial rates (Cebrián et al., 1997), particularly in terms of slow growing long lived species such as *P. oceanica*, which have a more important role in terms of net oxygen release and as CO_2 and nutrient sinks, than the faster growing short lived species. The heavily lignified rhizomes and roots of *Posidonia* are very slow to decompose and the resulting “matte” structure may act as a long term carbon sink, due to the plants ability to trap particulate organic matter (Mateo et al., 1997; Kennedy et al., 2010). Their sediments are largely anaerobic, consequently seagrass-derived organic matter can be preserved for long-time periods (Mateo et al., 1997). In this study, we use the carbon burial rate estimated by Gacia et al. (2002) for *P. oceanica* (1.82 $tC\ ha^{-1}\ yr^{-1}$), and the rate reported for a Spanish seagrass meadow (Cebrián et al., 1997) (0.52 $tC\ ha^{-1}\ yr^{-1}$) for *Z. marina*. It should be noted that carbon burial rates are likely to vary significantly both temporally and spatially (Duarte et al., 2011), and future data on this variance would allow a more accurate estimation of the contribution of these habitats to carbon sequestration.

Coastal wetlands have been lost through land reclamation for agriculture or urban/industrial development, agricultural run-off, coastal development and related pollution, as well as sea level rise (see Pendleton et al., 2012 for a summary of these losses). A review of loss, status and trends for coastal marine habitats in Europe suggests that approximately two thirds of European coastal wetlands that existed at the start of the 20th century have now been lost (Airoldi and Beck, 2007). Because of the simultaneous action of sea-level rise and isostatic movements, major losses of saltmarshes are continuing, for example, in the south-east of England. While for the whole UK saltmarsh habitat losses due to sea level rise have been relatively small to date (i.e. 4.5% over the past 20 years), habitat losses in coastal areas are projected to reach 8% overall by 2060 (Jones et al., 2011). That is probably because sustainable management of coastlines (e.g. a reorientation away from ‘hard’ defences to a mix of ‘hard’ and ‘soft’ measures) is becoming an increasingly relevant policy objective (Zedler and Kercher, 2005). Similar saltmarsh loss and restoration trends have been experienced across Europe. Given this current aggregate position, future losses are likely to be relatively modest as long as EU Environmental Directives provisions continue to be effectively enforced (protection, recovery and restoration). The future scenario for seagrass is more pessimistic and restoration efforts more costly (Fonseca et al., 2000). Waycott et al. (2009) estimated a global rate of loss in seagrass of 110 $km^2\ yr^{-1}$ since 1980, and there is strong evidence that seagrass is in decline in the Mediterranean where losses of seagrasses over the last 100 years were estimated (Langmead et al., 2007) at 446 $km^2\ yr^{-1}$. In the case of *P. oceanica* re-growth requires several centuries, making its destruction practically irreversible. Models using current estimates of increasing marine pollution and seawater temperature show that by 2060 the remaining amount of *P. oceanica* might be 10% of the current habitat extent, leading to its functional (and related services) extinction (Jorda et al., 2012). Eelgrass (*Z. marina*) was once a common seagrass bed across sheltered European coastlines but a ‘wasting disease’ in the 1930s led to losses of almost 90% of the *Zostera* populations. Although some beds recovered, substantial areas remain lost (Nienhuis, 1994), so now it is listed as a threatened and declining habitat under OSPAR.

2.2. European coastal blue carbon area distribution and carbon storage capacity

Our analysis covers the EU-27 countries. The methodology adopted for the aggregation of carbon storage values in saltmarshes across Europe relies on maps of the European Environment Agency – CORINE land cover maps 2000 and 2006 – and on a series of assumptions, as data on carbon storage for coastal wetlands are not widely available and have mostly been collected for the North of Europe. Overlaying the CORINE maps to analyse saltmarsh rate of change produces contradictory results, with increases in saltmarsh area for all but the Mediterranean. Rather than showing the positive results of coastal realignment schemes in European coastal wetlands, this may be an artefact of better mapping techniques in use by 2006. Our analysis is limited to the differences between 2000 and 2006 because the areas covered by the 1990 dataset are significantly different (i.e. less countries were mapped). The estimated current extent of European saltmarshes is 330,653 ha.

Adams et al. (2012) estimated net C sequestration in natural (0.94 $tC\ ha^{-1}\ yr^{-1}$) and mature managed realignment saltmarsh (1.15 $tC\ ha^{-1}\ yr^{-1}$) located in the East of England given a 5.4 mm assumed sedimentation rate. They focus on only the less reactive C destined for long term storage in sediments. Their estimates are net of the green house gas emissions released back in the atmosphere in the process of C burial. In this study, considering that managed realignment sites are quite experimental in Europe, we use the estimate of natural saltmarshes and assume that this estimate is suitable also for the whole north of Europe climatic zone. For the south of Europe, although it is reported in the literature that C storage decreases with increasing average annual tempera-