Economic evaluation of coral reef ecosystem service of coastal protection: A pragmatic approach

Nicolas Pascal, Michel Allenbach, Angelique Brathwaite, Lauretta Burke, Guillaume Le Port, Eric Clua

Abstract

The identification and economic valuation of ecosystem services (ES) are becoming important components of coral reef management. In many contexts, protection of human assets against coastal floods is one of the most important ES provided by coral reefs. The methods utilized to characterize this ES should be able to accommodate situations with low data availability, without sacrificing robustness. In this paper, we suggest such an approach that utilizes expert opinion and does not require copious amounts of data. Our primary objective is to produce an economic valuation of the coral reef ES of protection against coastal floods. The approach has three steps: (i) identify geographic zones and assets at risk, (ii) identify the contributing role of coral reefs in the protection of coasts and, (iii) value the annual repair costs of assets through the avoided damage cost approach. The proposed method seems appropriate for advocacy with policy makers, but appears to be less effective for small scale approaches, such as those required for Payment for ES negotiations or marine spatial planning.

1. Introduction

Economic evaluations of coral reef ecosystem services (ES) have been undertaken to address several objectives, such as raising environmental awareness among decision-makers and the public, evaluating the costs and benefits gained from different levels of investment in coastal management, incorporating present and future values of both negative and positive impacts via a common metric and fine tuning economic instruments (Burke et al., 2008; Laurans et al., 2013). In addition, valuations can form part of monitoring routines which utilize quantitative indicators to inform management (“we manage better what we can measure”) (Beukering et al., 2007; David et al., 2007; Pascal et al., 2012) and used in the implementation of tools such as ‘Payment for ES’ (PES) (Huwyler et al., 2014). To date, the most common use of economic valuations of marine ES has been for advocacy with policy makers (Waite et al., 2014). In these studies, the priority has been to transmit accurate information on the value of a large range of ES and their beneficiaries, without striving for the highest level of confidence (“science to inform policy”). For other studies, such as those focusing on monitoring or the design of a PES, the level of precision required is much higher (Sale et al., 2014).

Recent work on the economic valuation of coral reef ES shows that it is important to concentrate valuation efforts on three main ES, which under the Millennium Ecosystem Assessment’s classification (MEA, 2003) fall under the headings of provisioning, cultural and regulating (Hilmi et al., 2014; Laurans et al., 2013). The first two ES (provisioning and cultural) refer to respectively: (i) fish biomass production; coral reef associated fisheries provide an important source of protein and a basis for livelihoods and (ii) scenic beauty for recreational tourism; coastal recreation and tourism activities generate significant economic value depending on the quality and availability of specific marine ecosystem attributes. This article will focus on coastal protection provided by coral reefs, which falls under the third heading of regulating services.

Coral reefs form barriers which buffer coastal zones from severe weather events and in so doing, protect human lives, coastal properties and economic activities (Barbier et al., 2011). Several
studies show that reefs reduce ocean swells, which results in wave transformations and rapid attenuation of wave energy (Brander et al., 2004; Kench and Brander, 2009; Lugo-Fernandez et al., 1998). The fringing reef can absorb a large part of this force (Brander et al., 2004; Roberts et al., 1992) up to 90% at low tide (Lugo-Fernandez et al., 1998). Given the expected increase of extreme climatic event occurrences, as well as sea level rise due to climate change (IPCC, 2013), it becomes increasingly important to better understand, communicate and manage this ecosystem service of coral reefs.

Another service related to coastal protection, is the contribution of reefs to the regulation of erosion and sedimentation, which are critical to maintaining beaches and coastlines. Coastlines where coral reefs are located receive coral or algal derived sediments from this ecosystem via various hydrodynamic processes (waves, currents, tides). Accumulation on the coastline of those sediments (sedimentation) is the source of beach formation (Huang et al., 2007).

The ES of coastal protection is therefore relevant both for the protection of human lives and economic activities associated with beaches. Economic valuation of shoreline protection provided by coral reefs is a useful tool in highlighting the importance of this service to decision-makers (Sale et al., 2014).

Characterization (with or without economic valuation) of the coastal protection ES however is extremely challenging, especially in a data scarce environment. Over 64% of coral reef ecosystems lay in developing countries (Bryant et al., 2011) which are often characterised by high population densities in the nearshore and limited government resources for coastal management. The development of ES valuation methodologies adapted to these contexts is a requirement if the full potential of ES valuations is to be realized.

Many factors contribute to make the valuation of coastal protection ES complex. The typology of the reef, its depth and the type of wave that impact it, result in great variability in the assessment of the role of reefs in coastal protection (Kench and Brander, 2009). In addition, the typology of the reef, its depth and the type of wave that impact it, result in great variability in the assessment of the role of reefs in coastal protection (Kench and Brander, 2009). In addition, the development of ES valuation methodologies adapted to these contexts is a requirement if the full potential of ES valuations is to be realized.

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2. Material and methods

To fulfill the objective of this paper, five studies were used to illustrate the valuation of coastal protection provided by coral reefs (Table 1). Chosen study areas have many similarities: (i) insular

<table>
<thead>
<tr>
<th>Ocean/Regional Seas</th>
<th>Country/Island or specific area</th>
<th>Method of valuation</th>
<th>Valuing method</th>
<th>Scale of the study</th>
<th>Main characteristics of case studies</th>
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<tbody>
<tr>
<td>North West Pacific Ocean/Philippines Sea</td>
<td>Northern Marianas/B.P.</td>
<td>ADC</td>
<td>Island</td>
<td>Study area</td>
<td>Use of Coastal Protection Index Burke et al. (2008), Van Zanten et al. (2014)</td>
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<td>North West Pacific Ocean/Philippines Sea</td>
<td>Palau</td>
<td>ADC</td>
<td>Island</td>
<td>Study area</td>
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<tr>
<td>North West Atlantic Ocean/South East Caribbean Sea</td>
<td>Trinidad&amp;Tobago, Belize, St Lucia</td>
<td>ADC</td>
<td>Island</td>
<td>Study area</td>
<td>Use of Coastal Protection Index Burke et al. (2008), Van Zanten et al. (2014)</td>
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<tr>
<td>South West Pacific Ocean</td>
<td>New-Caledonia</td>
<td>ADC</td>
<td>Island</td>
<td>Study area</td>
<td>Use of Coastal Protection Index Burke et al. (2008), Van Zanten et al. (2014)</td>
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<tr>
<td>Pacific Ocean</td>
<td>North West Atlantic Ocean/North East Caribbean Sea</td>
<td>ADC</td>
<td>Island</td>
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