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Tropical islands quick data gap analysis guided by coral reef geomorphological maps

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ABSTRACT

A gap analysis is the initial step towards the identification of areas where data are needed. However, often, data coverage cannot be assessed against a reference that objectively guides the identification of both gaps and priority areas for data acquisition. Here, we describe a quick, effective and reproducible spatial data gap analysis approach based on the relationship between location of available metadata and coral reef geomorphological richness. In Solomon Islands, we identified gaps defined by high richness and low biological data coverage. We collected metadata only, to avoid dealing with data ownership, availability, and formats, and to be able to identify gaps in less than two months. This fast method does not replace quantitative and comprehensive gap analysis, but provides effective identification of areas of high natural value and limited knowledge. The method is widely applicable and particularly invaluable for large and complex domains such as the Coral Triangle.

1. Introduction

Conservation actions are booming at local and national levels in Indo-Pacific tropical islands to protect biodiversity, reverse habitat degradation and manage fishery resources. Initiatives emerge from governments, non-governmental organizations, and local communities, or from hybrid co-management schemes. Recently, attention has been given to giant marine protected areas that often include substantial no take areas (Pala, 2013). Newest giant (or mega) reserves include almost half of the Cook Islands EEZ with over 1 million km^2, part of the Coral Sea (Australia) with over 900 thousands km^2 and Chagos (British Indian Ocean Territory) with over 600 thousands km^2 (Sheppard et al., 2012). Other mega-reserves include the Phoenix Islands protected area (Kiribati), and the Papahanaumokuakea Marine National Monument in Hawaii (USA) with between 300 and 500 thousands km^2. Recently, the entire Republic of Maldives was listed, and nearly 1.3 millions km^2 of New Caledonia EEZ is a Marine Park since October 2013. These marine reserves include vast expanses of reefs, lagoons and open sea with significant ecological significance (Ceccarelli et al., 2013). For managers and politics, they were also ideal for easy implementation of marine reserves because most of these areas hosted limited population, human activities and exploitation conflicts due to their remoteness. Furthermore, decisions could be made without the need for new detailed biodiversity and resource usage (e.g. fishery) surveys. In fact, gaps in knowledge were not important to make decisions at such large scale. However, this is not the rule. In many other places, the situation is substantially different (Fernandes et al., 2005). Data are needed. And data gap analysis are required prior defining networks of small protected areas that would maximize biodiversity protection yet authorize routine activities, especially those critical to maintain food security, local economies, traditions and overall well-being (Hamel et al., 2013).

To resolve conservation targets and conflicting human uses, the location and extent of protected areas should be defined based on consistent and comprehensive ecological and socioeconomic data over the entire planning area (Margules and Pressey, 2000; Pressey, 2004). This principle should in theory also be applied to national or regional scale planning. In this paper, we consider cases where policy makers and conservationists focus on avoiding biodiversity loss and need to identify areas of biological significance at large scale. This is typically a top–down framework where a central entity coordinates a coherent series of locally implemented conservation actions. Methodologically, top–down planning often requires some type of gap analysis in the initial stages (Dudley and Parish, 2006; Pressey and Bottrill, 2009). Gap analyses review existing data and metadata, and assess what is missing and where for a given objective. This first step assesses representation gaps

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(i.e. representation of species), and ecological gaps (i.e., representation of processes supporting species). This information can be used further to identify where new data needs to be collected. A gap analysis can specifically inform on management gaps, for instance the level of representation of species and ecosystem processes in protected areas (Mora et al., 2006; Kool et al., 2010; Mills et al., 2011). In the past, the Gap Analysis Program (GAP), implemented these approaches for terrestrial ecosystems in the United States (Jennings, 2000). The goal was to "*keep common species common by identifying those species and plant communities that are not adequately represented in existing conservation lands. By identifying their habitats, Gap Analysis gives land managers and policy makers the information they need to make better-informed decisions when identifying priority areas for conservation*" (http://www.nbii.gov/portal/server.pt/community/gap_home/1482). GAP, was implemented first in Hawaii and in the continental US in the 1980s. It provided a conceptual and technical scheme to identify areas where species were poorly protected using habitat maps (Jennings, 2000).

In most coral reef conservation planning projects, habitat data are often patchy and irregularly distributed. At best, they are consistent, well replicated and with good spatial coverage but they seldom entirely cover the region of interest (Wabnitz et al., 2010; Plaisance et al., 2012; Brewer et al., 2009). This representation patchiness biases decision towards well documented areas, even if there are evidences that knowledge distribution and conservation needs are not correlated (Fisher et al., 2011). We propose here a gap analysis method that identifies areas where data collection at national level is needed. The method is suitable for areas where timely and unbiased decisions need to be made. The specifications of this gap analysis are to: (1) address national coverage consistently, (2) be quick, and we set a two month limit to perform the analysis, (3) be easily reproducible, (4) focus on coral reefs and (5) compare the amount of available data against a normalized spatial reference covering the entire domain. This later point is the key aspect of this study. For this, we used coral reef geomorphological maps to guide the identification of gaps. We based our analysis on the assumption that areas rich in habitats are of primary concern for conservation because they likely support a high diversity of species. Thus data-deficient areas with a high geomorphological diversity were considered a priority for further data collection, and areas where future management actions could take place. The originality and the feasibility of the method are demonstrated for Solomon Islands, a western Pacific Ocean island country.

2. Material and methods

2.1. Study site

Solomon Islands are one of the six countries forming the Coral Triangle, an Indonesia–centered area that is described as the epicentre of coral reef species biodiversity (Veron et al., 2011) (Fig. 1). The Santa Cruz Islands archipelago on the eastern part includes small oceanic high islands, banks and atolls. Ndendo, the largest high island, supports 600 km^2 of land, reefs and lagoons. The western archipelagos include much larger high islands (e.g., Guadalcanal Island, with 5400 km^2 of land) and several atolls and deep banks (e.g., Ontong Java). Overall, it includes approximately 28,000 km^2 of land and reef islands, and 8500 km^2 of lagoons and reefs. The region is tectonically active, resulting in differential reef uplift and subsidence rates that have favoured a great diversity of reef geomorphological configurations (Fig. 2).

2.2. Coral reef geomorphological habitat maps

The backbone of the gap analysis is a geomorphological map from the Millennium Coral Reef Mapping Project (MCRMP). The goal of the MCRMP was to map with Landsat satellite images at 30 meters spatial resolution all the reef complexes on the planet (Andréfouët et al., 2006; Mora et al., 2006). A global hierarchical classification scheme describes all coral reef geomorphological configurations found worldwide (Andréfouët et al., 2009), with five-level (Level 1 to Level 5) and up to 800 classes at the finest level of description. The value of the MCRMP product is to offer consistent description of coral reefs at a national (global) scale. It highlights depth and exposure of main reef types (e.g. fringing, barrier, patch reef, atoll, bank, etc., described at Level 3) and their main geomorphologic sub-units (e.g. forereef, reef flat, sedimentary terrace, channel, pass, etc., described at Level 4). The Level 5 description for a given polygon is achieved by combining all

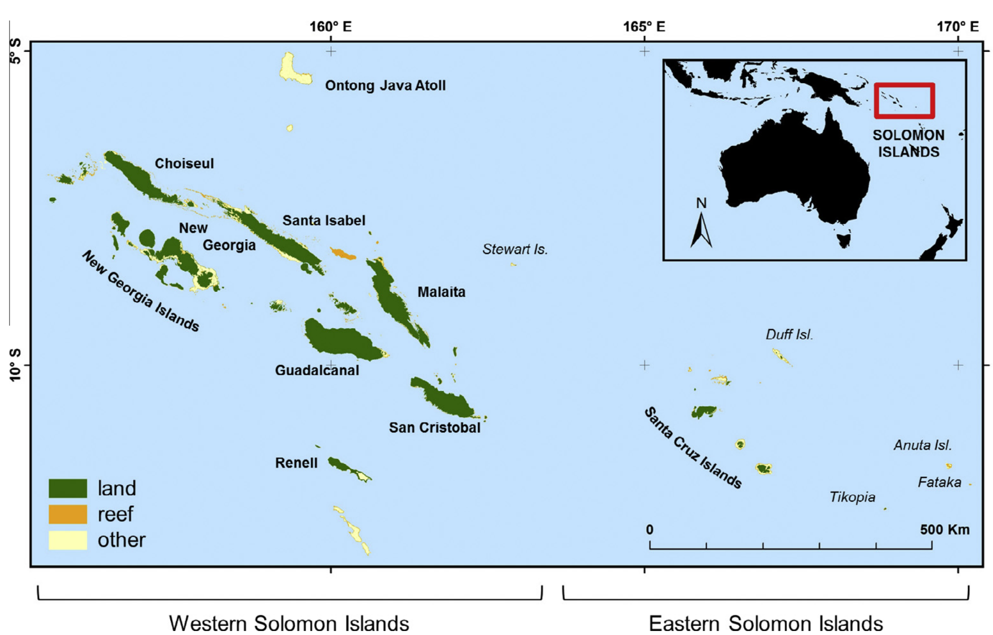

Fig. 1. Study area: Western and Eastern Solomon Islands.

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