Data-limited Marine Spatial Planning: Generating Maps of Priority Conservation Areas in Montserrat

Planeación Espacial Marina con Datos Limitados: Generando Mapas de Areas Prioritarias para Conservación en Montserrat

Planification Spatiale Marine en Limitation de Données: Identification des Zones Prioritaires de Conservation au Montserrat

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EXTENDED ABSTRACT

The oceans are becoming ever busier with activities such as fishing, shipping, recreational boating, diving and snorkeling all increasing in extent and intensity. Marine spatial planning (MSP) is frequently used to minimize overlap of incompatible activities, protect important conservation areas, and ensure sustainable fisheries. In small island nations, where coastal fisheries and tourism can be an important part of the economy, and, for fisheries, the culture, MSP can help avoid conflict over spatial use and potentially increase the economic value for both industries. For example, marine reserves can increase the biomass, species diversity and abundance of species that fall within them (Lester et al. 2009), which can be beneficial for both fisheries, through spillover benefits (Russ 2002), and the tourist industry, as divers and snorkelers want to see more, bigger fish (Gill et al. 2015). However, implementing MSP in small island nations can be challenging due to lack of data, funding, and local capacity. There is a need for free and open-source decision support tools that can be used to facilitate MSP. Marxan (Ball et al. 2009) and other systematic conservation prioritization packages have been used extensively for conservation planning worldwide. One of the most cited cases is the rezoning of the Great Barrier Reef Marine Park using Marxan (Fernandes et al. 2005) and it has also been used to aid MSP in the Caribbean (Agostini et al. 2015).

Montserrat provides an interesting case study of the challenges of MSP in the small island context as it is currently in the process of designating marine zones. The Blue Halo Steering Committee, which consists of representatives of stakeholder groups that utilize Montserrat's marine environment, is leading MSP for the island and requested scientific guidance on where best to place marine reserves. We used the R package 'prioritizr' (Hanson et al. 2017) to generate a map of priority conservation zones based on a set of conservation objectives using habitat, biodiversity, and proxies of spatial fishing effort data as inputs.

Prioritizr does not currently offer all the functionality of Marxan, but can solve conservation problems much faster and exactly; Marxan finds near optimal solutions. Similar to Marxan, prioritizr finds a least cost planning solution, using data on the biodiversity features that the user wants to protect and the cost of each planning unit. We used two data layers as biodiversity features: habitat data and species richness; and combined two sources of information on fishing effort to generate a cost layer. These data layers were generated as follows:

i) **Habitat data** – a benthic habitat map for 0 – 100 m water depth around the island of Montserrat was constructed using two maps from the literature (IRF 1993, Wild et al. 2007) as a starting point. These maps were updated using habitat observations from scuba/ free dive survey sites from the Waitt Institute Blue Halo initiative scientific surveys done in 2014 – 2015. These surveys went to a maximum depth of 30 m (n = approx. 600) and drop camera deployments covered depths from 30 – 100 m (n = 343). Benthic habitats were divided into 9 categories that describe both geoform and biological cover: algal reef (hard bottom), algal reef (mixed bottom), artificial reef, colonized volcanic boulders, coral reef, hard bottom and sand, sand, sargassum forest, and seagrass.

ii) **Coral and fish species richness** – we used reef survey data from the Waitt Institute Blue Halo initiative scientific surveys done in 2014 – 2015 to map coral and fish species richness around the island. This point data was interpolated to 500 m to produce a continuous surface of values.

iii) **Fishing effort** – a map of relative fishing effort was created using a combination of two data layers:
- Spatial survey data from fishers (n = 55) recorded using Seasketch, a collaborative planning platform that allows collection of spatial data from users. During this process, respondents were asked to outline polygons to show areas used for fishing and assign these areas relative values. These polygons and their values were

then combined to give a relative measure of spatial fisheries value around Montserrat.

- Fish pot GPS points recorded during the Waitt Institute scientific assessment. Points were buffered to 100m to account for movement of fish pots while underwater and horizontal distance between buoy and actual pot location.

The two data layers were given equal weight by scaling values in each layer on a 0 – 1 scale. For the fisher survey data this involved log+1 transforming the data due to a small number of extreme high values. The two (raster) data layers were then summed to produce the final fishing effort map.

Running prioritizr requires setting targets for each biodiversity feature. The Blue Halo Steering Committee was tasked with protecting 30% of Montserrat's nearshore waters in no-take areas. Using this as a guideline we set a target of protecting 30% of each of the nine habitats defined in the habitat layer. For the biodiversity feature, we tested various options for the protection target, ultimately setting a target of 50% of total biodiversity (defined as coral and fish species richness). This avoided excessive fragmentation of the conservation zones.

Prioritizr has boundary penalties which can be used to favor zones that are clumped together. To set the boundary penalties, we ran the optimization using multiple different scenarios incrementing the boundary penalty in each. For the final result, we used a penalty of 0.001 which provided a balance between the resulting zones being excessively fragmented and forced into a single contiguous zone. An edge factor of 0.5 was used to account for the planning units along the coast.

The final map of priority conservation zones achieves the conservation targets of protecting 30% of each habitat type, 50% of total biodiversity (coral and fish species richness), while minimizing cost; in this case overlap with fishing activity (Figure 1). Ideally multiple zoning scenarios would have been presented, showing for example, different possibilities for protection targets and number of zones. However, the steering committee asked for a single scientific recommendation, therefore only a single map of priority conservation zones was presented.

The steering committee used the priority conservation zone map to guide their marine spatial planning decisions and come to an agreed zoning plan that was put out for public consultation October – December 2017 (Figure 2). This zoning plan will be revised using the feedback received during the consultation process and the revised plan will go through a second round of public consultation early in 2018.

The map of priority conservation zones has formed an important input into Montserrat's MSP process and should help minimize resistance from fishers about placement of no-take zones by avoiding the most valuable fishing areas. Although we set protection targets using both a habitat layer and a biodiversity layer, only one layer is required to define the protection targets. This method is therefore flexible to the data available. All the software used in this analysis is free and open source (the authors will also share the code used on request). Although some technical skills are required, such as knowledge of the R programming language, there are considerable resources freely available online to assist those wishing to learn how to use these tools. The methods used here therefore offer a low-cost approach to marine zoning in other data-limited contexts.

KEYWORDS: Marine spatial planning, prioritizr, Montserrat, conservation, zoning

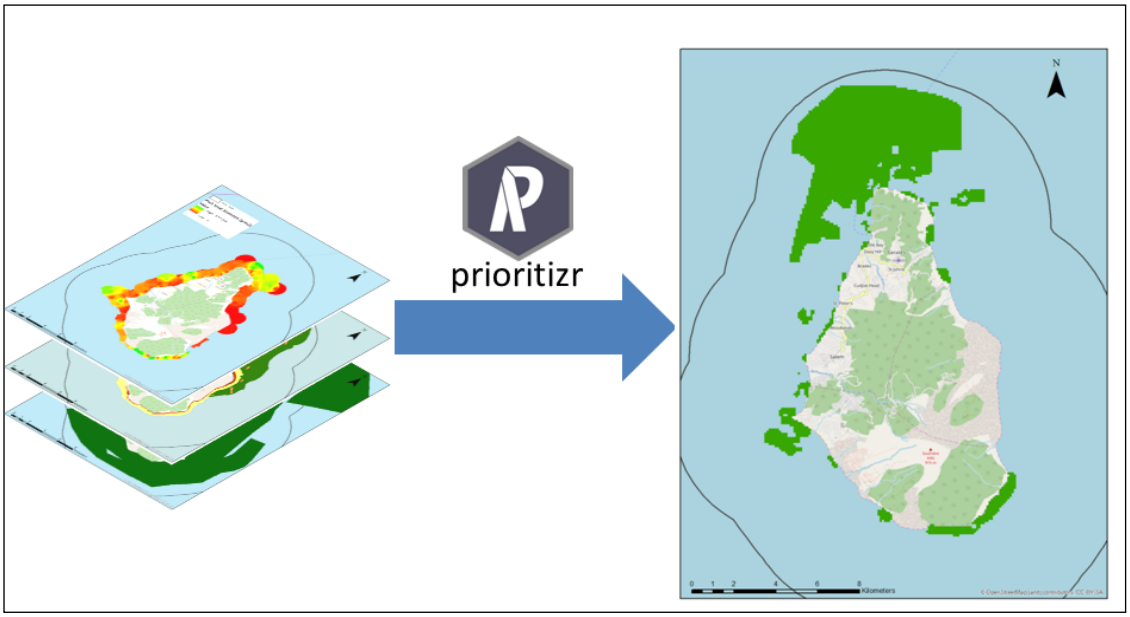

Figure 1. Visualization of the workflow used to generate the map of priority conservation zones. Stack of data layers on the left illustrate the inputs to prioritizr. Final map is on the right.

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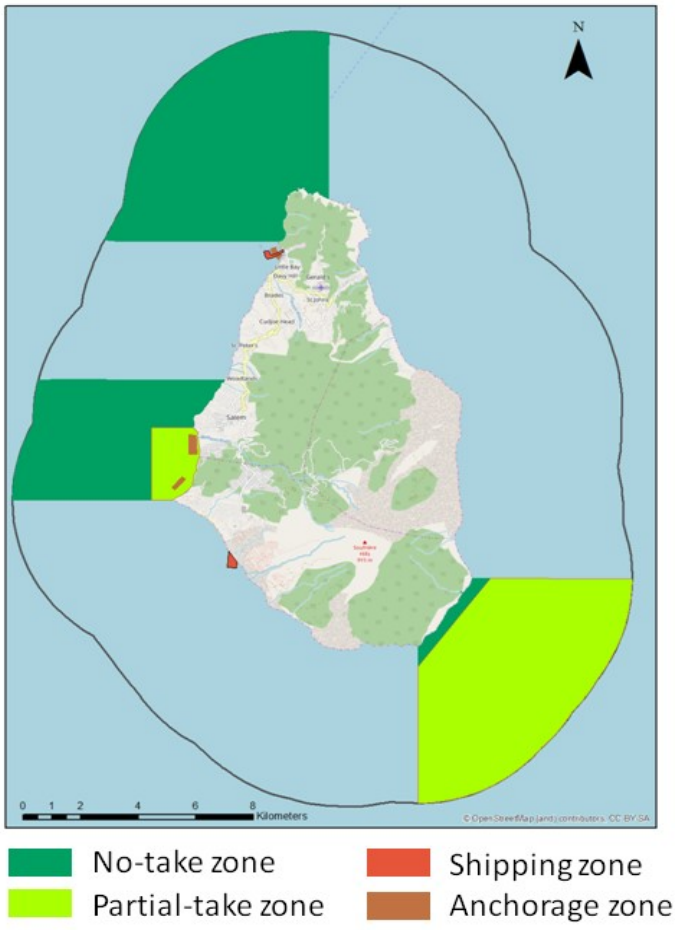

Figure 2. Zoning map approved by the Blue Halo Steering Committee and which has been presented for public consultation.