



Coral reefs under threat in a Caribbean marine protected area: Assessing divers' willingness to pay toward conservation

Juan C. Trujillo ^{a,*}, Bladimir Carrillo ^{b,2}, Carlos A. Charris ^{b,2}, Raul A. Velilla ^{b,2}

^a Environment Department, Wentworth Way, University of York, Heslington West Campus, York, North Yorkshire YO10 5NG, U.K

^b Departamento de Economia Rural, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil

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ABSTRACT

Coral reefs are an important environmental resource because they provide protection to coasts from erosion and the pounding of waves. In addition, reefs are a source of recreation and they encourage tourism. However, reefs are exposed to various threats from natural causes and human actions. One case of rapid coral deterioration is occurring in the Corals of Rosario and San Bernardo National Natural Park, located in the Colombian Caribbean Sea. This Park, a marine protected area, is subject to sedimentation from the Canal del Dique, which threatens the survival of the Park's coral reefs and, with it, some tourist activities. Among these activities, recreational scuba diving is the most prevalent in terms of monetary payments. This study aims to estimate recreational divers' willingness to pay for the conservation of the coral reefs in the Corals of Rosario and San Bernardo National Natural Park. For this purpose, both single-bounded and double-bounded dichotomous choice models were used. The results show that divers are willing to pay an average of US\$89.56 per person. The total benefit to the coral reefs is US\$376,152 per year. Using a discounted rate of 3%, the present value of this benefit is US\$ 12.54 million. This study provides valuable information that could help future assessments of coral reef management as well as the establishment of regulations for their preservation.

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1. Introduction

The Caribbean Sea contains a great biodiversity of plants and unique marine species. Due to the unique characteristics of this geographical zone, more than 25 million tourists visit it annually. The annual income from tourism in the Caribbean as a whole is estimated to exceed US\$25 billion [1]. However, some human activities threaten the existence of these natural resources. It is evident that exponential population growth increases the demand for ocean resources, as would the economic growth necessary to sustain this population. This growth directly threatens the habitat and biodiversity of marine ecosystems and may cause irreversible damage to the aquatic environment [2]. Most of the ecosystems in

the Caribbean Sea are composed of coral reefs; two-thirds of the corals in these ecosystems are currently threatened by human activities [1].

The Corals of Rosario and San Bernardo National Natural Park (CRSBNNP) is located offshore of the coast of the Colombian Caribbean. Since 2005, this Natural Park has been designated a marine protected area (MPA) by the national government.³ The park is unique for its variety of ecosystems, which are composed primarily of coral reefs [3]. This diversity of ecosystems and species in the CRSBNNP is testament to its high ecological and environmental importance, which is reflected in its abundance of environmental resources and its high supply of recreational services. These attributes make the CRSBNNP the most important MPA in both the Caribbean Region and in Colombia. This Protected Area attracts the greatest influx of domestic and foreign tourists in Colombia, with approximately 319,282 visitors a year [4]. However, several factors threaten the environmental sustainability of the park. The removal and dredging of the Canal del Dique's curves have increased the flow and speed of the Magdalena River, causing increased sedimentation. When the flow is light, the sediment

* Corresponding author.

E-mail addresses: jct523@york.ac.uk (J.C. Trujillo), bladimir.bermudez@ufv.br (B. Carrillo), carlos.andres@ufv.br (C.A. Charris), raul.gomez@ufv.br (R.A. Velilla).

¹ MSc in Economics, Universidad Nacional de Colombia, Bogotá, Colombia. PhD student, Environment Department, University of York, Heslington, North Yorkshire, YO10 5DD, UK.

² BSc in Economics, Universidad del Atlántico, Barranquilla, Colombia. MSc student, Departamento de Economia Rural, Universidade Federal de Viçosa, Avenida Purdue, s/nº, Campus Universitário, Edifício Edson Potsch Magalhães 36570.900, Viçosa, MG, Brazil.

³ The CRSBNNP was first declared a National Natural Park in 1977 by the Colombian Ministry of Agriculture and later an MPA under the 2005 Resolution 679 of the Ministry of Environment, Housing and Territorial Development of Colombia.

stays on the surface of the Canal del Dique, obstructing the sunlight. However, when the sedimentation is dense, it is decanted, and the flow of the Canal del Dique carries it into the coral reefs of the CRSBNNP. Under this setting, the practice of recreational scuba diving serves to accelerate the damaging of these reefs. Diving in the presence of sediment causes it to submerge once again, because of either the divers' fins or the boat's anchors, and causes it to move towards the corals, resulting in their death [3]. As a result, the extent of the CRSBNNP's live coral reefs has been reduced by 33% of their initial size [5,6]. It is necessary to regulate such activities in order to ensure the preservation of coral reefs in MPAs.

Many studies have estimated the economic benefits of recreational scuba diving in relation to the environmental deterioration caused by this activity to the coral reefs in MPAs. Asafu-Adjaye and Tapsuwan [7], Ransom and Mangi [8], and Seenprachawong [9] are of particular interest in the international context. These studies used the contingent valuation method to provide relevant information on potential solutions to the progressive deterioration of coral reefs in MPAs. In doing so, they estimated divers' willingness to pay (WTP) for recreational scuba diving to ameliorate the ecological damage to the coral reefs. Their results showed that most divers are willing to pay a monetary amount to preserve and improve the quality of the coral reefs. It should be noted that in most studies, foreign divers are willing to pay more money to preserve the coral reefs than are their peers from the country in question. The fact that the conservation of the natural wealth and the environment are not instant concerns for national tourists could explain this phenomenon [10]. According to these authors, the reasons for this lack of concern are related to the socio-economic situation in developing countries and the public good nature of the recreational services provided by the coral reefs.

In Colombia's case, studies estimating the economic benefits of recreational scuba diving services to coral reefs are scarce. Cruz and Calle [11] analyzed the economic potential of diving in the archipelago of San Andrés, Providencia, and Santa Catalina, compared with places such as Bonaire and the Grand Cayman. The authors reported that the WTP for the protection of reefs from visiting divers is higher than the figures charged for diving in other parts of the Caribbean Sea. Despite their efforts to estimate the WTP for coral reef conservation, some of these studies suffer from methodological drawbacks. Certain studies used reduced sample sizes, while the rest employed less efficient techniques for estimating the WTP. Mitchell and Carson [12] suggested using a high number of observations to attain more robust WTP estimates. In addition, Hanemann et al. [13] asserted that WTP estimation using the single-bounded dichotomous choice model (SB) or the travel cost method (TCM) necessarily involves a loss of efficiency, unlike the WTP estimated using the double-bounded dichotomous choice model (DB).

This study estimates the WTP of divers to preserve the coral reefs at the CRSBNNP. Similarly, the economic benefit of recreational diving in the coral reefs of this MPA is determined. For these purposes, the contingent valuation method (CVM) is used along with both SB and DB. This study is unique: it is the first to provide empirical evidence on the threat posed by the dredging of the Canal del Dique to these coral reefs, from the divers' standpoint. Its purpose is to provide information that may help assess the extent of damage suffered by the coral reef ecosystem in this MPA. Such information is relevant to the policy makers designing policies that seek to regulate the use of the environmental resources provided by coral reefs.

This paper is organized as follows. Section 2 describes the geographical context of the CRSBNNP. Section 3 presents a description of the data and methods used, wherein the econometric strategy and data collection are explained. Section 4 presents the theoretical framework. Section 5 presents the estimation results of

the economic benefits of diving in the CRSBNNP. Finally, Section 6 draws conclusions.

2. Geographical context

With an area of 1200 km², the CRSBNNP is located offshore in the Colombian Caribbean Sea, approximately 23 km south of the city of Cartagena (see Fig. 1). The Park is one of the 56 protected areas of the National Parks System of Colombia. This archipelago consists of a group of 43 islands located in the insular area of the city of Cartagena, Colombia. The CRSBNNP has the largest area of coral reefs on the Colombian continental platform, with 62 identified species of corals [3]. Ordinarily, one of the most popular seasons for tourist travel to the CRSBNNP runs from late June to late August, coinciding with the summer vacation period in the northern hemisphere. The number of tourists reaches its greatest level in July. In the high-season period, the average number of tourists may overcome 50 per day. According to the Colombian Ministry of Environment and Sustainable Development [4], tourism in the CRSBNNP has increased substantially in recent years. During the period from June to August, the environmental conditions are favorable for recreational diving in the Park. In this period, water visibility often reaches 30 feet or more because of the trade winds from the northwest of the archipelago. Additionally, many species migrate into the Park during this time.

3. Data and method

3.1. Survey design and data collection

The study data were collected through an *in-situ* survey in July 2013. This period was chosen because, as mentioned above, it is the busiest touristic period for the CRSBNNP because of its optimum environmental conditions for diving. A pilot test was conducted in June 2013 to confirm the reliability of the survey questions and the design of the other instruments in the questionnaire. The targeted population for the survey was certified divers of various nationalities aged 14–65 with incomes over zero, who financed their own trips to CRSBNNP. To avoid problems of bias in the sample, diving instructors and diving school leaders did not complete the survey; their employers cover these individuals' diving trip expenses. Surveys were conducted in person (face-to-face), as prescribed by the literature [14]. Respondents were randomly selected after the completion of their diving activities, as the accuracy of the divers' WTP estimation depends on the quality of the survey design and the format of data collection.

The questionnaire is divided into three parts. The first part includes questions on the socioeconomic and demographic characteristics of the diver and his/her position on environmental conservation. The second part contains questions about the diving experience, motivations that led the diver to visit the CRSBNNP, and expectations about the quality of coral reefs at the park. Finally, the third part includes questions on WTP for the conservation of the coral reefs at the park. For this section, participants were explained the environmental problems experienced by coral reefs at the park, particularly those related to the dredging of the Canal del Dique. In this section, divers could accept or reject the BIDs described in the survey. To solve the problem of 'strategic bias', divers learned that the BIDs or entrance fees were not actual fees and they would not be collected in the future by the park management. Thus, there was no possibility that the diver would select a BID on the basis of whether the future entrance fee to the Park would be increased or decreased. Once the diver fully understood the context of the survey, the BIDs were presented as

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