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Economic value of marine biodiversity improvement in coralligenous habitats

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ABSTRACT

Coralligenous habitats are an important 'hot spot' of species diversity in the Mediterranean and grant a variety of valuable ecosystem services. Currently, these areas are under threat due to human activities such as unsustainable and destructive fishing practices, environmental phenomena, and other significant pressures related to global environmental change. The coralligenous habitats are also endangered by practices that result in the presence of abandoned, lost, or otherwise discarded fishing gear (ALDFG) at sea, a worldwide phenomenon only recently stigmatized whose impacts on marine habitats and coralligenous areas are serious.

The aim of this paper is to investigate the economic value of restoration strategies promoted to safeguard and improve biodiversity in these coralligenous habitats through a contingent valuation survey administered to a sample of 4000 Italians. Households' willingness to pay (WTP) for biodiversity restoration and conservation ranges between €10.30 and €64.02 depending on the assumptions underlying the different models. The main positive and significant determinants of WTP are a previous knowledge or familiarity with coralligenous habitats and biodiversity issues, income, education, environmental attitudes, and the knowledge that indiscriminate fishing may be dangerous for biodiversity in a coralligenous habitat.

1. Introduction and motivation

Coralligenous habitats constitute one of the most important 'hot spots' of species diversity in the Mediterranean (Ballesteros, 2006). These habitats grant a variety of valuable services, commonly called ecosystem services. They provide sheltered areas for young fish, which leads to an increase in fish stocks available to humans; they also have an important role in energy flux and the carbon cycle, and they are one of the preferred diving spots for tourists due to the great diversity of organisms (Ballesteros, 2006).

Nowadays, these areas are under threat due to destructive human activities such as over-fishing, pollution, sediment deposition, recreational fishing and trawling, and diving (Ponti, 2001). Other important pressures are related to global environmental changes, leading to mass mortality events and invasions by alien species (Occhipinti-Ambrogi, 2007; Piazzi and Balata, 2009).

The coralligenous habitats of the Northern Adriatic, which have been defined as "submarine rocky substrates of biogenic concretions, irregularly scattered in the sandy or muddy sea bed" (Casellato et al., 2007, p 122), are locally called tegnùe. This name was given by the local fishermen, who have known of their existence since the eighteenth century (Olivi, 1792), although they were only truly documented by underwater explorations 50 years ago (Stefanon, 1967). In 2002, an area of tegnùe in the north-west Adriatic, near the city of Chioggia-Venice, was declared Biological Protected Area (Zona di Tutela Biologica – ZTB) and in 2011 it was declared Site of Community Importance (SCI).

In these areas, the most significant threat is related to unsustainable fishing practices since they are frequently associated with an increasing quantity of abandoned, lost, or otherwise discarded fishing gear (ALDFG) at sea; the impacts of such practices on marine habitats and coralligenous areas are well documented (Macfadyen et al., 2009). The negative impacts caused by the loss of fishing equipment (e.g. nets, traps, metal tools) on local biodiversity are mainly associated with damage to nursery zones and the unintentional capture of protected species. Even though ALDFG causes considerable damage to the marine environment, estimates of its impact on biodiversity losses in the North Adriatic area are scarce and very little has been done to reduce this problem (www.life-ghost.eu). Moreover, to our knowledge, the economic value of biodiversity loss caused by ALDFG is not available in the literature, and only some individual examples of the quantitative costs of ALDFG are documented (Macfadyen et al., 2009).

The aim of this paper is to investigate the economic value of restoration strategies promoted to safeguard and improve biodiversity in

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some coralligenous habitats of the Northern Adriatic Sea. This is done by implementing the contingent valuation method (CVM), a stated preference technique used for estimating the economic value of non-market goods.

This task is part of a wider EU funded project called LIFE Ghost *Techniques to reduce the impacts of ghost fishing gears and to improve biodiversity in North Adriatic coastal areas,* whose general objective is to study concrete measures for preserving and improving the ecological status of some coralligenous habitats in the north Adriatic Sea (tegnùe).

The economic importance of biodiversity has been measured by economic valuation techniques (Pearce and Moran, 1994; Nunes et al., 2003; Turpie, 2003; TEEB, 2008), which are based upon the identification and determination of the values and the benefits that biodiversity provides for the welfare of humans and the healthy function of ecosystems. These values are crucial for supporting the design of appropriate policies, including those for conservation, protection, and the sustainable use of marine resources. Without a comprehensive knowledge of the economic value of marine resources, it is difficult for policy makers to determine efficient levels of spending and investment in marine protection and management (Brouwer et al., 2016).

Policy makers are also increasingly recognizing the necessity to envisage sound policies for the management of marine resources, and are now appreciating the contribution of a wide variety of economic methodologies, including valuation, to guide, influence, and support environmental policy at large (Beaumont et al., 2008).

This paper is important because it contributes to the relevant literature by measuring the value of restoration that improves the biodiversity of coralligenous habitats in the North Adriatic Sea. This is an interdisciplinary study that provides a sound base for implementing biodiversity valuation techniques, thus clarifying the role of economic valuation in the management and conservation of marine biodiversity. To our knowledge, there are no similar studies in Italy that estimate the economic value of coralligenous habitats.

The paper is organized as follows: Section 2 illustrates the main characteristics of the case study area; Section 3 gives information on methodology, survey design, and valuation scenarios; Section 4 describes the structure of the questionnaire; Section 5 introduces the econometric model applied; Section 6 reports the main descriptive statistics of the sample; Section 7 analyses the main results of the models implemented; and Section 8 provides the main conclusions.

2. Study area

The case study (Fig. 1) is related to a coralligenous habitat, locally named tegnùe, which is located in the North Adriatic Sea in Italy. The word tegnùe derives from the Venetian dialect and means “hold” because, since ancient times, fishermen have experienced the frequent loss of their nets and fishing gear as it becomes trapped by the rock formations (Casellato et al., 2006).

This particular ecosystem, known among local fishermen since the eighteenth century, was initially documented only 50 years ago (Stefanon, 1967). These formations are localized irregularly over the Northern Adriatic at depths between 10 and 40 m, with high variable morphologies and structures, and ranging in size from a few to several thousand square meters.

A full description of the study area and its natural characteristics is available in Tonin and Lucaroni (2017). The rocky habitats present some characteristics similar to tropical coral reefs and, analogously, they exhibit a high rate of biodiversity and offer a wide array of ecosystem services. A recent survey of the literature based on 50 tegnùe sites reported the existence of 740 species, 12 of which are on protection lists, and 97 of which are considered as commercially valuable (Nesto et al., 2014).

The map in Fig. 1 shows the geolocation of the tegnùe verified with the help of a survey administered to fishermen and divers during the activities of the LIFE Ghost project. The precise number of tegnùe is still uncertain, but local researchers assert that in the Veneto Region there are more than 3000 (Casellato et al., 2007).

2.1. Overview of the habitat of tegnùe

The tegnùe habitat provides several ecosystem services that coincide with those of coral reefs, although with specific differences and on a different scale. Coral reefs play a relevant role on a global scale because they influence the oceans, whereas the tegnùe areas have a local but nonetheless important role on the Adriatic Sea. They are a refugee for numerous fishes and for other marine organisms, have productive and cultural services, and perform an important role in regulation processes. However, these ecosystems have a limited function in sediment retention and erosion control since they are located at a greater depth than coral reefs and are not continuous but instead appear as small islands. Table 1 identifies the main ecosystem services and functions provided by the tegnùe areas. The results reported in Table 1 are based on a classification of marine ecosystem services provided by Böhnke-Henrichs et al. (2013) and revised for the tegnùe ecosystem thanks to interviews with biologists and environmental scientists as part of the research activities implemented during the LIFE Ghost project.

Coralligenous areas similar to tegnùe have been localized in Southeast Florida, the French–Italian Riviera, Corsica, Croatia, the northern Baltic areas, the Oslo Fjords, and Greenland (Casellato et al., 2007). In Italy (see Fig. 2), other similar habitats are located in Sardinia, the Sicilian islands, along the southern Italian coasts, the Tyrrhenian, and the Adriatic coast (Giaccone, 2007).

Tegnùe are currently suffering damage from several sources that have a negative impact on biodiversity. Of these, the loss of fishing equipment is a serious and ongoing problem. ALDFG causes substantial ecological and socio-economic problems; one of the most well-known effects is the ghost-fishing phenomenon, which has received increasing international attention in the past decade. Ghost fishing means that, for numerous reasons, the nets lost accidentally or voluntarily discarded at sea continue to entrap marine animals, causing long lasting large-scale dangers to marine ecosystems (Macfadyen et al., 2009).

3. Study design

As mentioned above, the case study in this paper concerns the improvement of marine biodiversity in a coralligenous habitat in the North Adriatic Sea through restoration and conservation activities.

In this section, we first describe contingent valuation (CV) scenarios and then provide details on the design and structure of the CV questions used in this study. CVM is a survey-based methodology that asks people to directly state their willingness to pay (WTP) to obtain a specified good or service that is not exchanged in regular markets (Mitchell and Carson, 1989) thus creating hypothetical markets. When designing a CV survey, a scenario should provide information to respondents about the characteristics of a specific policy or project and the context, which has to be comprehensible, plausible, and meaningful in order to increase the credibility of the survey and the reliability of the results.

3.1. A. Contingent valuation scenarios: three different environmental goods

All three scenarios refer to a comprehensive hypothetical project funded by the European Union with a duration of three years, which is targeted at:

- The fulfilment of a European directive through a harbormaster regulation aimed to prevent adverse and dangerous effects on biodiversity. In particular, the regulation will establish procedures and duties for the correct decommissioning, recovery, and disposal of ADLFG.
- The creation of a foundation with the specific task of carrying out the restoration project of the coralligenous habitat regarding