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Using choice models to inform large marine protected area design☆

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ABSTRACT

During the last decade a number of Large Marine Protected Areas (LMPAs) – marine protected areas that exceed a minimum size threshold and are often in offshore or open ocean waters – have been designated in an effort to meet marine conservation objectives. Research on the human dimensions of LMPAs is limited, though comprehensive policy analysis requires an understanding of the full range of social, cultural and economic benefits associated with LMPA designation. This paper addresses this need by employing a stated preference choice experiment survey of U.S. west coast households to examine public preferences for different protected area designs sited off the U.S. west coast. Using data from over 3000 randomly selected households in California, Oregon, and Washington we estimate choice models and calculate economic values for a suite of LMPAs that vary in size and in the types of restrictions within area boundaries. Results show that the LMPA size yielding the highest value is ~15.6% of the west coast Federal waters. Results also underscore the importance of restriction type, as there are considerably different threshold sizes above which diminishing returns and negative economic values are derived from no-access reserves, no-take, and multiple-use designations. While the value of any specific configuration can be estimated using the model, results offer insight on optimal use designations from a public perspective for small (< 2.5% of west coast Federal waters), medium (2.5%–~10%) and large (> 10%) LMPAs sited off the U.S. west coast.

1. Introduction

Over the last two decades the establishment of Marine Protected Areas (MPAs) has become a high profile strategy for marine conservation. This is exemplified by the increasing number of MPA designations as well as international doctrine such as Target 11 of the 2010 Aichi Biodiversity Targets under the United Nations Convention on Biological Diversity, which aims to protect more than 10% of coastal and marine areas globally by 2020. Studies demonstrating the myriad benefits provided by MPAs, including ecological [23], economic [4], and social [5] have incentivized governments to designate MPAs in coastal and offshore marine waters, controversy notwithstanding. In Australia for example, there are over 200 MPAs in coastal and marine waters, covering about 10% of Australia's exclusive economic zone (EEZ) [12]. In Namibia nearly one million hectares of marine area and island outcrops are protected via the Namibian Islands Marine Protected Area. In the United States the establishment of four protected marine monuments increased the area of U.S. managed MPAs by about 400% [25]. These marine monuments (Papahanaumokuakea Northwest Hawaiian Islands, Marianas Trench, Pacific Remote Islands, Rose Atoll National Monuments), established between 2006 and 2009, are examples of a growing number of Large Marine Protected Areas (LMPAs), defined here as areas larger than 30,000 km^2 (based on the threshold established by [6]; see [27,28], or [15] for various LMPA definitions). Australia's Great Barrier Reef Marine Park, established in 1971, is generally considered to be the first LMPA; since then approximately 24 additional LMPAs have been designated or are in the process of designation, most within the last 10 years [15]. Some studies suggest that the designation of LMPAs may render Target 11 attainable by 2025 – without them it may take 20 years longer [28].

LMPAs have been designated for many of the same inherent reasons as smaller-sized MPAs – protecting ecological and cultural resources, biodiversity conservation, rebuilding depleted stocks, and promoting sustainable development. While some authors argue that LMPAs are simply lines on a map with limited enforceability and of questionable value for biodiversity and fisheries protection [7], other researchers have argued that smaller MPAs need to be 'scaled up' to fully attain the intended ecological benefits [9]. Wilhelm et al. [32] notes that many LMPAs are large enough to encompass and connect ecosystems, protect portions of habitat for highly migratory species, and protect deep-sea or

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open ocean habitats that aren't often protected by smaller coastal or inshore MPAs. In addition, some authors suggest that LMPAs may be politically easier to establish than smaller near-shore MPAs [2] and that, per unit area, LMPAs may be less costly to establish than smaller MPAs [24]. Though empirical evidence is somewhat limited, these claims are likely bolstered by the perception of fewer social and political repercussions associated with imposing restrictions in offshore open ocean areas.

A number of studies have asserted the economic benefits generated from LMPAs; some of the more frequently cited are those derived from Australia's Great Barrier Reef Marine Park. The economic value of activities such as recreational fishing, scuba diving, and snorkeling on the Great Barrier Reef are well documented [8,26]. However, these types of use values may not always be applicable for offshore open ocean sites, where LMPAs are often designated. For these areas economic value may be derived from things such as preserving ocean wilderness even if the area is rarely visited by people, protecting entire ecosystems or large areas of critical marine habitat, or protecting an area for future generations to use. These types of values are sometimes referred to as non-consumptive use values or non-use values. An emerging body of literature has examined these types of values for protecting areas of the ocean and/or preferences for the types of restrictions within these areas. While the few studies undertaken have not explicitly referenced the term LMPA, three of the four studies discussed below focus on large offshore areas that meet the LMPA criteria defined above.

Wattage et al. [31] use a choice experiment survey to examine the economic value of protecting deep-sea corals in Irish waters. The corals have limited scope for recreation or tourism [31], thus the authors focus on estimating the non-use value of protecting varying proportions of the total amount of deep-sea corals by restricting commercial fishing. Their results suggest that most survey respondents prefer expanding the current protected area (approximately 2500 km^2) to include all deep-sea corals that are thought to exist in Irish waters – an area substantially larger than the status quo. Results also suggest that respondents prefer to ban all trawling in deep-sea coral areas rather than banning commercial fishing entirely. While the authors do not formally compute willingness-to-pay (WTP), a measure of economic value, their results imply, at least qualitatively, that respondents were willing to pay a small personal tax to protect all deep sea corals in Irish waters. Turpie et al. [29] estimate the non-use value of three MPAs off the coast of South Africa using a contingent valuation survey. They ask survey respondents about different scenarios related to the MPAs, including an elimination of all three MPAs, increasing the total amount of area that is protected and restricting fishing, and allowing some fishing in one of the protected areas that currently prohibits fishing. Their results suggest that the value of increasing the total amount of protected area from the status quo and restricting fishing is about US$ 4.8 million, and that eliminating the MPAs entirely results in a loss of about US$ 27.6 million. Allowing some fishing in areas where it is currently prohibited resulted in a smaller loss of about US$ 4.4 million. Wallmo and Edwards [30] use a choice experiment survey to estimate the value of "habitat areas of particular concern" (HAPCs), defined as habitats that are especially important ecologically or particularly vulnerable to degradation, in the northeastern U.S. EEZ. They found that the value of protecting all proposed HAPCs, which would increase the amount of federally protected area in the northeastern U.S. EEZ by about 4.2%, ranged from about US$ 23 per household to US$ 106 per household in the northeast U.S., depending on what types of restrictions were in place. Their results also suggest that there was considerable preference heterogeneity among respondents, and the protection of HAPCs generated negative value for some individuals. Finally, Gillespie and Bennett [12] estimate the value of establishing a network of MPAs covering up to 30% of the south-west marine region in Australia. Their results suggest that Australian households would pay about AU$100 to establish an MPA network protecting 30% of south-western Australian waters, though WTP was not affected by different sized networks (10%, 20%, or 30% of south-western waters), indicating insensitivity to scope.

The above studies imply that individuals derive values from LMPAs even if they never see or visit them; they also offer some evidence that preferences can vary for both the size and the restrictions that will be established for these areas. These preferences ultimately will determine an individual's willingness-to-pay for LMPAs, and provide one measure of their economic benefits. This suggests that an understanding of the relationship between LMPA configurations (in terms of size and restrictions) and economic value can be extremely useful for LMPA planning and decision-making. Gruby et al. [15] underscore this point in developing an LMPA social science research agenda that calls for an examination of the "full range, magnitude, and distribution of actual and perceived social, cultural, political, and economic benefits associated with LMPAs". This paper directly addresses their research agenda by estimating economic values, including non-use values, for LMPA configurations in U.S. Federal Waters (referring only to waters between 3 and 200 miles offshore, and not including inshore/coastal State waters) off the coasts of California, Oregon, and Washington, referred to in this paper as west coast Federal waters. The research extends the current literature on the human dimensions of LMPAs by adding an economic benefit estimate for large protected areas off the U.S. west coast. In addition the results should be of high interest for managers and decision-makers as they identify (a) the effect of LMPA size on value; (b) the effect of varying levels of restrictions within LMPAs on value; and (c) specific size/restriction combinations that maximize the economic benefits of offshore LMPAs for U.S. west coast households – three policy-relevant aspects of LMPAs that are often contested but have limited empirical evidence on which to base decisions.

2. Methods

2.1. General overview

This research employs a stated preference choice experiment (SPCE), a specific type of economic valuation technique for non-market goods and services. There are relatively limited applications of SPCE to marine protected area valuation [13], though Glenn et al. [13] suggest that the multi-attribute approach of SPCE can facilitate a more in-depth analysis of protected areas than other types of non-market valuation methods (i.e. contingent valuation). They provide a summary of these advantages over the more traditional contingent valuation method; full expositions on SPCE can be found in Adamowicz et al. [1]. A general overview of the method followed by a more detailed description as it applies to this research is presented below.

SPCE are grounded in Lancastrian consumer theory [21], which specifies that an individual's utility for a good is a function of the good's attributes. For example, one's utility for a house may depend on attributes such as the number of bedrooms, bathrooms, location, price, etc. For environmental applications, the good is typically a non-market good – i.e. not bought or sold in traditional markets – characterized by attributes of policy or management interest. As non-market goods are typically unfamiliar to consumers, a survey is used to provide basic information about the attributes of the good. A range of numeric or categorical levels is specified for each attribute, and experimental design plans are used to generate different combinations of attribute levels. Survey respondents are shown choice task questions that contain two or more alternatives (different bundles of attribute levels), and are asked to indicate which is their most (and sometimes least) preferred.

The survey described potential protected areas sited in Federal waters off the U.S. west coast in terms of the following attributes and attribute levels:

- The percent of west coast Federal waters that would be protected as an ecological reserve, with no human activities or access permitted within the boundaries (0.05%, 1.0%, 2.0%, 3.0%, 5.0%).