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Comparative analysis of factors influencing spatial distributions of marine protected areas and territorial use rights for fisheries in Japan

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ABSTRACT

As increasingly large extents of the global oceans are being managed through spatial measures, it is important to identify area characteristics underlying network distributions. Studies discerning spatial patterns in marine management have disproportionately focused on global networks. This paper instead considers the single country context of Japan to illuminate within-country drivers of area-based conservation and fishery management. A dataset containing potentially relevant socioeconomic, environmental, and fisheries factors was assembled and used to model prefecture-level counts of marine protected areas (MPAs) and territorial use rights for fisheries (TURFs) throughout Japan's waters. Several factors were found to significantly influence the number of TURFs in a particular area, whereas MPA patterns of use remain largely unexplained. TURFs are frequently noted as more suitable for managing fisheries of low mobility species and our analysis finds greater use of TURFs in areas that rely heavily on benthic catch. The number of trading ports was also found to be positively related to TURF distributions, suggesting economic infrastructure may influence the use of this fisheries management tool. In-line with global analyses, MPA patterns of use were not found to be significantly related to any of the potential explanatory variables after correcting for the number of statistical comparisons that were carried out. Differences in our ability to model the use of TURFs and MPAs may arise due to the narrower objectives associated with the former (e.g., income, employment) in comparison to the often broad and varied goals that motivate use of the latter.

1. Introduction

Over one-third of the global population lives within 100 km of the coast [1,2], and many in these regions depend on the numerous ecosystem services provided by coastal and marine environments, such as food provision, employment, natural disaster mitigation, and water filtration [1,3]. Yet, threats including population growth, land use change, overfishing, pollution, and climate change impair ecosystem functioning through biodiversity loss and habitat fragmentation [4–7]. In response, spatially explicit ocean zoning approaches have gained global recognition as a practical way to organize marine spaces and minimize adverse impacts [8,9]. Ecosystem-based coastal and marine spatial planning (MSP) is an integrated approach that assigns spatial and temporal constraints on human activities in marine areas to balance environmental, social, and economic objectives [10]. MSP aims to explicitly assess user-user and user-environment interactions and trade-offs to maximize the full range of ocean services [11,12]. Despite its widespread use, research exploring the relative value, drivers, and distributions of different forms of MSP in various socio-environmental contexts is much needed and essential to understanding its implications and benefits in achieving sustainable use of marine resources. Here, the spatial distributions of two marine spatial management techniques in Japan are examined, conservation-oriented marine protected areas (MPAs) and production-focused territorial use rights for fisheries (TURFs), in order to identify drivers for their use and better predict and understand future expansion of MSP worldwide.

Setting aside marine and coastal regions as MPAs has become a common MSP approach to achieving conservation and restoration targets. Commonly defined as "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" [13], MPAs may range from inaccessible no-take marine reserves to multiple use areas. Successful MPAs can facilitate the conservation of critical species and sensitive habitats, as well as enhance biomass, density, and biodiversity within and around its boundaries [14–17]. The 2010 Convention on Biological Diversity (CBD) set the international goal of implementing "protected areas and other effective area-

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based conservation measures" on at least 10% of the world's coastal and marine area by 2020, with a focus on areas important for biodiversity or ecosystem services [18]; currently, MPAs cover about 4.12% of all oceans [19]. Global application has rapidly increased over the last decade [20,21], and MPAs are now a major component of marine conservation and management in many places worldwide.

Rights-based fisheries management (RBFM) has become increasingly prominent as a fisheries management tool since overexploitation and resource degradation are often associated with a lack of property rights [22,23]. RBFM presents a potential solution by granting fishers ownership of resources and thereby incentivizing sustainable resource use [24–26]. TURFs are a widely implemented RBFM strategy that allots individuals or communities a geographic area within which they are allowed exclusive access to marine resources [27]. TURF use has been shown to enhance managed species stocks [28], and well-enforced TURFs may act similarly to MPAs by benefitting non-target population growth and overall biodiversity [29–31]. Historical island fishing communities like Fiji and Samoa have long practiced TURF management through customary marine tenure rights [32–34], while other nations have more recently distributed TURF rights to replace open access areas or other forms of management (e.g., Chile transitioned to a large system of coastal TURFs following the collapse of their loco fishery in the late 1980s [28]).

Aside from the fact that both MPAs and TURFs rely on spatially defined controls, the two management approaches differ substantially. Despite multiple uses of many protected areas, MPAs often establish zones of no use and are generally implemented as conservation measures. TURFs, however, are primarily intended for managing important fisheries and marine resources [35]. With the exception of no-access areas, MPAs are public lands, whereas TURFs are rights-based, private properties only accessible by certain user groups. MPA management is typically top-down with authoritative bodies at the national or state levels (with some notable exceptions; e.g., Alcala and Russ [36]), while TURFs are frequently co-managed by individuals or local fishing communities together with government agencies [35]. Due to these distinctions, the implementation of each likely responds to different sets of socioeconomic and biological conditions. Nevertheless, there have to date been few comparative examinations of MPAs and TURFs in a single spatiotemporal context (see Afflerbach et al. [37] for an exception examining TURF-reserves globally).

Marinesque et al. [38] and Fox et al. [39] examined global MPA distributions and both found little link between potential explanatory factors and number or area of MPAs at the international level. The well-documented ecological benefits of MPAs [14,40,41] suggest that spatial patterns of establishment should be related to environmental conditions. Depending on context, one might expect MPA implementation to be positively or negatively correlated to ecosystem productivity or services, e.g., by targeting vulnerable, yet productive, marine ecosystems to maximize conservation benefits or by avoiding highly productive areas in order to minimize adverse impacts to fisheries [42–44]. Additionally, given the short-term costs of area closures to fisheries and other maritime sectors, as well as the potential long-term fisheries benefits of MPAs via spillover of larvae or adults to fished areas [45], one might also predict MPA distributions to be linked to socioeconomic factors. Despite these logical associations, global examinations have not observed strong correlations between national MPA distributions and biological or socioeconomic indicators [38,39]. These findings may be due to extremely heterogeneous sociopolitical and environmental contexts on a global scale, suggesting regional or national analyses could yield useful insights.

While several studies have examined the relationship between TURF characteristics and their effectiveness for resource management [35,46], relatively less attention has been given to potential explanatory factors underlying TURF implementation and distributions. As a fisheries management tool, the use of TURFs should depend upon the presence of fishers and fisheries resources. Moreover, usage may be a function of the type and extent of marine resource exploitation in an area. Spatially-explicit RBFM techniques are more appropriate for managing low mobility species whose full life cycles are likely to be contained within the tenured boundaries [35,47–49]. It is thus anticipated that TURF distributions are associated with high quantities of sedentary and benthic species, as well as environmental conditions which favor productive benthic communities. TURFs might also be more plentiful in areas with fewer stakeholders competing for marine space. Conflicts between coastal fisheries and other interests like shoreline development, energy production, recreation, and conservation (MPAs) could deter TURF formation [50].

The goal in this study is to identify potential socioeconomic, environmental, and fisheries drivers influencing the distributions of these two MSP techniques within the maritime borders of one particular country – Japan. By working within the framework of a single nation, these regression models aim to identify spatial determinants that may have been obscured by the extreme heterogeneity of national contexts in other global surveys (e.g., Marinesque et al. [38]; Fox et al. [39]). Japan provides an ideal setting for understanding MSP drivers as marine resources play an important role from national to local levels [51–53], and, therefore, one would expect a close link between pertinent explanatory factors and MSP. In addition to hosting extensive TURF networks [35] and committing to MPA expansion under CBD agreements, Japan is subdivided into a set of states (i.e., prefectures) that vary substantially in terms of socioeconomic characteristics and marine ecosystems [52], presenting sufficient contrast to examine subnational differences in MSP use.

The rest of this paper is organized as follows. An overview of the uses of MPAs and TURFs in Japan is provided, followed by descriptions of the geographic, socioeconomic, and biological datasets used in this study. Statistical methods to relate prefecture-level data to the use of MPAs and TURFs are then described before presenting results. The discussion then places the results in the wider context of national and international use of MSP for conservation and fisheries management.

2. MPAs and TURFs in Japan

Japan has a coastline of around 29,750 km and the sixth largest Exclusive Economic Zone (EEZ) in the world. Temperate to tropical climates and distinct ocean currents support a range of coastal and marine ecosystems including salt marshes, mangroves, seaweed beds, rocky shores, and coral reefs. This biodiversity has formed some of the world's richest fishing grounds. Most of the country's land area consists of mountainous terrain which has led to particularly dense coastal populations [52]. As coastal pressures continue to mount, efforts to understand how Japan has allocated marine space with respect to conservation and fishing sectors becomes increasingly important.

Although Japan is participating in the international commitment of achieving 10% global MPA coverage, the country does not currently have a centralized MPA management system. Several laws, including the Natural Parks Law, Nature Conservation Law, and the Act on the Protection of Fisheries Resources, can establish MPAs with various goals and management types [54]. Supervision lies with the prefectural governments and, depending on the legislation that established the protected area, falls under the auspices of either the Ministry of the Environment (MOE) or the Ministry of Agriculture, Forestry, and Fisheries (MAFF) [54]. Therefore, in contrast to several other nations (e.g., the European Natura 2000 network, the US National MPA Center, and the French Agence d'Aires Marines Protégées), Japan lacks a single administrative body for its collective MPA network. Nevertheless, the Japanese government's 2011 Marine Biodiversity Conservation Strategy aims to increase coordination between the two national ministries responsible for MPAs by establishing guidelines for nationwide MPA network expansion [55]. While the guidelines do provide direction for future growth, only approximately 0.49%, or 19,940 km^2, of Japan's EEZ is currently protected [56].