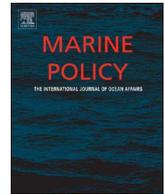


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## Ecotourism, climate change and reef fish consumption in Palau: Benefits, trade-offs and adaptation strategies

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### ABSTRACT

Marine ecosystems play a central role in economic and social life in the Republic of Palau, a Small Island Developing State in the Western Pacific. Marine resources underpin subsistence and commercial fisheries, as well as tourism activities, contributing substantially to Palau's GDP and employment. Since 1992, Palau has been actively developing conservation initiatives to protect marine resources, promote ecotourism, and ensure revenue generation. Marine reserves represent a particularly important tool in the country's sustainable development strategy. In 2015, Palau designated 80% of its marine EEZ as a National Marine Sanctuary, with the remaining 20% slated for domestic fisheries. That same year, Palau received 160 thousand tourists, over 9 times the country's population. In early 2017, the President proposed a bill effectively limiting budget travel and actively promoting high-end tourism. This study uses a quantitative social-ecological model to explore policy scenarios involving tourism, marine conservation and local food security. While climate change had the largest expected impact on local ecosystems, reef fish consumption contributes considerably to future projected declines in marine resources. Therefore, for Palau to achieve its goals of boosting revenues while sustainably stewarding marine resources, it will be necessary to transfer some level of consumption from reef fish on to tuna and other pelagics. Such changes, which align with the current proposal of developing an offshore national fishery as part of the Sanctuary's management plan, may allow Palau to meet future seafood demand, while protecting reef systems and the industries that rely on them.

### 1. Introduction

The Republic of Palau is an archipelago consisting of over 700 islands (only 12 of which are inhabited) stretching over 700 km in southwest Micronesia, about 750 km east of the Philippines and 1300 km southwest of Guam. A barrier and fringing reef complex encircles most of the archipelago, creating a vast lagoon of varying depth with an area of over 1200 km<sup>2</sup>.

Palauans have a long history of a strong relationship with the ocean as central to their culture and social organisation [1,2], and a source of food and livelihoods [3–5]. A 2003 survey indicates that 87% of households are linked to fishing for subsistence or commercial purposes [6]. The adoption of new fishing technologies and strategies over time has led to a greater understanding of fish behaviour and exposure to a greater variety of environments [7]. However, such developments have also resulted in increased fishing pressure in coastal environments [8], especially close to urban centres, with a number of studies indicating

important declines in the biomass and abundance of reef fish populations [6,9–11]. A recent study shows that most fishers in the more rural northern province perceive that catches today are about half what they were seven years ago, that reef fish in general are much smaller now, and that local reefs are severely overexploited as a result of the current level of local-, tourism- and export-driven demand for fresh fish [12].

Marine protected areas (MPAs) have been a central element to Palau's goal to protect marine biodiversity and allow for the sustainable exploitation of marine resources. In 1996, a national conservation law was enacted for the preservation of both terrestrial and marine wildlife. In 2003, Palau legally established the Protected Area Network (PAN) to effectively conserve local natural resources, and in 2009 Palau declared the world's first shark sanctuary. The country was also instrumental in establishing the Micronesia Challenge, an initiative between the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, Guam, and the Commonwealth of the Northern Mariana Islands to protect more than 30% of the region's nearshore

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marine ecosystems by 2020. Today, 23 MPAs and the Southern Lagoon Management area account for over 45% of Palau's coastal habitats being under some form of protection and/or management (albeit only 14% of Palau's reefs and seagrass beds are effectively in no-take zones [11]). In October 2015, Palau committed to the creation of a new National Marine Sanctuary [13,14]. The Sanctuary's objectives include a ban on all foreign fishing for tuna and other large pelagic fish, support for the development of an offshore national fishery in 20% of the Exclusive Economic Zone (plus territorial sea out to 12 nm), and closure of the other 80% to any type of extraction by 2020 (Fig. 1). The national pelagic fishery would land all catches in Palau to supply fresh fish to local markets, increase food security and, by reducing fishing pressure on reef fish, support tourism.

Palau's rich marine environment and the protection the country has afforded its biodiversity play an important role in generating income. Tourism, particularly ecotourism, contributes to about three quarters of GDP growth, 15% of total tax revenue, and 40% of total employment [15]. The value to Palau's economy of protecting sharks, one of the main attractions for tourists visiting Palau, was estimated at US\$1.9 million through dive tourism, compared to US\$10,800 if these sharks were killed for sale [16,17]. There are many definitions of 'ecotourism' [18], and it is used here to refer to activities focused on watching marine living organisms or natural areas, with an expectation of concurrent benefits to local ecosystems and human communities (*sensu* [19]). This contrasts with 'nature-based tourism' where conservation or local benefits are not specifically promoted. This distinction is relevant as this study departs from the assumption that sustained benefits to local social-ecological systems will necessarily follow from nature-based (or "ecotour-ish" [20]) activities, though they certainly could [21]. While tourism packages to Palau may not necessarily have the promotion of local benefits in mind, green fees collected from all tourists at departure, and for diving, snorkelling or any other water-based activities, specifically support conservation initiatives. Indeed, revenue from these fees is used for a number of actions, including the development of Palau's PAN and better sewage management.

While tourism development significantly contributes to local

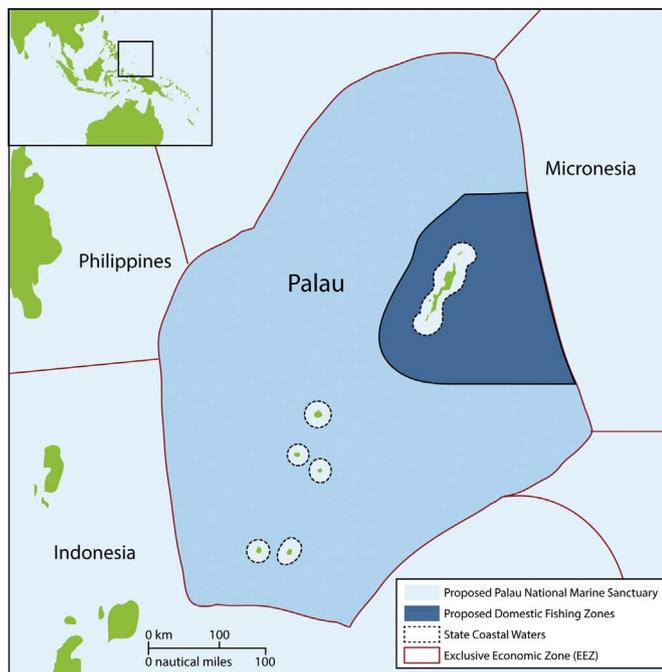


Fig. 1. The Palau National Marine Sanctuary (500,000 km<sup>2</sup>, 80% of Palau's Exclusive Economic Zone), in which no extractive activities will be permitted by 2020, and the proposed domestic fishing zone.

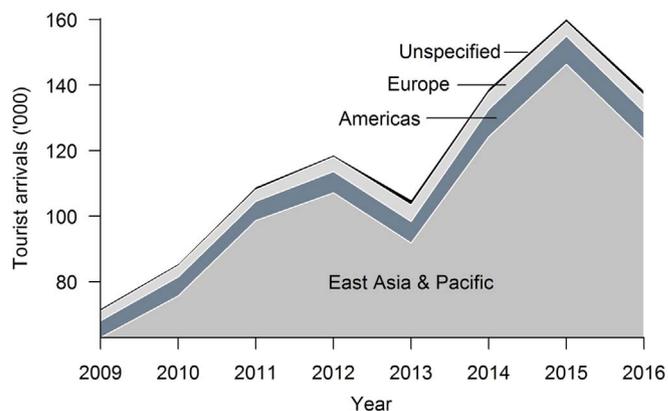


Fig. 2. Tourist arrivals (in thousands) into Palau, according to region, between 2009 and 2016, [27].

incomes and provides a key source of employment in many coastal communities [22,23], it also presents a number of challenges (e.g., [24,25]). The promotion of Palau as an outstanding dive destination has been successful, with visitor arrivals more than doubling over the last decade to 160,370 in 2015, representing about 9 times the local population [26,27] (Fig. 2). However, such large numbers of, often inexperienced, divers have raised concerns about overcrowding at dive sites and poor diver behaviour (e.g., coral holding or kicking, full body layouts on corals, etc.) contributing to coral reef decline [28–31]. Visitation rates have also led to increased pressure on resources through greater freshwater usage, mostly reef-sourced seafood consumption in restaurants, rapid coastal development to accommodate and provide for a greater influx of people, and increased waste generation [6,11].

In light of negative tourism impacts, President Remengesau recently proposed a bill that would deter budget travel and only allow high-end, high-value resorts and hotels on the island, with corresponding recreational activities for luxury tourists [32,33]. By halving flights from China, transporting mainly package tour travellers, visitor rates declined by 15% in 2016 [27] (Fig. 2). The new strategy outlined by the President also seeks to use tax breaks and other benefits to attract investors who would be willing to improve upon existing, and develop new, sanitation and water treatment systems.

Given Palau's strong ties to the oceans, a significant underlying challenge is posed by climate change, expected to impact not only marine environments, but also Palau's culture and livelihoods. Reefs throughout the archipelago experienced considerable bleaching and as high as 90% mortality during the 1997–1998 El Niño event, with further mortality recorded during the 2001 and 2010 thermal stress episodes [34–37], and the 2012 and 2013 Bopha and Haiyan super typhoons [38]. While species richness recovered 10 years after the first El Niño, reef composition has changed [34,39]. Reefs located in bays suffered lower bleaching rates than those on outer and patch reefs [34], and while they may therefore shelter some species from climate change, these reefs are more vulnerable to land-use modifications and other human impacts [34,37,40].

This study outlines a quantitative social-ecological framework to explore the current and future impacts of tourists on reefs through diving activities as well as fish consumption, and ascertain consequences for local lifestyles against the backdrop of climate change. Potential trade-offs are outlined through specific scenarios, including: (i) climate-related impacts on marine ecosystems; (ii) direct diver impacts; (iii) reef fish consumption by both locals and tourists; and (iii) currently proposed government tourism and conservation strategies. Results are discussed in the context of policy development to inform future sustainable marine resource management in Palau.

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