Restoring Reefs, Empowering Communities: A Holistic Approach to Sustainable Tourism in Okinawa's Coral Reefs

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Abstract

Coral reefs across the globe are currently experiencing unprecedented rates of degradation, and this is no exception in Okinawa, Japan. The reversion from the U.S. administration to Japan in 1972 triggered the rapid growth of the tourism industry, which continues to have direct negative effects on coral reefs. From an ecological perspective, tourism development and activity often impact the physiology and biological interactions of coral reefs, compromising their ability to benefit coastal communities. On the other hand, coral reefs on Okinawa attract millions of tourists annually, making tourism a key sector of Okinawa's economy. Although the current literature regarding Okinawa discusses such ecological and societal aspects, it inadequately integrates them to provide insight into promoting sustainable tourism in Okinawa. This paper reviews how tourism ecologically damages coral reefs via pollution and sedimentation, trampling, and coastal alteration. Tourism also jeopardizes local well-being, fishers' livelihoods, and the income from tourism services that are closely linked to the health and visual appeal of coral reefs. While tourism generally contributes to coral degradation, there are some examples of tourism services collaborating with academic institutions, government, and local stakeholders to conserve and restore coral reefs by reducing trampling impacts. Such collaborative efforts are a start to conserving coral reefs, but coral conservation must also tackle pollution, sedimentation, and coastal alteration, as well as secure local well-being, fishers' livelihoods, and economic benefits. In this way, building sustainable tourism in Okinawa requires a holistic approach that can provide specific conservation measures to other Pacific island communities that face similar challenges regarding tourism and coral conservation.

Keywords: Coral Reef Conservation/Restoration, Environmental Conservation, Tourism, Okinawa

1. Introduction

Over the past several decades, the cover and diversity of coral reefs around the world have dropped considerably across the globe (Pandolfi et al., 2003). While biodiversity in all ecosystems is declining on a global scale, considering the health of Okinawa's coral reefs is important because of its exceptional species richness, which is enough to exceed that of the Great Barrier Reef in Australia (Shilla et al., 2013). Among many other anthropogenic factors, tourism damages the local marine environment in the forms of pollution and sedimentation, trampling, and coastal alteration (Erftemeijer et al., 2012; Liddle & Kay, 1987). Since the reversion of the Okinawa Prefecture (Fig. 1) from the U.S. administration to Japan in 1972, Okinawa's cities and coasts have rapidly developed as part of the governmental measures to improve the economy, education, infrastructure, and land use (Hasegawa, 2011). This societal change resulted in the expansion of the tourism industry (*pers. comm.*, Timothy Ravasi; *pers. obs.*). While there have been initiatives to protect coral reefs (Environmental Policy of Okinawa Prefecture, 2015), much of the coral damage caused by development occurs in unmonitored areas (Tanaka et al., 2022). Preventing coral degradation (Fig. 2) is particularly important because Okinawa's reefs act as a barrier against tropical typhoons and an important resource for fisheries (Cinner et al., 2018), and also provide income to tourism businesses.

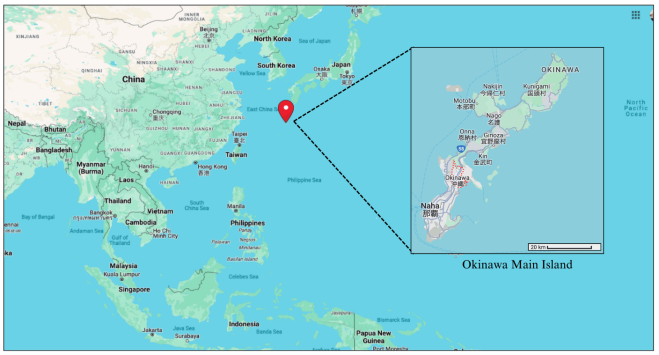

Figure 1. Okinawa is one of the 47 prefectures of Japan and lies between the East China Sea and the Pacific Ocean. The island's coast, which is over 450 kilometers (280 miles), is ringed with fringing coral reefs, coastal reefs that grow outward toward the sea. Map source: Google (2024) Okinawa. Available at http://maps.google.co.jp (Accessed 8 January 2024).

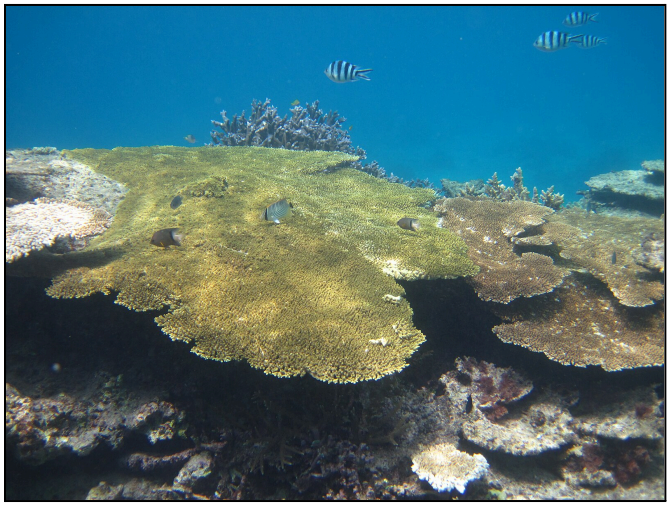

Figure 2. A generally healthy reef in Okinawa with intact tissues and the presence of fishes suggests that the coral maintains ecological relations with marine organisms. However, in some parts of the reef (left and bottom-right), the coral is bleached white and therefore prone to further damage or death. This is due to stressors such as increased sea temperatures, sedimentation, and poor light conditions, which have caused severe degradation of Okinawa's coral reefs in the past century. Photograph: mariemon.

1.1 Economy and COVID-19

The tourism sector produced a substantial 16% of Okinawa's prefectural income in 2018 (Culture, Tourism and Sports Department Tourism Policy Division, 2019; Okinawa Prefecture Planning Department Statistics Division Planning Analysis Group, 2021). The appeal of Okinawa's coral reefs, which attract many tourists, are pillars of the economy (Haas et al., 2015). The drop in tourist numbers (Fig. 3) due to COVID-19 was a financial blow to Okianwa's economy in 2020 and 2021, but likely benefited coral health. In a similar reef ecosystem, for example, fish biomass and species richness increased drastically in Bora-Bora, French Polynesia during the COVID-19 pandemic lockdown season (Lecchini et al., 2021). Such findings suggest that coral biodiversity is impacted by tourism activities.

In the summer of 2020, Okinawa's tourism numbers decreased by almost a third, and while there has been no study in Okinawa to find the relationship between the COVID lockdown season and coral cover, it is likely that coral degradation by tourists decreased drastically during this period of low tourism. However, tourist numbers are quickly returning to pre-COVID levels (Fig. 3; Culture, Tourism and Sports Department Tourism Policy Division, 2023). This will benefit the tourism industry and therefore Okinawa's economy, but makes it increasingly important to minimize coral degradation by tourism as Okinawa's tourism industry rebounds.

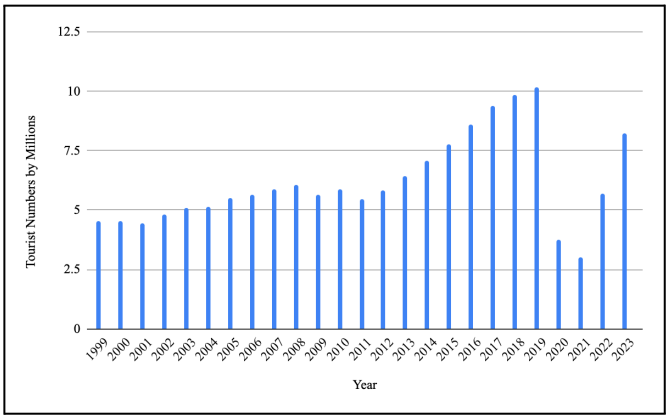

Figure 3. Between 1999 and 2010, annual tourist numbers showed a steady to moderately increasing trend. In 2018, however, annual tourist numbers in Okinawa doubled compared to 2010. While tourist numbers dropped by over 60% in 2020 due to COVID-19 lockdown policies, they increased by almost 90% in 2022 and are expected to continue rising. Data was summed from monthly data for yearly tourist counts (Culture, Tourism and Sports Department Tourism Policy Division, 2023*).*

1.2 Sustainable Tourism in Okinawa

Coral reefs in Okinawa both attract and are harmed by tourism, which requires a symbiotic relationship between tourism and coral reefs, meaning these both benefit each other. Sustainable ecotourism must be properly managed through the collaboration of a diverse group of people (Omori, 2011), which includes small and large-scale governments, academic institutions, and local communities

that have depended upon coral reefs for centuries. Because Okinawa belongs to the developed nation of Japan, it is in a position to be a model of sustainable ecotourism for other Pacific island communities (Kakazu, 2011) that similarly depend on the tourism industry. Furthermore, successful conservation efforts in Okinawa can encourage sustainable tourism in other coastal regions around the world.

This paper, acknowledging both ecological and societal components of tourism and coral reef health, asks how sustainable tourism can be built in Okinawa. It specifically reviews how tourism affects coral reef health, and then discusses how coral reefs, conservation, and local communities are related. Based on these ecological and societal aspects of tourism, the paper will outline the key components of sustainable tourism for coral reefs in Okinawa.

2. Ecological Impact of Tourism

The ecological impact of tourism on corals can be largely broken into three components: pollution, trampling, and coastal alteration, all of which are observed in Okinawa. It is important to understand that pollution and trampling are direct consequences of tourists, while coastal alteration, such as landfilling, comes from the industrial aim to make space for more tourism facilities. The two types of visitation are on-reef visitation, where tourists directly enter coral waters, and overall visitation, which includes entering coastal areas such as beaches but not coral waters (Lin et al., 2023). Combined, these can cause degradation and loss of marine biodiversity across tourist sites. In Okinawa, which is home to diverse coral ecosystems, tourism may contribute to the loss of key ecosystem services of coral reefs. These include food supply and breakwater roles, which are the natural protection of coastal communities from typhoons (Heery et al., 2018).

2.1 Pollution and Sedimentation

There has been increased construction of tourist hotels and resorts on Okinawa's coast (*pers. obs.*), which often results in sedimentation from construction sites that limits the photosynthetic ability of zooxanthellae, dinoflagellates that live in symbiosis with corals (Erftemeijer et al., 2012). Coastal construction triggers red soil runoff (Hasegawa, 2011) and causes turbidity in the water, stressing corals, fishes, and benthic species (Environment Department Environmental Conservation Division, 2023). Largely due to the development of southern Okinawa accompanied by higher city populations, nearby rivers have been found to include nutrients and pollutants that obstruct healthy coral growth (Shilla et al., 2013). In fact, the abundance of hard coral species, distinguished by its self-built carbonate skeleton, in this area was lowest near the city's center (Heery et al., 2018). Additionally, the runoff of certain land use, such as the construction of tourism facilities, negatively affects the chemical environment of Okinawa's fringing reefs (Sakamaki et al., 2022), and can compromise corals' growth, calcification rates, regeneration, immunity to diseases, and physically damage the reef structures and tissues (Erftemeijer et al., 2012).

Coral ecosystems are composed of an extremely diverse variety of coral types and support the abundance and diversity of marine creatures that live within (Graham & Nash, 2013). However, this biodiversity is threatened partly by tourism. Domed corals are physiologically much less susceptible to sedimentation and low light conditions than their branching counterparts (Heery et al., 2018). Consequently, the biodiversity of coral species is jeopardized by pollution and sedimentation (Graham & Nash, 2013), even influencing the ecological functions of fishes that rely on coral (Cinner et al., 2018). The rapid decline of coral cover and diversity due to sewage, dredging, and land reclamation has also been observed in cities in Southeast Asia including Singapore (Low and Chou, 1994) and Jakarta (Kunzmann et al., 2022, underscoring the severity of tourism's impacts.

Sunscreens released in coastal waters by swimmers, tourists, and non-tourists alike, pose ecological threats to Okinawa's coral reefs. The ingredients used in sunscreens promote coral bleaching and thus compromise their resiliency in the face of climate change (Danovaro et al., 2008; Downs et al., 2016). Okinawan reefs face this challenge, as multiple UV filters from sunscreens have been suspended in Okinawa's seawaters (Tashiro & Kameda, 2013). The highest concentrations in July and August coincided with the tourist peak season, suggesting that tourists can directly release harmful substances into Okinawa's coastal waters.

2.2 Trampling

In popular tourist destinations like Okinawa, tourists, including scuba divers, can unintentionally trample corals, damaging their physiology. Heavy human trampling can damage coral reefs and affect a reef's species composition. This effect has been observed around the globe including in Mexico (Gil et al., 2015), Egypt (Hawkins and Roberts, 2023), and the Great Barrier Reef (Woodland and Hooper, 1977). Trampling requires corals to expend excess energy on tissue repair (Liddle & Kay, 1987), decreasing corals' reproduction and growth rate. Trampling also compromises the aesthetic appeal of reef flats in both the short and long term, resulting in a lower expectation of coral beauty (Braverman, 2020). Although unquantifiable, this can potentially have a social effect regarding locals' respect for natural beauty (Larson et al., 2015).

2.3 Coastal Alteration

Tourist hotel construction along the coast has become increasingly common to meet tourist demands, and many beaches have been reshaped for visitation purposes (*pers. obs.*). Coastal construction not only causes sedimentation and turbidity in shore waters (Erftemeijer et al., 2012; Heery et al., 2018) as mentioned above, but landfilling often destroys the habitat for corals and other marine creatures. Coral reefs act as a food source and shelter for coastal organisms that cross between land and sea. Construction of coastal roads, seawalls, and tetrapods (Fig. 4.) results in a landscape far from the original and raises concerns about habitat loss and fragmentation (Masucci & Reimer, 2019; Hasegawa, 2011). For example, the extensive construction of the "Kaichu-Doro" in Uruma City, Okinawa, resulted in reduced water flow, increased mud content, and reduced biodiversity in some benthic species (Reimer et al., 2015).

Figure 4. *Over 60% of Okinawa's coastline is altered, which affects the habitats of corals and marine creatures, and vegetation (Reimer et al., 2015).* Photograph: Si-take

The growing tourism industry in Okinawa over the past century has resulted in coral degradation by pollution and sedimentation, trampling, and coastal alteration. These compromise coral reefs' biodiversity, growth, and visual appeal. From an ecological viewpoint, the impact of tourism on corals is mostly detrimental, as it is to zooxanthellae, fishes, and benthic species that interact with corals.

3. Societal Impact of Tourism

The existence of coral reefs itself is significant for local well-being, as it inspires awe and respect for the natural environment and its resources (Larson et al., 2015). Local support is crucial to the success of conservation efforts (Diedrich, 2007). Separately, tourism in many ways enhances locals' quality of life. Okinawa is a cultural haven, influenced by Chinese, Japanese, and American culture. Many tourists not only visit the beautiful beaches but also the famous Shuri Castle and other castle ruins, many of which are UNESCO Cultural Heritage sites. The tourism industry provides a vast amount of job opportunities, improving the locals' quality of life, as is also the case in communities adjacent to the Belize Barrier Reef (Diedrich, 2007). The tourism industry itself is a prospect for participatory conservation and tourism services such as hotels and resorts can be tools to encourage tourists' understanding and conservation of corals, while also securing the interests of members of the local community (Shani & Pizam, 2012). On the whole, the conservation and restoration of coral reefs call for collaborative efforts that engage people beyond ecotourism managers (Budowski, 1976; Matarrita-Cascante et al., 2019; Tanaka et al., 2022).

3.1 Local Values and Participation

In Okinawa, locals value natural capital such as coral cover and marine biodiversity over man-made capital such as infrastructure development (Shah et al., 2019). This supports the correlation between proper management of coral reef ecosystems and locals' quality of life in communities adjacent to the Belize Barrier Reef and Australia's Great Barrier Reef (Diedrich, 2007; Larson et al., 2015). The most important value among locals of the Great Barrier Reef is the visual appeal and maintenance of the Great Barrier Reef, both of which are unrelated to the reef's utilization as a tourism resource (Larson et al., 2015). Considering that Okinawans hold similar views, which is discussed next, conserving the health and appeal of coral reefs benefits not only tourists but also the residents along fringing reefs.

In order to promote effective conservation in Okinawa, locals must be involved in decision-making and maintain a reliable relationship between authorities (Omori, 2011). First, it is important to understand the motivations of Okinawan locals because it determines their degree of participation and thus the effectiveness of conservation. According to a recent survey, there are five core elements of human-ocean relations: resources as livelihood means, attachment and inspiration, local marine culture, respect and fear for nature, and Anthropocene environmental issues (Sugimoto et al., 2022). Although these values are non-monetizable, they are a key aspect of conservation efforts and awareness (Dawson et al., 2021; Shah et al., 2019). Compared to top-down management regimes of conservation, bottom-up regimes encourage higher local participation and compliance because of the higher level of trust locals place in community-based regimes (Shah et al., 2019). For example, in Akajima, Okinawa, diving services and fishermen restricted their activities at one of the most popular spots (Nishihama) for three years, and the coral

cover significantly increased (Omori, 2011). A potentially important system in Okinawa is the Conservation and Use Agreement. Defined by the Act on Special Measures for the Promotion of Okinawa 2022, it is a certification by the Okinawa prefectural government that approves the management of a tourism service as sustainable. It is given to qualified eco-tour operators who request the certification. This bottom-up system demonstrates that authorities should play the role of empowering local conservation efforts (Tanaka et al., 2022).

3.2 Collaborative Conservation

When tackling the large issue of coral degradation, collaboration and a combination of knowledge and insight from multiple sources are required (Shah et al., 2019). In 2011, the Clownfish Restoration Project in Nago, Okinawa was initiated by Hyatt Regency Seragaki Island Okinawa and the Okinawa Institute of Science and Technology Marine Climate Change Unit, a project through which tourists staying at the Hyatt Regency can participate in coral transplanting operations and explore the clownfish nursery area (Okinawa Institute of Science and Technology Graduate University, 2021; Hyatt Regency, 2019.; pers. comm., Timothy Ravasi). Similarly, Iberostar Hotels and Resorts initiated the Wave of Change project in 2018, which aims to improve coastal ecosystems by becoming waste free and carbon neutral and promoting sustainable seafood. They have been involved with NGOs, local governments in the Latin American Caribbean, and academia (Old Dominion University, Virginia, USA) to improve ecosystem health and profitable tourism. Iberostar Hotels and Resorts' efforts illustrate that the tourism sector can not only be a financial investor but also a direct participant in the scientific and operational processes of restoration (Blanco-Pimentel et al., 2022). The Clownfish Restoration Project and Wave of Change project show that the conservation of coral reefs is most effective when tourism businesses collaborate with other organizations outside of the economic sector.

3.3 Significance Outside Okinawa

The growing tourism in Okinawa is an opportunity to supplement local motivations to protect the natural environment and promote sustainable tourism services. In 2012, Okinawa held the Pacific Leaders Meeting, a summit-level meeting where leaders of Pacific island countries gather and discuss common issues every three years. According to the Okinawa "Kizuna" Declaration proposed in the 6th PALM meeting, PALM leaders share the vision to advance sustainable development and emphasize the importance of "people-to-people exchanges" or "Kizuna", a Japanese term for "bond". People at the local and governmental levels must be involved in protecting vulnerable coral ecosystems (Shah et al., 2019). Okinawa, being part of a developed nation, has well-organized transportation systems and political stability, a privilege that many other Southeast Asian islands do not have. Okinawa therefore acts as an especially good base for developing island models for sustainable and inclusive development (Kakazu, 2018).

3.4 A Holistic Approach to Effective Conservation

From a societal perspective, coral reefs and tourism both benefit local communities by elevating well-being and providing business opportunities. Effective conservation is dependent on the relationship between organizations and how they collaborate. While both top-down and bottom-up management regimes have their pros and cons, holistic approaches to coral conservation that engage people beyond the tourism sector (Fig. 5) will produce effective outcomes (Matarrita-Cascante et al., 2019).

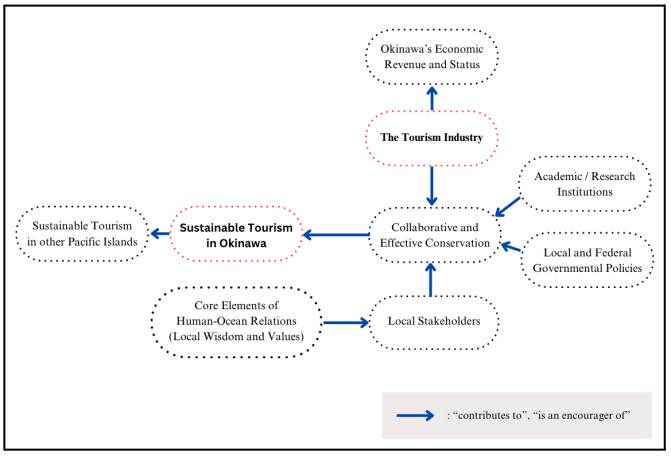

Figure 5. An illustration of how each component should ultimately contribute to sustainable tourism in Okinawa. At the center is "Sustainable Tourism in Okinawa" which is determined by the effectiveness that comes from collaborative coral conservation. This conservation requires a combination of the values and knowledge of local stakeholders (Five Core Elements of Human-Ocean Relations, discussed earlier), local and federal government, and academia. This will especially benefit from the participation of the tourism industry as it currently has detrimental effects on coral reef health while upholding the Okinawan economy. Ultimately, successful tourism can not only lead to sustainable tourism in Okinawa, but to other Pacific Islands as well.

4. Discussion

In addition to the global causes of coral degradation, such as rising sea temperatures and fishing pressure (Pandolfi et al., 2003), tourism degrades coral reef ecosystems at a local level. Through pollution and sedimentation, trampling, and coastal alteration, the health, diversity, and resilience of coral reefs are threatened. It is important to tackle specific

components of tourism's impact on coral reefs. On a local level, hotels and resorts can work with local stakeholders and academic institutions to spread awareness and provide coral transplantation opportunities as part of the tourism experience (Blanco-Pimentel et al., 2022; Hyatt Regency, 2019; Okinawa Institute of Science and Technology Graduate University, 2021; *pers. comm.*, Timothy Ravasi). The Clownfish Restoration project unites a resort business and academia in providing tangible ways for tourists to be aware of staying away from healthy coral reefs, use coral-friendly sunscreen, manage their litter, and practice other environmentally aware actions. The fact that two organizations united toward the shared goal of conservation gives hope for a long-term relationship to continue creating collaborative efforts and encourage other organizations to do the same. For example, when Akajima's diving services restricted tourist activity around coral waters, coral cover increased significantly in the following years (Omori, 2011), illustrating that local-scale stressors are comparatively resolvable.

Although the health of coral reefs in Okinawa is slightly better than other Pacific islands (Heery et al., 2018), it is important for locals and visitors to understand that coral reefs are nonetheless threatened. Government and local stakeholders must simultaneously tackle the issues of pollution, sedimentation, and coastal alteration. For example, Okinawa's local government can reduce the impact of coastal alteration and any resulting sedimentation, such as red soil runoff by restricting landfilling and construction of infrastructure along the northern coasts of Okinawa's main island, which is currently still in its unaltered state (Masucci & Reimer, 2019**).** Furthermore, this will benefit locals' wellbeing rooted in coastal management and visual appeal, supporting the livelihoods of local fishermen (Cinner et al., 2018) and attracting more tourists, resulting in economic benefits. Because Okinawa's tourism is complex and interconnected with other industries, mitigating coral degradation requires conservation efforts on multiple fronts, both on the local and prefectural levels. This will determine the effectiveness of coral conservation on the whole, and thus the future health of Okinawa's coral reefs.

Coral reefs in Okinawa are experiencing degradation no different from reefs around the world. In post-war Okinawa, tourism has posed local threats, destabilizing its economic contribution. Once reviewing the ecological impacts of tourism on coral and its relationship to Okinawa's society, the paper sees tourism as a key component of coral conservation, not degradation. Coral reefs have also been linked to locals' quality of life and wellbeing, and play a key role in attracting tourists from around the world. In islands like Okinawa that heavily rely on coral reefs, locally inclusive and effective conservation is the hope for creating a sustainable future for corals, the economy, and local communities.

5. Conclusion and Next Steps

Okinawa's coral reefs are facing high levels of degradation, resulting in the loss of marine biodiversity, ecosystem functions, and key ecosystem services (Heery et al., 2018). While tourism contributes to this issue, it is also an important aspect of Okinawa's economy and local well-being. Creating a mutually beneficial relationship between coral health and tourism will be important for shaping sustainable tourism (Lin et al., 2023). This requires the collaboration of various people and organizations, including local stakeholders, academic institutions, and government.

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