Matorres, D. E., Fabinyi, M., Barclay, K., & Harrison, P. (2023). Coral restoration in the Philippines: Interactions with key coastal sectors. *Ocean & coastal management*, *246*, 106881. https://doi.org/10.1016/j.ocecoaman.2023.106881

Title: Coral restoration in the Philippines: Interactions with key coastal sectors

Authors: Dane Erlo Matorres[1,2], Michael Fabinyi[3*], Kate Barclay[3], Peter Harrison[4]

[1]Marine Environment and Resources Foundation, UPMSI Building, P. Velasquez Street, U.P. Diliman, Quezon City, 1101 Metro Manila, Philippines. erlomatorres@gmail.com

[2] Department of Sociology, College of Social Sciences and Philosophy, University of the Philippines Diliman, Quezon City, Philippines

[3]Climate Society and Environment Research Centre, University of Technology Sydney, Australia, Ultimo, NSW 2007.

*Michael Fabinyi (Corresponding author): michael.fabinyi@uts.edu.au , https://orcid.org/0000-0001-5293-4081

Kate Barclay: Kate.barclay@uts.edu.au, https://orcid.org/0000-0002-4779-0965

[4] Marine Ecology Research Centre, Southern Cross University, Lismore, NSW 2480, Australia peter.harrison@scu.edu.au , https://orcid.org/0000-0002-4048-2409

Abstract

Much work on coral restoration to date has focused on experimenting with diverse technical approaches and techniques. As the implementation of coral restoration globally increases, it is increasingly recognized that there is a need to better understand how to govern this emerging technology effectively, which requires assessing the social, economic and political contexts in which reefs are restored. This study examined the interactions (both current and potential) between the dominant economic sectors in coastal Philippines and coral restoration. Informed by ongoing coral restoration efforts in Pangasinan province, the paper draws on social data collection of the major coastal economic sectors in the province. Large-scale aquaculture of milkfish generates significant challenges to existing and new efforts at coral restoration as the industry is poorly regulated and environmentally damaging. Destructive fishing methods persist due to weak enforcement capacities and likewise pose challenges to coral restoration. Tourism, as an increasingly important economic activity in the region, potentially provides synergies between coral restoration and local economies. This study highlights that interactions between these business sectors and organisations working to protect coral reefs will go a long way to shaping the eventual governability and sustainability of coral restoration projects. Future reef restoration initiatives need to understand the interactions and dynamics of these sectors in specific contexts, and to identify strategies to manage them for the restoration interventions to work effectively and ultimately generate sustained benefits.

1. Introduction

Globally, threats to coral reefs are accumulating, including the impacts of climate change and other human impacts (Hoegh-Guldberg et al., 2018; Hughes et al., 2018). The increasing scale and pace of these threats and functional reef loss has led scientists and practitioners to work on more active governance tools, including the development of various forms of coral restoration (Anthony et al., 2020; van Oppen et al., 2017; Harrison et al. 2021; McLeod et al. 2022). Much work to date has focused on developing the technical aspects of coral restoration, experimenting with diverse approaches and techniques (Omori 2019; Boström-Einarsson et al. 2020; Banaszak et al. 2023). However, as the implementation of coral restoration expands globally, it is increasingly recognised that there is a need to assess the range of interactions with diverse social contexts in order to optimise the potential social benefits from coral restoration, and to mitigate risks (Kittinger et al. 2016; Hein et al., 2017, 2019; Westoby et al., 2020; Gibbs et al., 2021). In this paper we contribute towards this need, and go further in asserting that social, economic and political contexts shape how people treat reefs, and thus are foundational influences on the sustainability of restoration projects. We make this argument through an examination of how three key coastal sectors of fisheries, mariculture and tourism interact with coral restoration in Pangasinan province in the northern Philippines.

The Philippines is a globally significant site for coral reefs and marine biodiversity, and a pioneer in the development of various forms of marine resource governance, including marine protected areas (MPAs) (Alcala and Russ, 2006). The Philippines economy also has a high reliance on marine resources. Small-scale fisheries are prevalent, supporting livelihoods

and food and nutrition security for millions of coastal people (Anticamara and Go, 2016). Coastal tourism has been emerging rapidly in some parts of the country, while mariculture of various forms, including for seaweed, grouper, milkfish and shrimp is also widespread (Salayo et al., 2012). In recent years, the Philippines has also served as a site for coral restoration scientific research and projects.

Multiple types of coral restoration exist, including coral gardening, substrate stabilization, coral repositioning, macroalgae removal, larval-based restoration, and coral seeding (Boström-Einarsson et al. 2020; McLeod et al., 2022). In the Philippines, the most common restoration methods include asexual transplantation using artificial reefs (Balgos, 1995; Bahinting et al., 2022) and coral gardening (Ancog et al., 2019; Feliciano et al., 2018) that use hard corals that have been naturally detached from the reef (Monty et al., 2006), and the more recent method of larval restoration techniques (dela Cruz and Harrison 2017, 2020; Harrison et al. 2021, 2022; Harrison and dela Cruz 2022). This latter method uses either *ex situ* or reef-based coral spawning of colonies of branching *Acropora* and other species, rearing and culture of larvae in the laboratory or in reef-based larval pools, and transfer of larvae into larval enhancement plots that are temporarily enclosed in fine mesh during their larval settlement period, or released freely onto the reef (op cit.).

The social sciences literature sheds light on the social contexts of interventions such as coral restoration, including understanding the social impacts of marine conservation interventions. While literature from a marine conservation perspective tends to highlight the flow of benefits from marine resources to people, literature from the wider social sciences has emphasised how agricultural and conservation interventions operate in a context of diverse stakeholders and contested interests (Cook et al., 2021; Curry et al., 2021; Douthwaite and Hoffecker, 2017). This context is also shaped by connections to wider sets of economic and political processes operating at multiple scales (Armitage and Johnson, 2006; Farmery et al. 2021; Jentoft and Chuenpagdee, 2015). As well as mediating the impacts of marine conservation interventions on communities, these diverse, multi-scalar social, economic, and political processes in turn mediate the biophysical outcomes of the interventions. In other words, the governance of coral reefs and the surrounding environment is key to whether restored coral reefs will remain healthy.

Literature on governance of coral restoration provides a basis for thinking about how governance structures may affect the effectiveness of restoration efforts, and thus the social benefits that may arise from restoration. Coral restoration raises a series of governance challenges (Vella et al. 2022; Hughes et al. 2023). At a broad level, one cited risk is for coral restoration to become a form of adaptation that distracts from more fundamental efforts to mitigate against the causes of climate change (Morrison et al. 2020). Others have pointed to the risks of neo-colonialism (Gibbs et al. 2021), and to the potential for Western knowledge and science to be privileged over local values and interests (Moore 2021; Vandenberg et al. 2021). At the level of management, there is a need to align coral restoration within existing regulatory landscapes (Fidelman et al. 2019), and to generate and monitor social benefits for various stakeholders (Hein et al. 2017, 2019; Westoby et al. 2020). In the Philippines, researchers have identified several governance challenges, including the cost of different methods of coral restoration (Abrina and Bennett 2021), and

the need to manage coral restoration in conjunction with the management of ongoing, external threats to reefs (Edwards and Gomez 2007; Feliciano et al. 2018). However, beyond the assessment of ecosystem interactions, and of social benefits and impacts for livelihoods at the local level, there is a need to consider how coral restoration interacts with wider social and economic systems, including how these wider systems shape whether people take care of restored reefs.

In this paper, we draw from interactive governance perspectives that highlight the distinctions between governing systems and the 'system-to-be-governed', and how this subsequently informs relative 'governability' (Chuenpagdee and Jentoft, 2009). In this approach, the governing system is seen as composed of a mode (e.g. hierarchical, collaborative or self-governance), institutions (e.g. formal and informal), and policy instruments (e.g. fisheries management tools), while the system to be governed is composed of both the natural system and the socio-economic system with which it is fundamentally linked (Chuenpagdee and Jentoft, 2009). The interactions between the governing system and the system to be governed subsequently inform relative governability. Acknowledging that marine resource use governance is typically a 'wicked problem', an interactive governance lens aims to provide a holistic perspective that takes into account the diverse forms of governance that are possible within a given social context, and the multiple social drivers that affect this relationship. It has been applied extensively to various contexts of marine resource use globally (Jentoft and Chuenpagdee, 2015), and within the Philippines (Ferrer, 2015). This perspective provides a useful way to understand the 'fit' between a new technological intervention and the existing social-economic and political context.

To understand how coral restoration fits with the activities and priorities of local communities and governments in the Philippines, the primary focus of this paper is on the system-to-be-governed. In the interactive governance literature, there are a range of ways to define the system-to-be-governed (Chuenpagdee and Jentoft, 2009), including value chains (Barclay et al., 2019). In this paper we focus on the dominant economic sectors of the coastal zone in the rural Philippines, which constitute the economic and social contexts in which coral restoration is taking place: aquaculture, fisheries and tourism. All three sectors play major roles in shaping the outcomes of coral reef governance more generally, both in the Philippines and elsewhere (Cinner, 2014; Cruz-Trinidad et al., 2009).

This paper presents early findings from a project to better understand the institutional effectiveness of coral restoration. Among the objectives of the broader project are to understand the kinds of social, political and economic factors to consider in site selection to avoid wasting resources on coral restoration that is not sustained. Informed by ongoing coral restoration efforts in Pangasinan province, the specific objective of the paper is to identify the central features of each of the three sectors that interact with coral restoration, and how these features influence the governability of coral restoration. The goal of the paper is not to advocate for coral restoration but to assess key issues for governing coral restoration in the context of existing coastal sectors.

2. Background and Methods

2.1 Coastal Resource Governance in the Philippines

Coastal livelihoods in the Philippines are largely dominated by small-scale fisheries. Municipal fisherfolks, reported at 2.19 million in 2021 (BFAR, 2022) and with the highest poverty incidence among the basic sectors (PSA, 2020), engage in different types of fisheries activities along the value chain. Another key coastal sector is aquaculture which has consistently contributed half of total fisheries production in terms of volume since 2012 (BFAR, 2022) and remains a banner program of the Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR), as reflected in the Comprehensive National Fisheries Industry Development Plan 2006 – 2025. Tourism is a third major economic activity in coastal areas: figures for tourism direct gross value added grew from P460 billion in 2008 (USD8.4 billion) to P2.5 trillion (USD45 billion) in 2019, representing about 12.8% of the country's gross domestic product (Caynila et al., 2022). Both aquaculture and tourism offer employment opportunities and economic benefits to fisherfolks and coastal residents, and thereby also potentially reduce fisheries pressure on marine resources. However, this has proved variable in practice (Hill et al., 2012).

The management of coastal resources is coordinated by local government units (LGUs) as mandated by Republic Act 7160 or the *Local Government Code of 1991*. The law influences coastal resource management (CRM) around the principle of decentralization and political autonomy through bestowing power to LGUs to levy taxes, fees and other charges (DENR et al. 2001). RA 7160 also promoted cooperative undertakings between LGUs for integrated CRM programs in the form of MPA networks and inter-LGU alliances (Horigue et al., 2014), which facilitated innovations in integrated fisheries management and governance (Pomeroy et al. 2010). Another key legislation is R.A. 8550 or the *Philippine Fisheries Code of 1998* (amended in 2014 with R.A. 10654), which clarified jurisdiction and obligations of LGUs over municipal waters measured from 15 kilometers of the coastline (DENR, et al. 2001). The decentralized set up was recently further strengthened with the issuance of Executive Order 2021-138, which gives LGUs a bigger revenue allotment from national taxes and is thus expected to better deliver devolved services (DBM, 2021).

2.2 Study Areas

The study areas are three LGUs in the Northern Luzon province of Pangasinan: the municipalities of Anda and Bolinao, and Alaminos City (Fig. 1). Bolinao is a 'first-class' municipality (classified as having average annual income of at least fifteen million pesos [about USD274,000.00] at the municipal level), and is comprised of 30 barangays[1], 23 of which are coastal. Most of its residents depend on fishing for livelihood, and aquaculture production has also significantly increased over the years, raising concerns on its negative impacts to marine life (Villanueva et al. 2005). Another key sector is agriculture including crop production, livestock, and poultry raising (LGU Bolinao, n.d.). The major crops grown include rice, corn, peanuts, cassava, and fruits like mango, coconut, and citrus.

[1] A *barangay* is the smallest political unit in the Philippines, often translated as village or community.

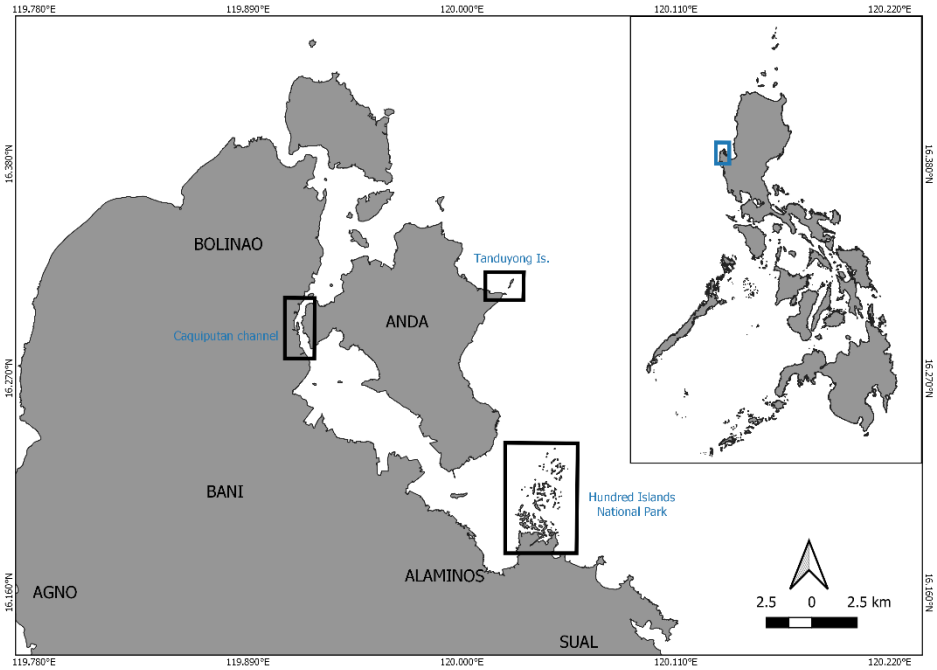

Fig. 1. Map of Bolinao, Anda and Alaminos City.

Anda is classified as a 'third-class' municipality, with an average annual income at the municipal level between five to ten million pesos [USD91,350-USD182,700]). Agriculture makes the greatest contribution in terms of production value, mainly for growing of commercial crops like vegetables, watermelon, root crops, banana and other fruit trees (LGU Anda, n.d.). A notable portion of its population engages in capture fisheries and, similar to Bolinao, aquaculture has also expanded significantly, resulting in cases of environmental degradation (Quimpo et al. 2020). Retail industries also provide the local government with a significant source of revenue from taxes and rental fees.

Alaminos City is classified as a fourth-class component city (average annual income between ten and fifteen million pesos [USD181,700,000.00-USD274,050.00]). It has a total of 39 barangays, 10 of which are coastal. Alaminos is largely agriculture-dependent with about 80% of its residents engaged in agriculture as the major source of income (LGU Alaminos City, n.d.). Municipal fishers are a significant portion of the population and unlike Bolinao and Anda, the aquaculture industry is regulated more effectively through zoning and is now limited to the growing of fingerlings. As a result of a growing tourism industry, trade and commerce have become key industries as well with a total of 2,291 registered establishments in 2015.

Several attempts have been made to establish inter-LGU coordination and management of shared marine resources among the three local governments. First is the ABBA (Alaminos, Bani, Bolinao, Anda) network, which was initiated by DA-BFAR for the integrated management of Tambac Bay. DA-BFAR also initiated the formation of the SABAC (Sual, Alaminos, Bani, Anda Council) network, with the objective to coordinate law enforcement programs. Both ABBA and SABAC did not prosper as envisioned due to inadequate support of other government agencies.

2.3 Coral Restoration Work in Pangasinan

The Philippine government has rolled out several national programs on coral restoration, including several funded by the Department of Environment and Natural Resources (DENR), the DA-BFAR, and the Department of Science and Technology – Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAARRD). Pangasinan specifically has been a pioneer site for the development of coral restoration technology in the Philippines through the initiatives of the University of the Philippines Marine Science Institute (UP MSI). Early UP MSI reef restoration projects were mainly funded by DOST-PCAARRD, the Commission on Higher Education, and in-house grants from the University. These projects produced numerous studies on the growth and survival of juvenile and fragmented corals (Yap and Gomez, 1985; Yap et al., 1998; Villanueva et al., 2012).

National government support to UP MSI through DOST-PCAARRD funded projects continued to produce research on reef restoration, including dela Cruz et al. (2014) on a community-based and low-tech method of restoration, and Conaco and Cabaitan (2020) on the influence of salinity and temperature on the survival and settlement of coral larvae. International funding also significantly increased efforts in coral restoration, including the Global Environment Fund-World Bank Coral Reef Targeted Research Program. This project supported the research of Baria et al. (2010) on a caging experiment to enhance post-settlement survival of coral juveniles, and Cabaitan et al. (2015) on the performance of single versus mixed coral species for transplantation. Over the past decade, funding support from the Australian Centre for International Agricultural Research (ACIAR) facilitated studies of sexual reproduction, larval-based culture and the novel technique of larval enhancement (Harrison et al. 2016; dela Cruz and Harrison 2017, 2020; Harrison et al. 2021, 2022; Harrison and dela Cruz 2022). The different forms of coral restoration may have different governance requirements in terms of inputs, however, in this paper we are more concerned with how people's activities impact on the health of coral reefs, which is not dependent on the techniques of restoration used.

2.4 Data Collection and Analysis

To assess the key characteristics of the fisheries, mariculture and tourism sectors and how they contribute to the governability of coral restoration, we adopted a mixed methods approach that incorporated document review, focus group discussions, insights from workshops with local governance stakeholders, participant observation and semi-structured interviews with key informants.

Fisheries profiles of the three LGUs provided basic information about the present status of mariculture and capture fisheries. These include the number of registered municipal fisherfolk and fish cages/fish pens, common fisheries gears used, and estimated annual production. Tourist arrival and collection reports and tourism-related ordinances helped contextualize and supplement analysis of the sector. Official government reports provided information about the incidence of fish kills, while scientific journal articles provided information on the impacts of coral restoration on fisheries and impacts of aquaculture on coral reef health in Pangasinan.

We conducted fieldwork in order to generate more detailed data about fishing, tourism and aquaculture activities; the effectiveness of regulations for each sector; perceptions of coastal residents and LGU officials about the benefits of each sector; and the challenges and opportunities presented by coral restoration for each sector. The coral restoration efforts in Alaminos City and Anda are still largely experimental to date. Given the relatively early stage of the restoration projects, interactions with fisherfolks and community members are likewise limited, which meant that most respondents in communities did not hold strong opinions or detailed knowledge about coral restoration. Consequently, many interviews ended up focusing on coral reef governance in general, and perceptions about coral restoration specifically were largely expressed by government officials at the municipal/city level. The relatively early stage of the restoration project also means that many of the challenges and opportunities refer to future challenges and opportunities, and the ongoing sustainability of coral restoration projects. The field work was carried out from February to September 2022 as part of two ongoing projects funded by ACIAR – one focused on the technical aspects of coral restoration, the other focused on the institutional effectiveness of coral restoration. It consisted of monthly trips and conducted key informant interviews, focus group discussions (FGD), workshops, and participant observation. The field work was informed by an interpretive, qualitative methodological perspective that draws on the techniques of triangulation (i.e., multiple sources and types of data on the same issue from different perspectives); on saturation (i.e., conducting interviews until new interviews provide no new qualitative information or insight) (Grady, 1998; Yin, 2016; Noble and Heale, 2019); on prolonged engagement in the field; and on cross-checking of fieldnotes and data among the first two authors. These techniques contributed towards the validity and reliability of the data (Rose and Johnson 2020).

Individual interviews and FGDs served as the primary material from which the study obtained the data used for qualitative thematic data analysis. A total of 58 interviews were conducted with relevant local government offices, *Bantay Dagat* (fish wardens), and barangay officials. FGDs were facilitated in three barangays in Bolinao and two in Anda, all located along the mariculture zone. A policy scenario tool modified from Pomeroy et al. (2010) was developed where fisherfolks identified observed or perceived benefits and risks of mariculture to the environment and local economy under the following scenarios: (1) status quo; (2) ban on mariculture; (3) regulated mariculture; and (4) unchecked expansion. FGDs were also conducted with tourist boat operators from two barangays in Alaminos City and one in Anda. The discussion covered awareness of operators on MPAs and observed/perceived benefits of healthy coral reefs to tourism.

In addition, we conducted one SWOT workshop per LGU and one mariculture management planning workshop for all the three LGUs to identify gaps and issues and review current policies and programs. While these workshops were designed and implemented primarily to assist LGUs in their coastal resource management mandates, they also provided useful information for this study. Transcripts from interviews and FGDs were supplemented with field notes from workshops and meetings.

The research was approved by the University of Technology Sydney Human Research Ethics Committee (ETH21-6531), which included free, prior and informed consent. During the

interviews, concerns over alleged unregulated operation and monopoly of the aquaculture industry by certain political families and corporations came out in the interviews and FGDs with fisherfolks and barangay officials. Similar themes also emerged from community discussions where allegations about commercial fishing operators engaged in illegal fishing activities and with links with authorities transpired. While we do not have any evidence to support these allegations, do not make any allegations ourselves, and do not name the individuals and organisations alleged to have been involved, these perceptions are fundamentally important dynamics in understanding the politics and economy behind marine resource governance in the study areas that are otherwise not discussed in formal, public interviews and meetings, and need to be acknowledged (Walley, 2004). Regardless of whether perceptions about illegal activity are based in fact, they drive assessments of legitimacy about marine resource governance (Fabinyi 2012).

3. Results

3.1 Governance Arrangements & Capacities

Coral restoration sites in the Alaminos City region and in the municipality of Anda are located inside protected areas. In Alaminos City, restoration efforts are within the Hundred Islands National Park (HINP), a protected area by virtue of Republic Act 7586 or the *National Integrated Protected Areas System (NIPAS) Act of 1992* as amended by R.A. 11038. The experimental setups are declared to be Strict Protection Zones and hence closed to all human activities unless for the purposes of research, biodiversity monitoring, and regulated navigation. The restoration site in Anda is located inside of Magsaysay Reef Marine Sanctuary, a 14.8-hectare fish sanctuary established through Municipal Ordinance 2001-01. However, the MPA has not been functional for years and monitoring and enforcement activities are not conducted on a regular basis. Bolinao is included in this study as one of the project sites in Pangasinan where restoration efforts may be undertaken. The candidate restoration site in Bolinao is also inside an MPA but the management of the sanctuary is likewise beset with challenges due to lack of funding.

The coral restoration efforts are initiated, implemented and managed by collaboration between staff from Southern Cross University, Australia and UP MSI supported through multiple ACIAR coral larval restoration projects since 2012, with additional collaborators from Queensland University of Technology, University of Melbourne, and University of Technology Sydney in current ACIAR projects. UP MSI drafted a Memorandum of Agreement with each local government, and project partners have participated in the coral larval restoration training activities and reef ecology education and capacity building (Harrison et al. 2022). For Alaminos City, the HINP Protected Area Management Board (PAMB) issued Resolution No. 2018-03 to formally recognize the partnership with UP MSI, which granted UP MSI 4,000m^2 inside the national park to conduct mass coral larval restoration (*sensu* Harrison et al. 2021, Harrison and dela Cruz 2022).

In Alaminos City, a multi-level governance arrangement aims to facilitate effective coral reef protection. The Hundred Islands Protected Landscape and Seascape Protected Area Management Plan formulates a long-term framework plan and proposes programs that are

regularly funded by the national government. For its part, the local government passed the City Tourism Code of Alaminos in 2013, which governs all activities in the protected area, including licensing, registration, and supervision of tourism-related establishments and activities. It also issued Executive Order No. 2017-36, which established a multi-stakeholder task force that enforces local ordinances and national laws on the environment and fisheries.

In contrast to Alaminos City, Anda is confronted with institutional challenges with respect to coral reef governance. In addition to the specific challenges facing management of the Magsaysay MPA mentioned earlier, one key institutional gap is the current absence of a Coastal Resource Management Plan. The local government has a Municipal Fisheries Ordinance passed in 2002 and a Coastal Development Plan drafted in 2003, but neither of these documents have yet been updated to incorporate amendments on the Fisheries Code.

3.2 Key Coastal Sectors

The following sections discuss the reciprocal challenges and opportunities between the key coastal sectors of aquaculture, capture fisheries and tourism, and coral restoration: how restoration might be affected by these sectors and how it might affect these sectors.

3.2.1 Aquaculture

The large-scale aquaculture of milkfish (*Chanos chanos*, or *bangus* [local name]) generates significant challenges to existing and new efforts at coral restoration due to poor regulation and impacts on water quality. Studies by Villanueva et al. (2005) and Quimpo et al. (2020) revealed the detrimental effect of intensive fish farming in Bolinao on the survivorship of coral juveniles, while a simulation of seagrass bed dynamics (Yoshikai et al. 2021) showed that discharges from the mariculture area in Caquiputan Channel can reach the reef area of Anda. However, the prospect for sustainable aquaculture management is being hampered by the failure to effectively implement reforms in Anda and Bolinao. Correspondingly, the potential future expansion of coral restoration could be expected to generate challenges to the current status quo of the aquaculture industry via support for more sustainable management.

The aquaculture industry in Anda and Bolinao, which takes the form of fish cages, has significantly increased over the years but without effective regulation (Table 1), while Alaminos City prohibited the use of fish cages and only allows a manageable number of fish ponds for growing of fingerlings and oyster farms. The only fish species that is being cultured in Anda and Bolinao is *bangus*. The fishponds in Alaminos City grow *bangus* fingerlings with an estimated production of 2,034 metric tons for 2021, and also a small volume of groupers (22 metric tons for 2021). The carrying capacity has only been estimated for Bolinao, and is less than 544 units (Sugimoto et al., 2016).

Table 1. Milkfish (cage and pond) and grouper (pen) production in Anda, Bolinao & Alaminos City (blank cells indicate no data)

Year	No. of Units				Estimated Production (MT)
	Fish Cage	Fish Pond	Fish Pen	Total	

Bolinao	2019	329		179	508	14,166
	2020	400			400	12,000
	2021	606			606	18,180
	2022	606			606	18,180
Alaminos City	2019		105	35	140	2,035
	2020		103	24	127	2,021
	2021		103	56	159	2,056
Anda	2019	266			266	814
	2020	764			764	5,934
	2021	773			773	8,084
	2022	795			795	7,566

The local governments adhere to coastal zoning policies where specific areas for aquaculture structures are allotted. The designated mariculture zone for Bolinao and Anda is Caquiputan Channel (Fig. 1). However, the local governments currently lack programs to monitor and regulate the industry. In the case of Bolinao, the local government has established a water quality monitoring team, which conducts two types of monitoring: (1) water quality which covers dissolved oxygen (DO), nitrate, and ammonia and is monitored in 16 stations in Caquiputan Channel; and (2) Structure Inventory Report which lists the names of operators, caretakers, feeds used, stocking date and expected harvest. When certain physical parameters are breached (e.g., low DO levels), the operators are advised to either change feeding behavior, adjust stocking density, or harvest early. Unfortunately, monitoring halted from 2018 because of a lack of budget and problems with government audit systems. Partial monitoring briefly resumed in 2021.

Anda does not have any regulatory programs for aquaculture. Water quality monitoring and actual inventory of fish cage units have not been implemented for several years now, and there is no carrying capacity study to set the number of allowed fish cages. The operators are regularly reminded in Facebook Messenger to follow the recommended distance between units and restocking schedules. In order to avoid *gataw gataw* (an event when *bangus* surface to gasp for air) or fish kill, aquaculture operators themselves have in-house technicians to conduct regular water quality monitoring. Due to poor regulation, Anda aquaculture operations experienced the highest incidence of fish kill over the last decade according to DA-BFAR (Table 2).

Table 2. Occurrence of fish kill, volume and estimated value of losses, and cause of fish kill

	Date of Occurrence	Specific Location	Volume of losses	Estimated value of losses	Cause of fish kill
Anda	December 22, 2012	Siapar and Awag	No reported volume	No reported estimations	Low dissolved oxygen
	May 20-22, 2013	Siapar	Around 400,000 – 600,000 pcs.	No reported estimations	Low dissolved oxygen, *"gataw"*
	May 21, 2016	Siapar	Around 200,000 – 300,000 pcs.	No reported estimations	Low dissolved oxygen, *"gataw"*

	May 29-31, 2018	Mal-ong, Awag and Siapar	Around 880,000 pcs or around 200 MT	Php86.111 million (USD1,529,571.00)	Low dissolved oxygen, *"gataw"*
	May 19-21, 2020	Awag, Dolaoan and Mal-ong	Around 1-2 million pcs of milkfish stocks	Php18.06 million (USD320,796.00)	Low dissolved oxygen, *"gataw,"* high ammonia level
Bolinao	April 25-30, 2015	Luciente I, Lucero, Pilar, Salud, Luciente II, Luna, Culang, Catubig	70% of stocks, 2,300 MT of potential production	Php218.50 million (USD3,881,167.00)	Low dissolved oxygen
	May 29-31, 2018	Luna, Luciente II, Culang	Around 2.4 million pcs of juvenile and harvestable stocks	Php16.128 million (USD286,478.00)	Low dissolved oxygen, *"gataw"*
	May 19-21, 2020	Culang, Luna, Catubig	Around 1.5-2 million pcs of milkfish stocks	Php21.94 million (USD389,715.00)	Low dissolved oxygen, *"gataw,"* high ammonia level

Many LGU officials of Bolinao and Anda do not favor aquaculture expansion, recognizing that carrying capacity limits have already been breached with subsequent environmental impacts. However, enforcement and punishment for violations is limited, and allegations of corruption are common. Despite the ongoing expansion of aquaculture units, in Bolinao the LGU is not getting significant revenue from aquaculture. The local government only collects auxiliary tax worth Php3.00 (USD0.05) per tub of catch and about Php12,000.00 (USD219.00) annually per fish cage for the permit. In addition, operators pay Php5,000.00 (USD92.00) as "performance bond", which serves as collateral of the LGU when operators and their caretakers violate existing guidelines.

Fisherfolks are likewise opposed to the expansion of aquaculture because the industry affects their livelihood. Fisherfolks in a range of barangays in Bolinao and Anda complained about various declines and extirpations that they attributed to sedimentation from aquaculture, including: corals, seagrass beds, sea cucumbers, *suso* (gastropods), *Sargassum*, and shells. Secondly, fisherfolks decry the reduction in fishing grounds because of the uncontrolled establishment of fish cage units. They say fish cages pushed them away from the nearby shore where they used to fish. For example, the fisherfolks of one barangay in Bolinao said that fish cages are continually expanding and getting closer to their *skylab* (indigenous fish trap consisting of triangular bamboo stakes). In another barangay in

Bolinao, fisherfolks are prohibited by operators from fishing near the cages. *Skylab* units are also not allowed to be put up near the vicinity. In most cases, fisherfolks do not come near the units for fear of being accused of intentionally tearing the nets enclosing the cages.

Lastly, fisherfolks believe that employment benefits from aquaculture are limited. Residents only play menial roles and receive below the prescribed national level 'official' daily minimum wage. According to residents in one barangay of Anda, residents serve the following roles: *bantay* (caretaker), *taga-linis* (net cleaner), *taga-tahi* (net seamstress), *taga-palit* (net changer); *ilador* (ice dealer); classifier; harvester; and those involved in the transport of *bangus*. The caretakers receive monthly allowances ranging from Php3,000.00 to Php5,000.00 (USD54.00-USD92.00) plus commission from the total net income, which is significantly below the poverty threshold monthly income of Php12,892 (USD35.00) to meet a family of five's basic food and non-food needs (PSA, 2022). Local traders and fish vendors do not also benefit from *bangus* production since the intended market is Manila.

3.2.2 Capture Fisheries

Fisheries are important in all three sites. Coral restoration can potentially improve fisheries productivity, but environmentally destructive fishing practices pose a challenge to restored reefs. Mean live coral cover in the Magsaysay reef experimental plots increased from 19% prior to larval restoration to 40% three years after larval release (Harrison et al., 2021), which likely influenced some changes in reef fish assemblages including small but significant increased abundance of pomacentrids and corallivore chaetodontid reef fishes coinciding with growth of the restored *Acropora tenuis* colonies that provided habitats and food (Harrison et al., 2021). In Anda and Alaminos City, long-term monitoring results revealed increasing trends in mean fish abundance and, in some cases, increases in mean fish species richness and biomass in the larval restoration plots compared with control plots. This improvement in fish assemblage was supported by fisherfolks in Anda (Harrison et al., 2020). Accordingly, fisherfolks who have visited the restoration sites reported seeing more juvenile fishes and more diversity within and in adjacent reef areas to the restoration site in comparison with other degraded reefs nearby and afar. Coral restoration therefore has the potential to improve capture fisheries productivity through the protection of spawning fish stocks and the subsequent 'spill-over' effect of progeny moving into other reef areas that are fished (Russ et al. 2015).

Diverse forms of small-scale fishing activities remain important as a fallback livelihood strategy. Large-scale commercial[2] fishing inside the municipal waters, using destructive fishing methods, likewise persists in some areas because of weak enforcement capacities and alleged cooperation with enforcement authorities. In Bolinao, many fisherfolks use *skylab* and *pasabin*, which consists of one or two static stake circles towards which fish are guided by long rows of stakes. *Skylab* and *pasabin* operators pay a permit fee worth Php1,700.00 (USD30.00) and Php1,500.00 (USD27.00) for renewal. Other gears/methods include *bingwit* (hook and line), *lambat*, and *pana* (spear). In Anda, fishers also use *pasabin*. They also use *lambat*, hook and line, and fish traps. For Alaminos City, fisherfolks use *baklad*, *lambat, kitang* (hook and line), and *nasa* (crab trap). *Padas* (juvenile siganids)

[2] In the Philippines, commercial fishing vessels are defined as greater than three gross tons, and are only allowed to fish further than 15km from the coastline.

gathering for *bagoong* (fish paste) is also practiced. Most of the catch are either sold in the local markets or reserved for buyers/middlemen who, in return, sell them as far as regional cities (Harrison et al. 2020).

In Anda, illegal fishing is an immediate, direct threat to the MPA where the restoration efforts are located. The fisherfolks of Brgy. Tondol identified dynamite, cyanide poisoning, and the use of fine mesh nets as the most prevalent illegal fishing activities in the municipality (Harrison et al. 2020). Dynamite fishing, in particular, is said to be undertaken by fisherfolks from regional cities. Other illegal fishing methods mentioned include the use of rabbitfish trawl, air compressor, triple net, and root poison. In contrast, Bolinao fisherfolks reported no cases of dynamite fishing but only "minor" violations such as encroachment in sanctuaries and use of triple nets.

The non-enforcement of fishery laws on illegal fishing in both Anda and Bolinao is attributed to a large extent to institutional weakness resulting from lack of resources. The *Bantay Dagat* of Bolinao do not have their own boats and other necessary assets such as binoculars and two-way radio system for patrolling and surveillance. Similarly, Anda does not have dedicated motor vessels, and patrolling activities depends on availability of diesel. All the *Bantay Dagat* work on a voluntary basis and receive a meagre honorarium worth Php500.00 (USD9.00) per month. Most of them also need to undergo deputization training to gain knowledge and skills in fishery law enforcement. In addition, fisherfolk and community organizations that form the MPA Management Body and can assist in monitoring and surveillance activities are no longer active.

In the HINP, illegal fishing is contained due to strengthened enforcement of the national park and the resources invested by the local government. The management of HINP by the local government is mainly embedded on the tourism industry. The local government passed City Tourism Code of Alaminos, through Resolution No. 10-2013, which governs all activities within HINP, including licensing, registration, and supervision of tourism-related establishments and activities. Particular to fishery enforcement, the local government issued Executive Order No. 36 series of 2017 which established an official Task Force to protect and preserve HINP against environmental offenses. It oversees the implementation of local ordinances and national laws on environment and fishery laws. The composite team is comprised of the City Tourism Office, PAMB, barangay officials, Bantay Dagat, City Police Station, Philippine National Police Maritime Group, Coast Guard, and the BFAR.

3.3.3 Tourism

Tourism is an increasingly important economic activity in the three coastal LGUs and potentially provides opportunities for coral restoration to interact with local economies. The central attraction is island hopping, where tourists swim and snorkel to see fish and corals. The sector offers fisherfolks improved income, and the significant revenue it generates can potentially be leveraged for coral reef protection and rehabilitation.

Government officials in Alaminos City see coral restoration as potentially improving the amenity values of HINP and as a chance to promote the national park. The restoration

efforts, while closed to snorkelling and diving, are used in promotional materials and in this sense, tourism is not only potentially beneficial for coral restoration, but coral restoration is also seen as a chance to promote tourism. The local government has the highest level of tourist arrivals and income collected from user fees. According to the City Tourism Office (CTO), tourist arrivals for both foreign and domestic tourists peaked in 2017 at 561,909. The highest collection of user fees recorded was in 2019 amounting to Php44,727,206.77 (USD794,479.00). The local government retains 75% of all revenue raised from user fees (PhP100/USD1.8 per person), taxes, donations, endowment, and grants under the NIPAS Act. The remaining amount goes directly to the national treasury. At the start of the pandemic, collection hit lows of Php9,090,553.01 (USD161,473.00) and Php6,133,482.25 (USD108,948.00) for the years 2020 and 2021, respectively (Table 3).

Table 3. Tourist arrivals and income for Bolinao, the HINP and Anda (blank cells indicate no data)

	Year	Number of Tourist Arrival	Income from user/environmental fees in PhP
Bolinao	2015	137,285	
	2016	257,664	
	2017	342,972	
	2018	359,264	
	2019	532,142	
	2020	91,380	
	2021	301,464	5,566,740.00 (USD98,881.00)
	2022 (as of June)	422,403	8,940,566.00 (USD158,809.00)
HINP	2015	364,578	28,208,577.00 (USD501,063.00)
	2016	451,231	32,969,551.36 (USD585,631.00)
	2017	561,909	41,051,093.75 (USD729,181.00)
	2018	547,490	43,185,062.20 (USD767,087.00)
	2019	522,917	44,727,206.77 (USD794,479.00)
	2020	93,344	9,090,553.01 (USD161,473.00)
	2021	67,355	6,133,482.25 (USD108,948.00)
Anda	2019	-	88,290.00 (USD1,568.00)
	2020	-	106,720.00 (USD1,896.00)
	2021	-	1,218,900.00 (USD21,651.00)
	2022 (as of July)	-	1,847,975.00 (USD32,825.00)

The primary tourist attractions are island-hopping, swimming, and water sports activities. Commercial scuba diving is not yet present but the local government has started to look for potential dive spots and to attract investors for diving equipment. For island-hopping, tourists pay Php2,000.00 (USD36.00) for large boats that can accommodate up to 15 persons and Php1,800.00 (USD32.00) and Php1,400.00 (USD25.00) for medium and small boats, respectively. Operators earn about Php500.00 (USD9.00) net income per day, excluding costs for repair and boat maintenance. The tourist boat operators of one barangay said that guests like to see corals and fish when snorkelling, and are aware of the prohibitions such as collection of and standing on corals, but, as in other reef regions (De et al. 2020), observed that most of the snorkelling sites are shallow and hence sometimes tourists unintentionally damage them.

Anda does not also allow any underwater activities in the restoration sites, yet potentials of restoration to increase coral cover and fish biomass to boost tourism is considered through opening the buffer zone of the MPA. The primary attraction is the stretch of white sand beach located in Brgy. Tondol with its shallow waters suitable for swimming, especially for children. It also has cottages, kiosks/food stalls, and a number of resorts/transient houses. While these activities currently have minimal interaction with coral restoration, they are indirectly linked with snorkelling activities which do. The local government collects Php40.00 (USD0.7) for environmental fee and Php5.00 (USD0.09) for entrance fee; of which the barangay receives 20% and 10% respectively. Following a local ordinance, 80% of the environmental fee and 90% of the entrance fee must be allocated for rehabilitation, environmental protection, and enforcement programs.

Island-hopping is also present in Brgy. Tondol where tourists are brought to Tanduyong Island (the location for the ACIAR project team hut and storage of the frames for the larval culture pools, Harrison and dela Cruz, 2022) and Panakalan MPA for swimming and snorkelling. Alaminos LGU also allows Anda to take their guests to HINP provided they pay user fee and secure permit from MARINA. The tourist boat operators are aware of the value of MPAs and believe that the number of tourists will increase if protection is further enhanced. They, too, understand the prohibitions inside the protected area such as collection of, and anchoring on, corals.

No island-hopping activities exist in Bolinao but the white sand beach in Brgy. Patar provides the municipality with large revenue. The local government only charges Php40.00 (USD0.7) for environmental fee and most of the fund goes to staff salary and promotional activities. Bolinao is known for the giant clam nursery established with the assistance of UP MSI. It is in the meantime closed to tourists and strictly for research and tourism promotion. The potential of MPAs for ecotourism has been considered by the Municipal Tourism Office, but has not been pursued as most reef areas are in shallow waters and hence tourism activities may cause damage to corals and also potential for injuries to tourists.

4. Discussion

The prevalence of coral restoration projects in the Philippines and elsewhere is rapidly increasing, with diverse approaches and outcomes. Greater academic and policy attention is now turning to the institutional and social-economic dynamics of these projects – how to

effectively regulate them and how to increase their social-economic contributions. Among these dynamics, a key issue that coral restoration projects need to assess and address is their interactions with the major pre-existing coastal sectors that generate coastal livelihoods, and that pose both opportunities and challenges to coral restoration (Cruz-Trinidad et al., 2009). From this perspective, the effectiveness and longer-term sustainability of coral restoration is closely tied to the effectiveness of coral reef governance more generally.

In all sites in Pangasinan, aquaculture and capture fisheries pose the greatest threat to coral reefs and can potentially compromise existing and future efforts at coral restoration (Harrison et al. 2022). Both sectors are deeply embedded in local political dynamics which maintain and reproduce them, consequently rendering institutions impotent to pursue their mandates. The aquaculture sector, in particular, offers only limited benefits to local livelihoods, and has effectively evaded environmental regulation. While aquaculture seems to have a more clearly antagonistic relationship with coral restoration, this can potentially be addressed via zoning and better management of the environmental impacts. Capture fisheries are still the most important livelihood activity in the region, and these can also be supported through improved MPA management and provision of honoraria for Bantay Dagat, which can enable more effective implementation and enforcement of laws. However, in the absence of sustained structural improvements to the security of coastal livelihoods in the rural Philippines, socio-economic pressures deriving from high levels of vulnerability will continue to pose significant challenges to coral restoration and marine resource governance more broadly (Andriesse and Lee, 2021; Fabinyi et al., 2022). Specifically, without improved enforcement and improved livelihood opportunities, destructive fishing practices pose particular challenges to governability of coral reefs in general, including restored reefs. In the long term, however, coral restoration has the potential to improve fisheries productivity.

Tourism offers potential benefits to coral restoration, and coral restoration can itself potentially serve as a driver of tourism as coral assemblages recover and enhance amenity values (Harrison et al. 2021). Some stakeholders in the sector increasingly recognize the value of healthy coral reefs, though existing regulations for interacting with corals can still be improved as most of the areas utilized for different activities are in shallow waters. It likewise provides employment opportunities for fisherfolks and thus can potentially help reduce fishing pressure and likelihood of illegal fishing. However, there is a need to contextualise tourism with its potential negative impacts as seen elsewhere in coastal Southeast Asia, including pollution/sewage, increasing land values marginalising local fisherfolks with limited land tenure, rising costs of living associated with tourism prices, coastal development impacting existing reefs and external actors capturing the benefits (Fabinyi et al., 2022). There are also many coastal tourism activities, such as beach swimming, that do not have a particular synergy with coral restoration.

While all three sectors pose challenges and opportunities to coral restoration, they are unfolding in divergent ways in the different local government units. In Anda, aquaculture is poorly regulated, leading to greater incidences of fish kill; illegal fishing activities are not effectively controlled; and the ability of the local government to manage tourism activities is low. In contrast, in Alaminos City aquaculture is restricted to the production of fingerlings; illegal fishing in the Hundred Islands National Park is effectively controlled; and tourism is generating significant income. The ways in which aquaculture, capture fisheries and tourism

interact with coral restoration in specific sites, therefore, is highly dependent on government capacity as a crucial mediating factor. Taken together, the greater levels of government capacity in Alaminos City indicate a greater likelihood of long term sustainability of coral restoration projects.

In conclusion, the results presented in this paper demonstrate how each coastal sector under different governance contexts influences the outcome and potential success and sustainability of coral restoration. It shows that no one sector aligns perfectly with coral restoration in all contexts, and that such interactions with the central features of the natural and social system to be governed will significantly influence and shape the eventual governability of coral restoration projects. This highlights that the benefits of coral restoration and synergies with existing coastal sectors cannot be assumed, and that 'step zero' analyses that identify contexts of more or less governability would generate useful insights before interventions commence (Chuenpagdee and Jentoft 2007). For example, industrial aquaculture could co-exist with restored reefs if the aquaculture is governed such that it stays within appropriate boundaries and does not damage water quality. The interests of some tourism operators align with ensuring healthy coral reefs, while some tourism activities do not align with reef health, or may actively damage it. Future reef restoration initiatives need to understand the interactions and dynamics of these sectors in specific geographical contexts of variable government capacity, the different challenges posed by different methods of restoration, and to identify strategies to manage them for the interventions to work effectively and ultimately to generate sustainable socio-economic and environmental benefits.

Acknowledgements

This research was supported by the Australian Centre for International Agricultural Research projects, FIS 2021/112, 'Political economy and institutional effectiveness of coral reef restoration in the Philippines', and FIS2019/123, 'Regional coral restoration networks and appropriate technologies for larger-scale coral and fish habitat restoration in the Philippines and Australia'.

References

Abrina, T.A., Bennett, J., 2021. A benefit-cost comparison of varying scales and methods of coral reef restoration in the Philippines. Science of the Total Environment 799, 149325. https://doi.org/10.1016/j.scitotenv.2021.149325

Alcala, A.C., Russ, G.R., 2006. No-take marine reserves and reef fisheries management in the Philippines: A new people power revolution. Ambio 35, 245–254. https://doi.org/10.1579/05-A-054R1.1

Ancog, R.C., Corales, C.G., Balatayo, A.G.L., Nacorda, H.M.E., Canesio, P.D., Rabajante, J.F., Subade, R.F., 2019. Impact Assessment Bulletin No. 12 [Bulletin]. Department of Science and Technology - Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (PCAARRD).

Andriesse, E., Lee, Z., 2021. Resisting the coastal squeeze through village associations? Comparing environmental, organizational, and political challenges in Philippine seaweed-growing communities. J. Agrar. Chang. 21, 485–503. https://doi.org/10.1111/joac.12405

Anthony, K.R.N., Helmstedt, K.J., Bay, L.K., Fidelman, P., Hussey, K.E., Lundgren, P., Mead, D., McLeod, I.M., Mumby, P.J., Newlands, M., Schaffelke, B., Wilson, K.A., Hardisty, P.E., 2020. Interventions to help coral reefs under global change—A complex decision challenge. PLoS One 15, 1–14. https://doi.org/10.1371/journal.pone.0236399

Anticamara, J.A., Go, K.T.B., 2016. Spatio-temporal declines in philippine fisheries and its implications to coastal municipal fishers' catch and income. Front. Mar. Sci. 3, 1–10. https://doi.org/10.3389/fmars.2016.00021

Armitage, D., Johnson, D., 2006. Can Resilience be Reconciled with Globalization and the Increasingly Complex Conditions of Resource Degradation in Asian Coastal Regions? Ecol. Soc. 11, art2. https://doi.org/10.5751/ES-01485-110102

Balgos, M. (1995). Evaluation of Artificial Reef Development in the Philippines. In J.L. Munro & M.C. Balgos (Eds.), *Artificial Reefs in the Philippines* (6-22). Manila: ICLARM Conference Proceedings.

Bahinting, S. E., Mostrales, T. P., Principe, A., & Licuanan, W. (in press). Deployment of Artificial Habitats Alone Cannot Make up for the Degradation of Coral Reefs. *The Philippine Journal of Fisheries, 29*(2). Advance online publication. https://doi.org/10.31398/tpjf/29.2.2021-0030

Banaszak, A.T., Marhaver, K.L., Miller, M.W., Hartmann, A.C., Albright, R., Hagedorn, M., Harrison, P.L., Latijnhouwers, K.R.W., Mendoza Quiroz, S., Pizarro, V. and Chamberland, V.F. (2023), Applying coral breeding to reef restoration: best practices, knowledge gaps, and priority actions in a rapidly-evolving field. Restor Ecol e13913. https://doi.org/10.1111/rec.13913

Barclay, K., Fabinyi, M., Kinch, J., Foale, S., 2019. Governability of High-Value Fisheries in Low-Income Contexts: a Case Study of the Sea Cucumber Fishery in Papua New Guinea. Hum. Ecol. 47, 381–396. https://doi.org/10.1007/s10745-019-00078-8

Baria, M.V.B., Guest, J.R., Edwards, A.J., Aliño, P.M., Heyward, A.J., Gomez, E.D., 2010. Caging enhances post-settlement survival of juveniles of the scleractinian coral Acropora tenuis. J. Exp. Mar. Bio. Ecol. 394, 149–153. https://doi.org/10.1016/j.jembe.2010.08.003

BFAR, 2022. Fisheries Profile 2021. Bureau of Fisheries and Aquatic Resources.

Boström-Einarsson, L., Babcock, R. C., Bayraktarov, E., Ceccarelli, D., Cook, N., Ferse, S. C.,

Hancock, B., Harrison, P., et al. (2020). Coral restoration–A systematic review of current methods, successes, failures and future directions. *PloS one*, *15*(1), e0226631.

Cabaitan, P.C., Yap, H.T., Gomez, E.D., 2015. Performance of single versus mixed coral species for transplantation to restore degraded reefs. Restor. Ecol. 23, 349–356. https://doi.org/10.1111/rec.12205

Caynila, K., Luna, K., Milla, S., 2022. The Philippine tourism sector amid the pandemic: developments and prospects. Econ. Newsl.

Chuenpagdee, R., & Jentoft, S. (2007). Step zero for fisheries co-management: What precedes implementation. *Marine policy*, *31*(6), 657-668. https://doi.org/10.1016/j.marpol.2007.03.013

Chuenpagdee, R., Jentoft, S., 2009. Governability assessment for fisheries and coastal systems: A reality check. Hum. Ecol. 37, 109–120. https://doi.org/10.1007/s10745-008-9212-3

Cinner, J., 2014. Coral reef livelihoods. Curr. Opin. Environ. Sustain. 7, 65–71. https://doi.org/10.1016/j.cosust.2013.11.025

Conaco, C., Cabaitan, P.C., 2020. Influence of salinity and temperature on the survival and settlement of Heliopora coerulea larvae. Mar. Pollut. Bull. 150, 110703. https://doi.org/10.1016/j.marpolbul.2019.110703

Cook, B.R., Satizábal, P., Curnow, J., 2021. Humanising agricultural extension: A review. World Dev. 140, 105337. https://doi.org/10.1016/j.worlddev.2020.105337

Cruz-Trinidad, A., Geronimo, R.C., Aliño, P.M., 2009. Development trajectories and impacts on coral reef use in Lingayen Gulf, Philippines. Ocean Coast. Manag. 52, 173–180. https://doi.org/10.1016/j.ocecoaman.2008.12.002

Curry, G.N., Nake, S., Koczberski, G., Oswald, M., Rafflegeau, S., Lummani, J., Peter, E., Nailina, R., 2021. Disruptive innovation in agriculture: Socio-cultural factors in technology adoption in the developing world. J. Rural Stud. 88, 422–431. https://doi.org/10.1016/j.jrurstud.2021.07.022

DBM, 2021. Briefer on Executive Order No. 138, s. 2021. Department of Budget and Management.

De, K., Nanajkar, M., Mote, S., & Ingole, B. (2020). Coral damage by recreational diving activities in a Marine Protected Area of India: Unaccountability leading to 'tragedy of the not so commons'. *Marine Pollution Bulletin*, *155*, 111190.

dela Cruz, D.W., Harrison, P.L., 2017. Enhanced larval supply and recruitment can replenish reef corals on degraded reefs. Sci. Rep. 7, 13985. https://doi.org/10.1038/s41598-017-14546-y

dela Cruz, D.W., Harrison, P.L., 2020. Enhancing coral recruitment through assisted mass settlement of cultured coral larvae. PLoS One 15, e0242847. https://doi.org/10.1371/journal.pone.0242847

dela Cruz, D.W., Villanueva, R.D., Baria, M.V.B., 2014. Community-based, low-tech method of restoring a lost thicket of *Acropora* corals. ICES J. Mar. Sci. 71, 1866–1875. https://doi.org/10.1093/icesjms/fst228

Department of Environment and Natural Resources, Bureau of Fisheries and Aquatic Resources of the Department of Agriculture, and Department of Interior and Local Government. 2001. *Philippine Coastal M*anagement Guidebook No. 2: Legal and Jurisdictional Framework for Coastal Management. Coastal Resources Management Project of the Department of Environment and Natural Resources. Cebu City, Philippines, 170 p.

Douthwaite, B., Hoffecker, E., 2017. Towards a complexity-aware theory of change for participatory research programs working within agricultural innovation systems. Agric. Syst. 155, 88–102. https://doi.org/10.1016/j.agsy.2017.04.002

Edwards, A. J., & Gomez, E. D. (2007). Reef Restoration Concepts and Guidelines: Making Sensible Management Choices in the Face of Uncertainty. Coral Reef Targeted Research & Capacity Building for Management Programme: St. Lucia, Australia.

Fabinyi, M., 2012. Fishing for Fairness: Poverty, Morality and Marine Resource Regulation in the Philippines (Vol. 7). ANU Press. http://www.jstor.org/stable/j.ctt24h9fn

Fabinyi, M., Belton, B., Dressler, W.H., Knudsen, M., Adhuri, D.S., Abdul Aziz, A., Akber, M.A., et al., 2022. Coastal transitions: Small-scale fisheries, livelihoods, and maritime zone developments in Southeast Asia. J. Rural Stud. 91, 184–194. https://doi.org/10.1016/j.jrurstud.2022.02.006

Farmery, A.K., Allison, E.H., Andrew, N.L., Troell, M., Voyer, M., Campbell, B., Eriksson, H., et al., 2021. Blind spots in visions of a "blue economy" could undermine the ocean's contribution to eliminating hunger and malnutrition. One Earth 4, 28–38. https://doi.org/10.1016/j.oneear.2020.12.002

Feliciano, G. N. R., Mostrales, T. P. I., Acosta, A. K. M., Luzon, K., Bangsal, J. C. A., & Licuanan, W.Y. (2018). Is gardening corals of opportunity the appropriate response to reverse Philippine reef decline? *Restoration Ecology, 26,* 1091–1097. https://doi.org/10.1111/rec.12683

Ferrer, A. J. G., 2015. Assessing governability of small-scale fisheries in Taklong Island National Marine Reserve in the Philippines. Interactive governance for small-scale fisheries: Global reflections, 379-395.

Fidelman, P., McGrath, C., Newlands, M., Dobbs, K., Jago, B., Hussey, K., 2019. Regulatory implications of coral reef restoration and adaptation under a changing climate. Environ. Sci. Policy 100, 221–229. https://doi.org/10.1016/j.envsci.2019.04.016

Gibbs, M.T., Gibbs, B.L., Newlands, M., Ivey, J. 2021. Scaling up the global reef restoration activity: Avoiding ecological imperialism and ongoing colonialism. PLoS ONE 16(5): e0250870. https://doi.org/10.1371/journal.pone.0250870

Grady, M. P., 1998. Qualitative and action research: A practitioner handbook. Phi Delta Kappa Educational Foundation. Bloomington, Indiana.

Harrison, P.L. and dela Cruz, D. 2022. *Methods for restoring damaged reefs using coral larval restoration* [Technical Report]. Southern Cross University, 35 pages. https://doi.org/10.25918/report.233

Harrison, P.L., Villanueva, R. and dela Cruz, D. 2016. Coral Reef Restoration using Mass Coral Larval Reseeding. Final Report to Australian Centre for International Agricultural Research, Project SRA FIS/2011/031, June 2016, 60 pages. ISBN 978-1-925436-51-8.

Harrison, P.L., dela Cruz, D.W., Cameron, K.A., Cabaitan, P.C., 2021. Increased Coral Larval Supply Enhances Recruitment for Coral and Fish Habitat Restoration. Front. Mar. Sci. 8, 1–22. https://doi.org/10.3389/fmars.2021.750210

Harrison, P., Gomez, R.D., Cabaitan, P., McLeod, I., dela Cruz, D. 2020. Annual Report for Baseline monitoring and evaluation of long-term impacts on fish stocks from coral restoration. Australian Center for International Agricultural Research.

Harrison, P.L., dela Cruz, D.W., Cabaitan, P.C., Conaco, C.G., Baria-Rodriguez M.V., Ligson, C.A., Baquiran, J.P., et al. 2022. Regional coral restoration networks and appropriate technologies for larger-scale coral and fish habitat restoration in the Philippines and Australia. Report to Australian Centre for International Agricultural Research, 69 pages.

Hein, M.Y., Birtles, A., Willis, B.L., Gardiner, N., Beeden, R., Marshall, N.A., 2019. Coral restoration: Socio-ecological perspectives of benefits and limitations. Biol. Conserv. 229, 14–25. https://doi.org/10.1016/j.biocon.2018.11.014

Hein, M.Y., Willis, B.L., Beeden, R., Birtles, A., 2017. The need for broader ecological and socioeconomic tools to evaluate the effectiveness of coral restoration programs. Restor. Ecol. 25, 873–883. https://doi.org/10.1111/rec.12580

Hill, N.A.O., Rowcliffe, J.M., Koldewey, H.J., Milner-Gulland, E.J., 2012. The Interaction between Seaweed Farming as an Alternative Occupation and Fisher Numbers in the Central Philippines. Conserv. Biol. 26, 324–334. https://doi.org/10.1111/j.1523-1739.2011.01796.x

Hoegh-Guldberg, O., Kennedy, E. V., Beyer, H.L., McClennen, C., Possingham, H.P., 2018. Securing a Long-term Future for Coral Reefs. Trends Ecol. Evol. 33, 936–944. https://doi.org/10.1016/j.tree.2018.09.006

Horigue, V., Aliño, P.M., Pressey, R.L., 2014. Evaluating management performance of marine protected area networks in the Philippines. Ocean Coast. Manag. 95, 11–25. https://doi.org/10.1016/j.ocecoaman.2014.03.023

Hughes, T.P., Kerry, J.T., Baird, A.H., Connolly, S.R., Dietzel, A., Eakin, C.M., Heron, S.F., et al., 2018. Global warming transforms coral reef assemblages. Nature 556, 492–496. https://doi.org/10.1038/s41586-018-0041-2

Hughes, T. P., Baird, A. H., Morrison, T. H., & Torda, G. (2023). Principles for coral reef restoration in the anthropocene. *One Earth*. https://doi.org/10.1016/j.oneear.2023.04.008

Jentoft, S., Chuenpagdee, R., 2015. Interactive Governance for Small-Scale Fisheries, MARE Publication Series. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-319-17034-3

Kittinger, J.N., Bambico, T.M., Minton, D., Miller, A., Mejia, M., Kalei, N., Wong, B., Glazier, E.W., 2016. Restoring ecosystems, restoring community: socioeconomic and cultural dimensions of a community-based coral reef restoration project. Reg. Environ. Chang. 16, 301–313. https://doi.org/10.1007/s10113-013-0572-x

Local Government Unit of Alaminos City. ____. Comprehensive Land Use Plan 2017-2026.

Local Government Unit of Anda. ____. Comprehensive Land Use Plan 2013-2022.

Local Government Unit of Bolinao. ____. Comprehensive Land Use Plan.

McLeod IM, Hein MY, Babcock R, Bay L, Bourne DG, Cook N, et al. (2022) Coral restoration and adaptation in Australia: The first five years. PLoS ONE 17(11): e0273325. https://doi.org/10.1371/journal.pone.0273325

Monty J. A., Gilliam, D. S., Banks, K., Stout, D. K. & Dodge, R. E. (2006) Coral of opportunity survivorship and the use of coral nurseries in coral reef restoration. Proceedings of the 10th International Coral Reef Symposium, Okinawa, 28 June–2 July 2004. International Society of Reef Studies, Okinawa, Japan.

Moore, A. (2021). We've never seen anything like it: Witnessing coral death and resurrection. *HAU: Journal of Ethnographic Theory*, *11*(2), 461-474.

Morrison, T. H., Adger, N., Barnett, J., Brown, K., Possingham, H., & Hughes, T. (2020). Advancing coral reef governance into the Anthropocene. *One Earth*, *2*(1), 64-74. https://doi.org/10.1016/j.oneear.2019.12.014

Noble, H., Heale, R., 2019. Triangulation in research, with examples. Evid. Based Nurs. 22, 67–68. https://doi.org/10.1136/ebnurs-2019-103145

Omori, M. 2019 Coral restoration research and technical developments: what we have

learned so far, Marine Biology Research, 15:7, 377-409, DOI: 10.1080/17451000.2019.1662050

PSA, 2022. Poverty Incidence Among Population in the Ilocos Region Registered at 20.2 Percent in 1"t Semester 2021. Philippine Statistics Authority.

Pomeroy, R., Pido, M., Pontillas, J.F., Francisco, B., White, A., Ponce de Leon, E.M., Silvestre, G. 2008. Evaluation of policy options for the live reef food fish trade in the province of Palawan, Western Philippines. Mar. Policy 32, 55-65. https://doi.org/10.1016/j.marpol.2007.04.006

Pomeroy, R., Garces, L., Pido, M., Silvestre, G., 2010. Ecosystem-based fisheries management in small-scale tropical marine fisheries: Emerging models of governance arrangements in the Philippines. Mar. Policy 34, 298–308. https://doi.org/10.1016/j.marpol.2009.07.008

PSA, 2020. Farmers, Fisherfolks, Individuals Residing in Rural Areas and Children Posted the Highest Poverty Incidences Among the Basic Sectors in 2018, Philippine Statistics Authority.

Quimpo, T.J.R., Ligson, C.A., Manogan, D.P., Requilme, J.N.C., Albelda, R.L., Conaco, C., Cabaitan, P.C., 2020. Fish farm effluents alter reef benthic assemblages and reduce coral settlement. Mar. Pollut. Bull. 153, 111025. https://doi.org/10.1016/j.marpolbul.2020.111025

Rose, J., & Johnson, C. W. (2020). Contextualizing reliability and validity in qualitative research: Toward more rigorous and trustworthy qualitative social science in leisure research. *Journal of leisure research*, *51*(4), 432-451. https://doi.org/10.1080/00222216.2020.1722042

Russ, G.R., Miller, K.I., Rizzari, J.R. and Alcala, A.C. (2015). Long-term no-take marine reserve and benthic habitat effects on coral reef fishes. *Mar. Ecol. Prog. Ser*. 529: 233-24

Salayo, N.D., Perez, M.L., Garces, L.R., Pido, M.D., 2012. Mariculture development and livelihood diversification in the Philippines. Mar. Policy 36, 867–881. https://doi.org/10.1016/j.marpol.2011.12.003

Sugimoto, A., San Diego-McGlone, M.L., Paciencia, F., Milan, S.P., Tomas, E.T., Ramírez, C.C., Echavez, A, et al. Comanagement for aquaculture: Suggestions from a comparative study between two major production areas of milkfish in the Philippines. J. Appl. Aquac. 28, 298–313. https://doi.org/10.1080/10454438.2016.1209712

Vandenberg, J., Humphries, A., Garcia-Quijanoa, C., Moore, A., Pollnac, R., & Abdullah, S. (2021). Assessing indicators and limitations of food security objectives in coral reef restoration. *Conservation & Society*, *19*(1), 68-79.

van Oppen, M.J.H., Gates, R.D., Blackall, L.L., Cantin, N., Chakravarti, L.J., Chan, W.Y., Cormick, C., et al., 2017. Shifting paradigms in restoration of the world's coral reefs. Glob. Chang. Biol. 23, 3437–3448. https://doi.org/10.1111/gcb.13647

Vella K, Baresi U, Lockie S, Taylor B (2021) Challenges and opportunities for assisted regional ecosystem adaptation: International experience and implications for adaptation research. PLoS ONE 16(9): e0257868. https://doi.org/10.1371/journal.pone.0257868

Villanueva, R.D., Baria, M.V.B., dela Cruz, D.W., 2012. Growth and survivorship of juvenile corals outplanted to degraded reef areas in Bolinao-Anda Reef Complex, Philippines. Mar. Biol. Res. 8, 877–884. https://doi.org/10.1080/17451000.2012.682582

Villanueva, R.D., Yap, H.T., Montaño, M.N.E., 2005. Survivorship of coral juveniles in a fish farm environment. Mar. Pollut. Bull. 51, 580–589. https://doi.org/10.1016/j.marpolbul.2005.04.033

Westoby, R., Becken, S., Laria, A.P., 2020. Perspectives on the human dimensions of coral restoration. Reg. Environ. Chang. 20. https://doi.org/10.1007/s10113-020-01694-7

Walley, C. J., 2004. Rough Waters: Nature and Development in an East African Marine Park. Princeton University Press. http://www.jstor.org/stable/j.ctt7rgh6

Yap, H.T., Alvarez, R.M., Custodio, H.M., Dizon, R.M., 1998. Physiological and ecological aspects of coral transplantation. J. Exp. Mar. Bio. Ecol. 229, 69–84. https://doi.org/10.1016/S0022-0981(98)00041-0

Yap, H.T., Gomez, E.D., 1985. Growth of Acropora pulchra. Mar. Biol. 87, 203–209. https://doi.org/10.1007/bf00539430

Yin, R. K., 2016. Qualitative research from start to finish, second ed. Guilford, New York.

Yoshikai, M., Nakamura, T., Tanaka, Y., Nakaoka, M., Watanabe, A., Herrera, E.C., Tsuchiya, et al., 2021. Modeling seagrass bed dynamics under environmental impacts of intensive mariculture activities in Bolinao and Anda, the Philippines. Estuar. Coast. Shelf Sci. 250, 107152. https://doi.org/10.1016/j.ecss.2020.107152