Social and ecological impacts, challenges, and lessons learned from the sandfish sea ranching experience in Maliwaliw Island, Eastern Samar, Philippines

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Publication Information:
Received 17 October 2022, Accepted 8 March 2023, Available online 30 April 2023
DOI: 10.21463/jmic.2023.12.1.03

Abstract

Since the 1970s, Samar and Leyte islands had a thriving sea cucumber fishery but have rapidly declined over the years. In Maliwaliw Island, anecdotal accounts validated by the community revealed that the island had a brisk sea cucumber fishery but collapsed due to uncontrolled collection. In 2013, a sandfish sea ranching project was implemented in Maliwaliw Island, Salcedo, Eastern Samar, to bring back the sandfish that has disappeared from the area, and subsequently provide a supplemental livelihood to the local fishers. This study was conducted to investigate the impacts and lessons learned from the sandfish project. Recruitment of wild stock, increased community knowledge of sea cucumber biology and ecology, additional income through sandfish bycatch, and perceived enhancement of the coastal marine environment of the island were among the positive gains from the project identified by the respondents. On the other hand, poaching by fishers from neighboring communities resulting in inter-community conflicts was a major challenge. Clearly, the sandfish sea ranching project in Maliwaliw achieved ecological, social, and economic impacts on the project participants and the community. However, these gains need to be strengthened with effective management measures including size regulation to sustain the sea cucumber fishery in the area.

Keywords

sandfish sea ranching, impacts, challenges, lessons learned, Philippines

1. Introduction

Sea cucumbers are a commercially important marine resource that is harvested and processed to produce *trepang* or *beche-de-mer*. Traditionally, *trepang* is exported to several Asian markets, particularly China, Hong Kong Special Administrative Region, Singapore, the Republic of Korea, Taiwan, and Japan (Choo, 2008; Conand, 2018 Schoppe; 2000). The demand for *trepang* is driven by its consumption for its nutritional and medicinal value and as a social status symbol (Chen, 2003; Fabinyi, 2011; Fabinyi and Liu, 2014; Fabinyi et al., 2017). Sea cucumbers also play important ecological roles as they contribute to sediment health, nutrient recycling, water chemistry, biodiversity enhancement, and energy transfer in the food chains (Conand, 2018; Purcell et al., 2016). Sea cucumbers' role in improving sediment health is primarily due to their feeding and burying habits (Hair et al., 2016).

Globally, 69% of sea cucumber fisheries were reported as overexploited (Anderson et al., 2011). In the Pacific Islands, the shift in export volume from high-value and medium-value to low-value and medium-value species indicates a decline in commercially valuable species mainly due to overexploitation (Purcell, 2014). Similarly, in China, the price for many low and medium-value species increased also indicating increased demand or low supply of premium-grade *trepang* (Purcell et al., 2018). An increase in the current market prices of some species indicates that the demand for *trepang* remains high (Purcell et al., 2018) which is considered a major driver of extinction risk (Purcell et al., 2014).

Of the commercially valuable tropical sea cucumber species, *H. scabra* commonly called sandfish has the highest recorded price in 2016 at US$1800/kg for extra-large and premium quality in Hong Kong stores (Purcell et al., 2018). But in 2013, *H. scabra* was listed as Endangered in the International Union for Conservation of Nature (IUCN) Red List of threatened species (Conand et al., 2014). This implies that the sandfish is at high risk of extinction. At the same time, depletion of the resource will directly affect the livelihood of small-scale fishers particularly those from low-income communities.

1.1 The Philippines and Maliwaliw sea cucumber fishery

In many parts of the world, particularly in the Pacific region, the sea cucumber industry followed a boom-and-bust cycle (Hair et al., 2016; Uthicke, 2004). The sea cucumber fishery in the Philippines dates to the late eighteenth century (Choo, 2008). Based on FAO trade statistics, the country was the biggest exporter of dried sea cucumbers in 2006 (Anderson et al.,2011) exporting high-value species such as *Holothuria fuscogilva*, *H. scabra*, *H. whitmaei*, *Stichopus chloronotus*, *S. herrmanni*, *S. horrens*, and *Actinopyga spp* (Choo, 2008). Sea cucumbers are exploited by commercial fishers gathering only sea cucumbers, by gleaners in shallow waters, and by netters as bycatch (Choo, 2008; Jontila et al., 2018; Purcell et al., 2011). In Palawan, male fishers gather sea cucumbers in deeper water by skin diving (Jontila et al., 2018).

In the islands of Samar and Leyte, commercial exploitation started around the early 1970s, but the sea cucumber trade declined after decades of unregulated harvesting (Gajelan-Samson et al., 2011). Despite the absence of sea cucumber catch and trade records in Maliwaliw, accounts from local fishers indicate that the island once had a brisk sea cucumber fishery but collapsed due to uncontrolled gathering. From the 1970s until the early 1990s, gathering sea cucumbers was a thriving livelihood activity for subsistence fishers on the island (de la Cruz et al., 2022; Villamor et al., 2021) providing much-needed income for household needs. Local fishers claimed that the intertidal zone of the island was home to several species of sea cucumbers including "Kigo" (*H. scabra*), "Hanginan" (*Stichopus spp.*), "Puron" (*Actinophyga echinitis*), "Pulutan" (*Bohadschia spp.*), and "Kulaw-ot" (*Synapta sp.*). Commonly traded species then were the Kigo,

Puron, Pulutan, and Hanginan. Environmental cues such as the lunar phase and changes in tides guide the locals when gleaning for sea cucumbers. They claim that more sea cucumbers can be gathered seven days after the full moon and new moon and on low tides. Men, women, and children were involved in sea cucumber gleaning and some fishers dive to collect sea cucumbers in deeper waters. Collected sea cucumbers were either sold fresh or processed dry.

With the increasing demand for sea cucumbers, however, the number of gatherers both from within the community and from nearby communities also increased. Unrestricted collection (Villamor et al., 2021), and the lack of local government regulation on the sea cucumber trade aggravated the situation. The proliferation of traders buying sea cucumbers regardless of size drove fishers to collect indiscriminately. The confluence of these factors resulted in overfishing and eventually the collapse of the once-thriving sea cucumber fishery in Maliwaliw Island.

By the 2010s', the two islands recorded 60 species of shallow water holothurians, however, density was incredibly low for each species (de la Cruz et al., 2015). Local traders from the 2 islands reported buying 22 species of sea cucumbers from local gatherers of which, *Actinopyga lecanora*, *Bohadschia marmorata*, and *Holothuria albiventer*, and several species of *Stichopus spp.*, are the most common species (Gajelan-Samson et al., 2011). However, the recent collection of previously non-commercial species, spatial expansion of the gleaning area, a decline in the catch, and a decrease in the average size of sea cucumbers harvested (Gajelan-Samson et al., 2011) indicate serial exploitation of the resource (Anderson et al., 2011).

1.2 Bringing back the sandfish: the community-based sea ranching project in Maliwaliw Island

In the context of historical overexploitation, mariculture in general is seen as a strategy to restock depleted resources, and concomitantly provide benefits to coastal fishing communities in terms of food accessibility, and generating livelihoods (Salayo et al., 2012). For tropical sea cucumbers, mariculture activities such as sea pen farming, and sea ranching can be a profitable industry while enhancing wild populations (Purcell et al., 2012). Fortunately, the culture production systems for sandfish are already developed in many countries including the Philippines (Juinio-Meñez et al., 2017).

Sandfish brood stock weighing >200grams each are spawned in land-based hatcheries to produce first-stage juveniles (Juinio-Meñez et al., 2012a). After 35 days from settling, sandfish juveniles are moved to the nursery system (Mills et al., 2012) or the floating ocean nursery system in the case of the Philippines (Juinio-Meñez et al., 2012a). In Vietnam and Northern Australia, sandfish juveniles (>3g) are released in ponds with muddy sand, or coral-sand substrates (Duy, 2012; Bowman, 2012) until they reach commercial size. Sandfish juveniles are also released in sea ranch sites until harvest. Sea ranching employs a "put, grow, and take" strategy which requires exclusive rights to the ranch site (Purcell, 2012). This technique also supports the recovery of depleted natural stocks and provides a supplemental income source for the local fishers (Juinio-Meñez et al., 2012b). According to Juinio-Meñez et al. (2012b), establishing a communal sea ranch involves the following: (1) acquisition of exclusive communal-use rights for a 5-ha sea ranch, (2) increasing production and improving the quality of hatchery-produced juveniles, and (3) regular monitoring to determine growth and survival of sandfish in the sea-ranch site.

In 2013, the Guiuan Development Foundation, Inc. (GDFI) with funding support from the Australian Centre for International Agriculture Research (ACIAR) piloted a community-based sandfish ranching project entitled "Expansion and Diversification of Production and Management Systems for Sea Cucumbers in the Philippines, Vietnam, and Northern Australia" in Maliwaliw Island. Community collaboration with Maliwaliw Multipurpose Association (MMA), a decades-old

people's organization (PO) on the island, coupled with strong support from the Municipal Local Government Unit (MLGU), facilitated the smooth implementation of the project. Discussions with the local government officials of Barangay[1] Maliwaliw and MMA were held to gain their approval and support for the project. The project was then presented to the Salcedo Municipal Legislative Council (Sangguniang Bayan). The sea ranch was legally established after all concerned local officials signed the Memorandum of Agreement (MOA) in October 2013 (Villamor et al., 2021). The project aims to bring back the sea cucumbers by improving hatchery systems and performance and developing grow-out technologies for sandfish suitable for the participating communities (de la Cruz et al., 2022)

Years of involvement in various coastal resource management (CRM) projects was a primary consideration in choosing the community as a pilot site for the sandfish sea ranching in Eastern Samar. The community, particularly through the MMA, is a notable partner of GDFI in various government and non-government-supported projects on CRM. Among the projects were the establishment and management of Marine Protected Areas (MPA), and the Community-based Forest Management Agreement (CBFMA) for the protection and management of their vast mangrove area, seaweed farming, and mangrove crab ranching. It is thus worth mentioning that community rapport is very good, and the concept of the project was well accepted by the community. For the sandfish project, the primary motivation of the community was to bring their once-abundant sea cucumber resource into the area.

Early-stage juvenile rearing started around mid-2013. The project used hatchery-produced juveniles from the Guiuan Marine Fisheries and Development Center (GMFDC). However, the sea ranch setups and the hatchery in Guiuan were severely damaged when Super Typhoon (ST) Haiyan (local name: Yolanda) hit the region in November 2013, followed by Typhoon Hagupit (local name: Ruby) in 2014. Thus, successive releases of juvenile sandfish were done only in 2015 (Villamor et al., 2021). From October 2015 to October 2016, a total of 5864 hatchery-produced sandfish juveniles weighing ≥5g were released in the sea ranch in seven batches (Villamor et al., 2021).

This paper investigated the outcomes of the pilot sandfish sea ranch in Maliwaliw Island from its establishment in 2013 up to the present employing a qualitative analysis approach. Community insights, and social and environmental challenges met were elicited and discussed to draw together important lessons learned from the project. Possible fishery management measures in the local context that could help sustain the current gains of the project were also discussed. The potential of sea ranching as a supplemental livelihood in Maliwaliw and the preferred mode of operation were likewise discussed. Moreover, the findings presented in this paper draw from both semi-structured interviews and the combined insights, knowledge, and experience of the authors as implementers of the project since its inception.

2. Methodology

2.1 Description of the Sandfish Sea ranch

This study was conducted in Maliwaliw Island in Salcedo, Eastern Samar, located in the northeastern part of the Leyte Gulf. Endowed with rich coastal marine resources, the whole island is surrounded by over 100 ha of mangroves and vast seagrass beds. This makes the island an important breeding, spawning, and feeding ground for various marine species.

According to the 2020 Barangay Profile, Maliwaliw has 116 households distributed in three major settlement sites: Kabarasan, Barrio, and Baybay. However, four years after the onslaught of TS Haiyan, all the families in Sitio[2] Kabarasan, except for two, were relocated to the G2A- Salcedo Village (situated in the Barrio), a resettlement site established in 2017 by GDFI in partnership with Give2Asia. Almost all the households in the island rely on fishing for their livelihood.

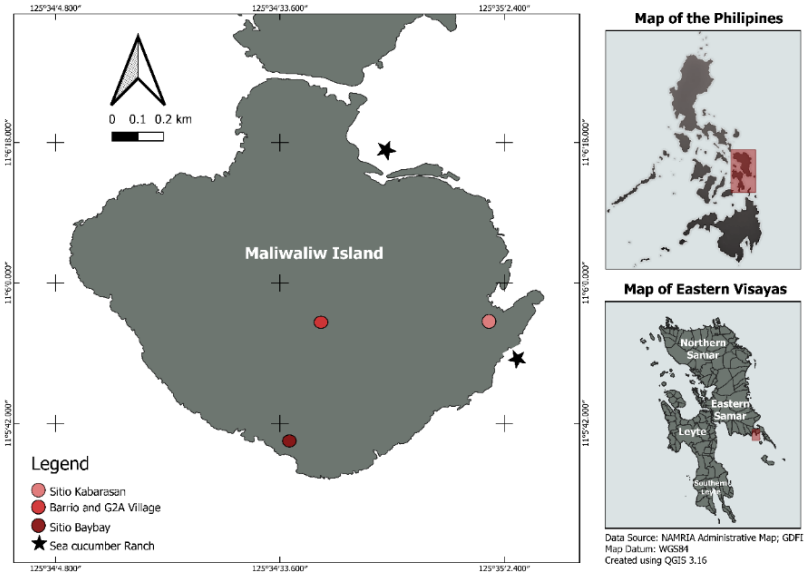

Fig 1. Map of Maliwaliw Island, Salcedo, Eastern Samar, Philippines.

2.2 Data Collection

A mixed qualitative methods approach was used to gather data in this study consisting of observations and informal conversations, participatory research method, and semi-structured interviews. These different methods were used to triangulate observations on community dynamics, experience and insights from the participatory action research, and key themes arising from semi-structured interviews thereby validating conclusions.

Participatory research approach. The implementation of the sea cucumber project was participatory in nature. The authors were engaged in the project implementation as researchers and community facilitators. All project activities conducted were participated by the community members. These include monitoring, pen construction and maintenance, hapa frame fabrication and installations, sediment sample collection, and other conservation activities (de la Cruz et al., 2022). In some activities such as the selection of sites for the ocean nursery and grow-out pens, the community members were consulted. During regular monitoring activities either in the sea ranch or in the ocean nursery, some community members assisted in weighing and counting sandfish. After processing the data gathered, the results were then shared with the community for validation. Their insights regarding the results were also solicited. During the whole project implementation, observations on the community dynamics in Maliwaliw Island, and informal conversations with the fishers during regular fieldwork and with fishers in nearby communities were noted and utilized in this study.

Semi-structured interviews. The qualitative survey questionnaire was designed by partners from the University of Technology Sydney (UTS) in Australia with inputs from different node leaders in Luzon — University of the Philippines-Marine Science Institute (UP-MSI), West Visayas — Southeast Asian Fisheries Development Center/Aquaculture Division (SEAFDEC/AQD), Eastern Visayas — GDFI, and Mindanao — Mindanao State University (MSU-Naawan). The interview primarily focuses on the background of the sea cucumber fishery, livelihood and income sources of the community, the implementation of the sandfish sea ranching, its impacts on the community, and the challenges met with the implementation of the project.

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A total of sixteen (16) semi-structured interviews were conducted in 2020 (August and September), and 2021 (March and July). Except for 2, all respondents are previously from Sitio Kabarasan who resettled at the G2A-Salcedo Village which is approximately 1 km away from the Sitio and the sea ranch site.

Interviewees were pre-selected based on their involvement in the project and key roles in the community. This was done to maximize the limited time that can be spent in the field due to the COVID-19 pandemic. For instance, one key informant was selected because of his age and length of experience in fishing which can better provide the historical context of the sea cucumber fishery on the island. Most of the informants had direct involvement in the project which is the best source of information in terms of their experience, project impacts, and other relevant insights. Other informants were selected because of their key involvement in the Barangay Local Government Unit (BLGU), and active involvement with the MMA to better capture the governance aspect of the project and the problems and conflicts experienced whether driven by internal or external factors. Interviews were stopped when no new information (i.e., reached saturation) was generated (Yin 2016). To avoid misinterpretations, the interviews were conducted in the local language, in this case, *Waray-Waray*. Since interviews were conducted during a pandemic, proper coordination with local officials was made before the entry into the community. During interviews, minimum health protocols were followed such as wearing of facemask and social distancing. The interviews were recorded with permission from the interviewees to ensure clarity of responses. The recordings were then transcribed and translated. Data from semi-structured interviews were then examined and analyzed for recurring key themes.

2.3 Ethics Statement

The study was conducted under the UTS Human Research Ethics Committee approval ETH19-4371. A printed copy of the participant's information and consent form was given to each respondent to read and their verbal consent to participate in the interview was also solicited. Before the interview, each participant was informed of the purpose of the research, the fund source, and the implementing organization of the study. They were also informed of their right to refrain from participating in the research if they are not willing to, or not to answer questions that they are not comfortable with. They were also assured of the confidentiality of the information that they will provide.

3. Results

3.1 Livelihood and income sources

All respondents identified fishing as their and the community's main source of livelihood. Important fishery products from the island include the blue swimming crab, reef fishes, siganids, mangrove crabs, squids, and small pelagics, among others. Freshly caught reef fishes and siganids are processed into dried fish locally called *bulad* and *boneless* and generally done by the women folk. Gleaning for seashells is also a common activity, particularly during lean months for household consumption. Gill nets, crab nets, and multiple handline (*kitang)* are the commonly used fishing gears. Some families own a fish corral. Wage labor comes in many forms such as honoraria received from serving in the barangay as Barangay Health Worker (BHW), Barangay Electrician, Barangay Secretary, Barangay Treasurer, Barangay Tanod, and Daycare Worker. A contractual job at the Local Government Unit of Salcedo is also a source of income for some. Land-based farming includes backyard gardening for vegetables and root crops. However, the produce from backyard gardens is mainly for household consumption and sharing with neighbors. Aquaculture activities are small-scale which include mangrove crab ranching, seaweed farming, and recently, the sandfish pen grow-out. Other livelihood source includes odd jobs such as carpentry, masonry, and other labor services. The Maliwaliw fishers do have diverse income sources, but

fishing remains the main source. Furthermore, local fishers do not focus only on a single species but are involved in multi-species fishery either to generate income or for their own household consumption.

Monthly household income is at its highest around late November to early March. During this period, the estimated average monthly income ranged from ₱3,000.00–15,000.00 (~USD 60–300) which can be attributed to the siganid season locally termed as *kathamul-od*. The siganids caught are deboned, dried, and delivered either to local buyers or directly to buyers in Manila. March to May is also anchovy season referred to locally as *katsarap* when fishers also enjoy good catch and income. During lean months (late May to early November), monthly household income is estimated to range from ₱1,000.00–10,000.00 (~USD 20–200). Local fishers attribute the lean season to the onset of the southwest monsoon or *Habagat*. Thus, monthly household income in Maliwaliw is primarily influenced by catch seasonality.

3.2 The pilot sea ranch in Eastern Visayas

At the start of the sandfish project, community members were directly involved in various activities such as the selection of suitable sea ranch sites, preparation of the hapa nets which are used in the rearing of post-settled juveniles (~1–3mm) in the floating ocean nursery system, and construction of grow-out pens (Figure 2). They were also involved in other activities such as guarding, monitoring, and maintenance of the whole sea ranch. The involvement of the community members in the project was basically voluntary. However, in some of these activities such as gathering wooden posts for the pens, setting up the pens, and guarding, community members involved were given some monetary allowances. Respondents also shared that they were actively engaged in monitoring activities of the growth and survival of released sandfish juveniles (Figure 3). Before ST Haiyan devastated their island, monitoring and guarding the sea ranch were relatively easy because of the proximity of their settlement, and accessibility to the ranch site. One respondent shared that guarding can be done while staying at their home. Women do the guarding mostly during the daytime whilst men do it during the nighttime. Women were not allowed to perform guarding duties during nighttime for safety concerns. Even so, some women still dared to guard the sea ranch at nighttime.

The Maliwaliw BLGU also supported the activities of the project most especially in the project monitoring and apprehensions of poachers in the sea ranch. During apprehensions, the sea ranch guards would seek help from the *barangay tanod* (village guards) and *bantay dagat* (sea warden) from the community.

Fig 2. Community members during the construction of grow-out pens.

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Fig 3. Community members helping in monitoring the juveniles in ocean nursery.

The MMA, being the partner organization in the community has always been at the forefront of the overall management of the sea ranch. While the researchers made decisions on the technical aspects involving the research operation, the MMA was the lead on the community aspect of the sea ranch operation. Assignment of guarding duties and division of labor were decided by the MMA members.

When asked about the governance model that can be tested in the community, many respondents answered the family-based approach. In the family-based approach, one family owns and manages a sandfish grow-out pen. One respondent shared that the family-based approach is better and much easier to manage. Another respondent shared that in the family-based, family beneficiaries would work hard because there would be a sense of ownership for them. Another also shared that with that approach, finger-pointing, which is common in a PO, will be avoided. Therefore, family-based sandfish farming is seen as a more viable livelihood approach compared to communal-sandfish ranching.

3.3 Sandfish sea ranching project impacts

3.3.1 Increase in wild populations

All household respondents claimed that the sea cucumbers in the area have increased. They linked the increase to the sandfish mariculture project implemented in the community. As claimed by one of the respondents, the seeding of sandfish juveniles increased the number of sandfish wild populations which, upon reaching sexual maturity, spawned to produce new individuals: *Due to the increasing numbers of sandfish, when they reach sexual maturity and spawn, their eggs easily get fertilized because they are aplenty and are near to each other.* Another respondent claimed that the guarding efforts by the community have reduced the fishing pressure on sandfish, giving them more chances to reproduce. A sea ranching study by Villamor et. al. (2021) showed that even after the last period of release, sandfish individuals <150g were found inside the sea ranch indicating recruitment to the population in the area. Recruitment of sandfish in many areas surrounding the island, including near the mangrove areas, had also been notably observed by the community. An increase in their numbers in the wild, as evidenced by the increase in the wild catch, was also observed. Table 1 shows that by 2020, community beneficiaries were collecting sandfish not only inside but also outside of the 5ha. sea ranch thereby validating the claims of wild recruitment and improving sandfish wild stock in the area. The

sandfish mariculture in Maliwaliw, therefore, has resulted in the recruitment and improvement of sandfish wild stock in the area (see Figure 4).

Fig 4. Sandfish collected from the coastal area of Maliwaliw Island, indicative of an increased sandfish abundance in the area.

Table 1. Data on the recovered/collected sandfish in Maliwaliw Island from 2016–2022.

Monitoring Period	No. of Individuals Collected	Weight (g) Range/Average	Collection Area	Remarks
2016				
February	2	80g/80g	Inside the 5ha. sea ranch	Experiment on sea ranching; data published in Villamor et al., 2021
April	24	80-370g/226g		
August	270	10-600g/219g		
2017				
January	66	50-460g/197g	Inside the 5ha. sea ranch	Experiment on sea ranching; data published in Villamor et al., 2021
May	388	15-750g/273g		
2018				
January	46	50-400g/165g	Inside the 5ha. sea ranch	Regular monitoring activity
April	27	37-271g/168g		
2020				
February	700	40-150g/74g	Inside and outside of the sea ranch but within areas surrounding Maliwaliw Island	Purchased by the project for stocking in the pen grow-out experiments in three expansion sites
2021				
April	1200	9-266g/92g	Inside and outside of the sea ranch but within areas surrounding Maliwaliw Island	Purchased by the project for stocking in the pen grow-out experiments in three expansion sites
August	100	53-155g/105g		
July	675	22-25g/24g		
2022				
March	600	11-200g/80g	Inside and outside of the sea ranch but within areas surrounding Maliwaliw Island	Purchased by the project for stocking in the pen grow-out experiments in three expansion sites

Moreover, stocking activities and protection of the sea ranch resulted in the recruitment of other sea cucumber species (Figure 5) such as *pulutan* (*Bohadschia marmorata*), *puron (Actinophyga echinitis), ulnitan (Holothuria fuscoscinaria). Seagrass growth was dense in areas where there were sandfish while less dense in regularly gleaned areas,* an observation shared by a key informant. Furthermore, appropriate boundary delineation of the 5-hectare sea ranch allowed the area respite from fishing, gleaning, and other anthropogenic disturbances. As claimed by one local fisherman, fishers entering the area were controlled because community members regulated the kind of fishing allowed in their area. For instance, fishers who use double nets cannot easily enter their area which allowed fish and other species to thrive. A respondent claimed that the sea ranch functioned as an MPA, where all species present were protected from poachers thereby enhancing coastal resources and biodiversity. However, this claim is not supported by empirical data.

Fig 5. Some of the commercially valuable sea cucumber species are believed to be recruited after the establishment of the sandfish sea ranch. These were collected during a nighttime sea ranch monitoring (Top Left: *Stichopus sp.*, Top Right: *Actinopyga sp.*; Bottom: various species of *Bohadschia*).

Some fishers from the community also reported catching large size sandfish weighing 1.5–1.8 kilograms in their crab nets. These were sold at around Php150–250 per individual:

> *"We can now earn from sandfish as bycatch. After years of sandfish ranching, our nets intended for catching blue swimming crabs were able to catch large sandfish usually weighing up to 1.8, 1.5 kilograms, and sometimes 1 kilogram. They were big. We did not expect this. Before we thought we cannot see them again, we were expecting to see them only in photos, but now they are already an added source of income."*

Despite having harvestable sandfish in the sea ranch, community members refrained from doing selective harvesting. Harvestable sandfish were allowed to spawn and reproduce more. It is thus worth noting that some fishers were able to earn income from sandfish but mainly due to sandfish bycatch in their fishing nets and supplying the stocks needed in the various project expansion sites.

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3.3.2 Increase in knowledge

Numerous activities and the direct involvement of the community in various sandfish mariculture activities provided added knowledge of sandfish biology and ecology among community members. One respondent shared that bigger sea cucumbers from shallow areas tend to migrate to deeper waters while small ones prefer near the mangrove area. Furthermore, locals learned the proper handling of collected sea cucumbers. As shared by a respondent, locals back then used to place sandfish inside a net and store them nearshore. They were unaware that their long-time practice causes lesions on the sandfish's body surface which then results in their death:

> *"Before, we just placed them inside a net and put them near the shore. We did not know that this practice creates scratches on their skin which results in their death. We thought that they will not die because they only feed on the sand. That is when we realized that it was wrong because once their skin is scratched, they can die."*

Another respondent shared a valuable lesson that there is a suitable number of individuals only that can be cultured in a grow-out pen and that adding more would cause overcrowding. Further, one respondent shared that once sandfish are closer to each other, fertilization gets easier. These accounts from local fishers, therefore, reflect an improved knowledge of sandfish biology and ecology, and of growing sandfish properly.

3.4 Key problems and challenges

3.4.1 Internal challenges and conflicts

Several problems and challenges were observed and experienced in the community (Table 2). For instance, guarding duties became difficult and challenging for most members because of the distance of their new settlement to the sea ranch area which is about 1 kilometer. One respondent shared that the distance of their new settlement coupled with health-related issues forced some members to end their participation in the project. Some became too occupied with improving their houses, and with fishing activities for their daily sustenance. Community participation was very much crucial at the start of the sandfish sea ranching project in Maliwaliw Island, but sea ranch operations and community dynamics were affected after the disaster brought by ST Haiyan.

Internal challenges in the PO were also identified by some respondents. For example, some MMA members were reported to be inactive even during organizational meetings. More serious internal conflicts within the organization were also reported by some respondents. One respondent shared about the poor leadership in the organization. Some felt that there was an unfair division of labor and opportunities which is why some members did not cooperate well. Another respondent who has been involved in guarding the ranch since the start shared that they were excluded when monetary incentives were already being provided to the guards. One respondent also shared that some MMA members did not perform their assigned tasks which sometimes results in poaching incidence on the ranch. Before ST Haiyan, families living in Sitio Kabarasan were assigned to do the regular guarding of the sea ranch. Whenever they need to apprehend a poacher, they would ask for extra help from the members living in the Barrio. In Sitio Kabarasan, families were divided into two religious' affiliations: the Roman Catholics and the Iglesia ni Cristo (INC). The INC members religiously attend their church service in Salcedo twice a week. During this time, the Roman Catholic families take over the guarding of the sea ranch. Despite the seeming internal conflicts in the MMA, the overall management of the sea ranch was not adversely affected because other members were actively participating and were able to develop adaptive strategies.

Table 2. Key challenges experienced by the community and their responses.

Key Challenges	Responses	Recommended Actions
Internal		
• Post-Haiyan resettlement and recovery made guarding duties difficult to perform.	• Ended participation in the project.	• Incentivize guarding duties. • Prioritize the involvement of those living near the sea ranch area and/or interested in doing guarding duties.
• Inactive members during organizational meetings	• Meeting with the PO to decide on their involvement in the project.	• For the PO to charge fines to those not attending organizational meetings/activities.
• Poor PO leadership in the form of unfair division of labor and opportunities	• Some PO members chose not to cooperate well. • Change of governance system from PO-based to family-based (i.e., for those who signified their interest to continue)	• Evaluate the PO's capacity to implement the project, particularly the PO leader. • Leadership training may be conducted as refresher course for the PO leaders.
• Some MMA members did not perform their assigned tasks thereby resulting in poaching incidence. • Conflict with other community members (i.e., sea ranch boundary markers were removed by some residents).	• PO meetings were conducted to resolve the issues.	• Penalties may be imposed; however, this should be taken with extra care as it may result in the PO membership's decline or possible conflict.
	• Presence of the project in the area was explained to the community by the MENRO during a community assembly.	• Continue coordinating with local officials, particularly in conducting education/information campaigns.
External		
• Poaching activities by fishers from neighboring communities.	• Poachers were apprehended but this sometimes result in further conflicts. • MLGU facilitated inter-barangay meetings and discussions to resolve the conflict. • Expansion of project site to other barangays.	• Extend education campaigns and project orientation to neighboring communities. • Collaborate with local officials from neighboring communities in seeking solutions to conflicts and apprehended poachers. • Legislate harvest control measures such as size regulations for sandfish and strictly enforce rules and regulations.
• Intense weather disturbances.	• Modified hapa frame and pen design.	• Select sea ranch sites that are not totally exposed to wave action (e.g., coves, lagoons).

Moreover, internal conflict with other community members due to the sea ranch operation was likewise mentioned. One respondent shared that the flaglets that they placed in the sea ranch boundaries were removed by some residents because it was blocking their boat's navigational lane. Another respondent shared that some old wooden posts inside the ranch that cannot be seen during high tide caused some boats to crash. Wooden poles used in grow-out pens were too short and may cause boat accidents. Therefore, the sea ranch operations caused minor internal conflict with some residents in the community.

3.4.2 External challenges and conflicts

Poaching activities reported to be committed by fishers from neighboring communities like Cantomoja and Cagaut were also a challenge, as identified by the community. When poachers are apprehended, this eventually resulted in confrontations which led to further inter-community conflict. There were several occasions when people from Maliwaliw received threats and intimidation from people in nearby communities who were previously apprehended. For instance, as told by a respondent, a fisherman from Maliwaliw was told not to fish near Cantomoja since they were also not allowed to fish in Maliwaliw. Another respondent shared that some fishers were also not allowed to dock, and others were prohibited from getting wooden poles for use in fishing. Conflicts with nearby communities were mostly mentioned as one of the negative impacts of their participation in sandfish mariculture. Moreover, the occurrence of inclement weather conditions like typhoons is also a challenge as typhoons threaten the potential economic returns from sandfish mariculture.

4. Discussion

The sandfish sea ranching project in Maliwaliw has brought about a positive ecological impact evidenced by the appearance of several species of sea cucumbers after only four years of project implementation. As claimed by local fishers, sandfish were recruited, and its wild stock has improved in the area. Interestingly, albeit culturing only a single species (*H. scabra*), recruitment of other commercially valuable species of sea cucumbers was also evident in the sea ranch. Recruited species were also reported by locals to have previously disappeared in the area. The no-take-no-fishing policy and protection of the ranch area reduced the anthropogenic disturbances and allowed the area to rest. This allowed the recruited larvae to attach to seagrasses and grow to adult size. But to validate this claim, there is a need for a thorough assessment of sandfish density (including other sea cucumber species) inside and outside of the sea ranch. This will provide an estimate of the sandfish biomass inside the ranch as a direct effect of the juvenile restocking activities and the possible spill-over effect outside as an indirect effect of the project. Recent studies in the Philippines (Villamor et al., 2021) and Papua New Guinea (Hair et al., 2022) revealed that sandfish sea ranching resulted in the recruitment of smaller sandfish and an increase in the abundance of other commercial sea cucumber species due to stocking, and protection of the sea ranch. However, how these positive ecological benefits in Maliwaliw can be transformed into an economic opportunity for the community is yet to be realized.

While communal sandfish sea ranching in Maliwaliw has helped rebuild depleted sea cucumber populations on the island, the sustainability of the current gains is uncertain if a proper local-level management system is not in place and enforced. Clearly, the brisk sea cucumber fishery in Maliwaliw in the past collapsed due to uncontrolled harvesting, and indiscriminate (no-size limit) collection can happen again. Unregulated harvesting is known to negatively affect diversity, and the population of commercially valuable sea cucumber species (Jontila et al., 2018). Although sea ranching is found to rebuild the depleted sea cucumber resource, it still must be coupled with local policies, and better enforcement to be truly effective. Thus, to avert resource depletion from recurring, better sea cucumber fishery management regulations, coupled with strict enforcement must be put in place.

4.1 Sustainability through effective fishery management measures

The currently implemented Municipal Fishery Ordinance (MFO) of Salcedo, Eastern Samar does not include regulatory provisions for sea cucumbers. For the sustainability of the resource, local policy, or ordinance on size limitation on sea cucumber harvesting, and trade must be put into law. Sandfish size larger than ~200g which is the average size at sexual maturity (Junio-Meñez et al., 2012b) can be the minimum size limit but the adult size of 300–400g which is the minimum accepted size among Chinese traders (Purcell et al., 2018) must be highly encouraged. This policy recommendation would be more beneficial rather than detrimental to the livelihoods of fishers as bigger sandfish fetch higher market prices (Juinio-Meñez et al., 2012b; Purcell et al., 2018) thus, providing better economic returns.

Local sea cucumber traders must also be encouraged to strictly implement minimum size limits when buying sea cucumbers from local fishers. In a study by Purcell (2014), small sea cucumber products have lesser prices than the animals harvested at the large adult sizes of the same species. This alone could encourage local traders to follow size limit regulations. Moreover, since most local fishers depend on their day-to-day income from fishing, the absence of a minimum size limit or the lack thereof on the traders' end, drives them to collect sea cucumbers regardless of size. Consequently, the implementation of minimum size limits by local traders as well as those in the export hubs would encourage local fishers to selectively collect or gather sea cucumbers.

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A local registry of sea cucumber traders should also be done to effectively monitor the sea cucumber trade in the local communities. It can also help ease the enforcement of minimum size limits for all species. Moreover, a regular trade recording from traders and trade data cumulation from the government's fishery bureau must be in place and, maintained to effectively monitor the status of the sea cucumber fishery. This would ensure a data-driven policy formulation on sea cucumber fishery management in the future.

4.2 Potential as a livelihood source

With the current outcomes of the project, can sandfish sea ranching be a potential livelihood source in Maliwaliw? Most fishers tend to live on a day-to-day basis thus, long-term mariculture, like sandfish sea ranching, can only be considered a supplementary income source. Supplemental livelihoods diversify income sources for families in coastal fishing communities. In island communities like Maliwaliw, where income from capture fishery is affected by monsoons, and seasonality of the marine resource among others, supplemental livelihoods are deemed necessary. Most families in Maliwaliw have diversified sources of livelihood. In capture fishing alone, fishers do not focus primarily on one target species. They tend to shift to another target species which allows them to adjust during the monsoon season or lean months of a certain species. As mentioned by Purcell et al. (2021), diversified access to marine resources can support coastal livelihoods and increases resilience among small-scale fishers. Fishers in Maliwaliw compare sandfish farming to a "piggy bank" which they can turn to in times of financial difficulties. This idea was inspired by their experiences in backyard hog raising which is common among rural communities. The low maintenance and low culture inputs make sandfish farming an attractive supplemental livelihood for coastal fishers. However, economic benefits cannot be fully quantified yet as production still has to reach the commercial level.

4.3 Social and ecological challenges

Poaching is one of the challenges identified by the respondents which is common in sandfish mariculture (Hair et al., 2020). Poaching has always been considered a factor affecting sandfish survival (Robinson and Pascal, 2012) and thus affecting potential economic returns (Juinio-Meñez et al., 2012b). The incidence of poaching in open-access areas is common in low-income communities with many poor subsistence fishers who are financially desperate (Juinio-Meñez et al., 2012b; Purcell et al., 2012). In Maliwaliw, poaching is reported to be mainly committed by gleaners from nearby communities. The presence of local buyers/traders from the same community may have driven gleaners to poach inside the sea ranch. Besides, their presence ensures that the gathered sea cucumbers from a night of gleaning can immediately be turned into cash. Moreover, local traders do not follow size regulation which contributes to the indiscriminate collection of sea cucumbers. During apprehensions, tensions rise between people from the two communities. This affected their inter-community relationship developing hostilities among fishers. Poachers assert their right to fish in the sea ranch because the area is a traditional fishing ground for siganid spear fishers and sea cucumber gatherers.

Community respondents were divided on whether the issue of poaching has already been addressed or not. For some respondents, the continued poaching incidence reported means that the issue has not yet been settled. While others believed that it was already addressed because the number of poachers had already declined. This decline is linked to the expansion of sandfish sea ranching in Cantomoja and the construction of a guard house which enabled them to guard the sea ranch in the evening. Some conflicts were settled peacefully through inter-community dialogues

participated by village officials, MMA representatives, and other stakeholders from the two communities. Although poaching is still happening, it is much less frequent now.

It is thus crucial that community-level education be extended to neighboring communities. Education campaigns and consultations must not be limited to the project site. This should also be extended to adjacent communities which share a common fishing ground. According to Purcell et al. (2012), community-level education can provide an understanding of the governance systems, and an appreciation of the shared benefits, and can even possibly minimize inter-community conflicts. Potential ecological benefits of sea ranching on their livelihoods such as egg supply from stocked adults (Juinio-Meñez et al. 2012b) and the whole fishery system must be thoroughly discussed during community orientations.

Mariculture operations of any type are vulnerable to climate challenges (Salayo et al., 2012). In the Philippines, the geographic location of Eastern Samar makes it one of the most frequently visited provinces by typhoons and other severe weather disturbances. This has put the future of mariculture at high risk. Like any other kind of mariculture activity, sandfish grow-out pens may be washed out by typhoons (Figure 6). In some instances, sea cucumbers were observed to be floating after a strong typhoon. Smaller sandfish were also observed to be affected by continuous heavy rains. For instance, small sandfish which preferred to inhabit near the mangrove were observed to die after a week of heavy rains. During these natural disturbances, not only sandfish survival is affected but also the sea ranching infrastructures such as guard houses (Figure 7), and pens. Without an insurance system in place, rebuilding the ranch infrastructures may be difficult for small-scale fishers.

Fig 6. Damaged sandfish grow-out pen after a typhoon hit the island.

Fig 7. Damaged guard house after a typhoon hits the island.

4.4 Conservation over income?

During the first five years of the sandfish sea ranching operation, MMA members refrained from doing selective harvesting despite released sandfish reaching the harvestable size. Since sea cucumber gathering is not their primary fishing activity, community members allowed sandfish to stay on the ranch so they can reproduce more. In communities with a deep understanding of natural resource conservation like Maliwaliw, potential economic returns from environment-friendly livelihood projects are sometimes set aside despite the time invested. For the community members in Maliwaliw, bringing back the sandfish to the island was more important than the immediate economic returns they could potentially get. They are more inclined toward the long-term benefits of the project which is the enhancement of their coastal resources rather than the short-term benefits. This is deeply rooted in their belief that conserving even one species or a specific area could bring a ripple of positive effects to their day-to-day livelihood and sustenance.

High appreciation for conservation measures for fishery management can be traced back to their years of involvement in CRM, and environment-friendly livelihood projects that GDFI introduced into their community. For instance, mangrove crab ranching was initiated in 2001 within the mangrove and seagrass areas of the island. This livelihood project primarily aims to restock the depleted wild population of mangrove crabs while at the same time gaining income from them. This may have increased their knowledge of the importance of restocking depleted wild populations for their livelihoods. Because of this prior knowledge, the importance of sandfish ranching as a tool to replenish their depleted sea cucumber stock was easily grasped by the community.

Moreover, MMA members have been managing and protecting two small MPAs for decades. The similarity of the concept of MPA and sea ranching was relatable for them as evidenced by the accounts from key informants. Hence, it was commonly used to describe how sandfish sea ranching works.

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4.5 Effectiveness of a PO-managed sea ranching project

Hair et al. (2020) stated that increased local leadership and cohesion is one of the requirements for a successful sandfish mariculture livelihood. Community organizations with numerous members coupled with poor local leadership could potentially hamper the success of sandfish mariculture livelihood. In community-based projects that involve an organization with numerous members, it is sometimes difficult to implement and realize the greater goal of the livelihood project being implemented. A PO with too many members, in some cases, would have a hard time assigning tasks, and responsibilities relative to the implementation of the project. More so with the distribution of benefits, and opportunities derived from the project. Moreover, selecting people who will perform mariculture activities like guarding duties that involve providing a monetary incentive is a critical aspect to consider since not all can be provided given the budgetary constraints of some projects. If such an arrangement is not well-planned, and well-discussed among members, this could lead to misunderstandings within the PO.

In Maliwaliw, the MMA has over 90 members within the community, and yet, not even half of them dedicatedly participate in the mariculture activities. Issues like selecting guards that favor a family member arose which also prompted some members to quit their involvement in the project. However, despite the few numbers of PO members that participated, socio-ecological impacts from the project were attributed to the active involvement of those who put dedication into the project. This defies the common notion that the strength of the PO is directly proportional to the number of its members. Hence, most respondents from the community favor the trial of family-based sandfish farming as it is seen to be a more viable approach although the success of the proposed governance model is yet to be proven. Further research on whether the proposed model should be treated as an addition to the community-based sea ranching activity or as a stand-alone governance approach (no sea ranching, purely grow-out pen managed by a family) needs to be conducted.

5. Conclusion

The release of sandfish in suitable and well-managed communal sandfish sea ranches has shown its potential to contribute to rebuilding depleted fishery stocks (Juinio-Meñez et al., 2012b). In Maliwaliw Island, sandfish sea ranching has achieved social and ecological impacts as based on the accounts of local fishers. The following are some lessons learned which may be useful for future sea cucumber ranching activities and its wider fishery management, particularly in the local context of Eastern Samar, Philippines:

1. Poaching and natural disturbances expose the vulnerabilities of sandfish sea ranching mariculture. To effectively combat poaching incidence, intensified guarding of the sea ranch must be routinely done. Although routine guarding may not fully combat poaching, this can at least reduce the incidence. With the more frequent occurrence of severe weather conditions, safer locations like lagoons and coves should also be considered in selecting future sea ranch sites.
2. Community-level education must extend to neighboring communities. In doing so, however, the discussion should be simplified, and technical terms should be avoided as much as possible to allow community stakeholders to easily understand how sandfish sea ranching works and the potential benefits to them even if they are not directly involved.
3. Community partners with prior knowledge and understanding of natural resource management are advantageous in developing a successful communal sandfish ranching. Knowledge and understanding of the vital importance of natural resource conservation to their livelihood encourage fishers to actively participate despite the uncertain

economic returns. In communities with little-to-no experience in environment-friendly livelihoods, a series of education campaigns must be conducted. Experiential learning through site visits can contribute to a better appreciation of sandfish sea ranching.

4. Community-based organization with numerous members does not always equate to better project management. Thus, the criteria in selecting future mariculture sites should not solely be based on the presence of a PO in the area. The composition, history of its foundation, and prior engagements and performance on previously implemented community-based projects should also be considered.

Clearly, the sandfish sea ranching project in Maliwaliw achieved socio-ecological impacts on the project participants and the community. A detailed resource assessment and sea cucumber inventory in the area is however recommended to fully document the positive ecological impact of the project. Bottlenecks such as the incidence of poaching, unregulated fishing (no-size limit), and natural disturbances may hamper the sustainability of the project gains. Thus, sea ranching and restocking efforts must be coupled with local policies, regulations, and serious implementations to ensure effective sea cucumber fishery management. These include size regulation, and regular monitoring of traders to sustain the sea cucumber fishery.

Acknowledgements

This work was supported by the Australian Center for International Agricultural Research FIS/2010/042 and [FIS/2016/122]. Sincere thanks to the collaborators from the University of Technology Sydney (UTS), Dr. Michael Fabinyi, and Dr. Nicholas McClean for developing the survey material. Our profound gratitude and appreciation to Dr. Fabinyi for his comments and suggestions that greatly improved this paper. We are also most grateful to the Bureau of Fisheries and Aquatic Resources 8 (BFAR-GMFDC) for their valuable support to the project and to the research participants from Maliwaliw Island for sharing their thoughts, experiences, and candid responses on the sea ranching project.

Endnotes

1. Barangay is the smallest political unit in the Philippines.

2. Sitio is a distinct clustering of households in a defined area within the barangay.

References

Anderson, S.C., Flemming, J.M., Watson, R., Lotze, H.K., 2011. Serial exploitation of global sea cucumber fisheries. Fish and Fisheries. https://doi.org/10.1111/j.1467-2979.2010.00397.x. 12: 317–339.

Bowman, W.M., 2012. Sandfish production and development of sea ranching in northern Australia, in: Hair, C.A., Pickering, T.D., Mills, D.J. (Eds.), Asia-Pacific tropical sea cucumber aquaculture, Proceedings of an international symposium held in Noumea, New Caledonia, 15–17 February 2011, ACIAR Proceedings No. 136, Australian Centre for International Agricultural Research: Canberra, pp. 75–78.

Conand, C., Polidoro, B., Mercier, A., Gamboa, R., Hamel, J.F., Purcell, S.W., 2014. The IUCN Red List assessment of aspidochirotid sea cucumbers and its implications. SPC Beche-de-mer Information Bulletin. 34: 3–7.

Conand, C., 2018. Tropical sea cucumber fisheries: Changes during the last decade. Marine Pollution Bulletin. https://doi.org/10.1016/j.marpolbul.2018.05.014. 133: 590–594.

Chen, J., 2003. Overview of sea cucumber farming and sea ranching practices in China. SPC Beche-de-mer Information Bulletin. 18: 18–23.

Choo, P.S., 2008. The Philippines: a hotspot of sea cucumber fisheries in Asia, in: Toral-Granda, V., Lovatelli, A., Vasconcellos, M. (Eds.), Sea cucumbers. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. No. 516. FAO, Rome, pp. 119–140.

de la Cruz, M.T, Cabansag, J.B., Gajelan-Samson, M.B.P., Diaz, F.A., Diococo, R.J., 2015. Diversity and abundance of shallow-water sea cucumbers in Samar and Leyte, Philippines. Asian Journal of Biodiversity 6(1).

de la Cruz, M.T., Villamor, J.L., Diodoco, R.J.P, Gacura, J.R.L. 2022. Participatory research and bringing back the sandfish in Maliwaliw Island, Eastern Samar, in: McClean N., Fabinyi M. (Eds.), Community-based sandfish sea ranching in the Philippines: Exploring social factors influencing success. ACIAR Technical Report Number 97. Australian Centre for International Agricultural Research, Canberra, pp. 72–82.

Duy N.D.Q. 2012. Large-scale sandfish production from pond culture in Vietnam, in: Hair, C.A., Pickering, T.D., Mills, D.J. (Eds.), Asia-Pacific tropical sea cucumber aquaculture, Proceedings of an international symposium held in Noumea, New Caledonia, 15–17 February 2011. ACIAR Proceedings No. 136. Australian Centre for International Agricultural Research: Canberra, pp. 34–39.

Fabinyi, M., 2011. Historical, cultural, and social perspectives on luxury seafood consumption in China. Environmental Conservation. https://doi.org/10.1017/S0376892911000609. 39.1: 3–92.

Fabinyi, M., Liu, N., 2014. Seafood banquets in Beijing: Consumer perspectives and implications for environmental sustainability. Conservation and Society. https://10.4103/0972-4923.138423. 12.2: 218–228.

Fabinyi, M., Barclay, K., Eriksson, H., 2017. Chinese trader perceptions on sourcing and consumption of endangered seafood. Frontiers in Marine Science. https://10.3389/fmars.2017.00181. 4.181: 1–12.

Gajelan-Samson, M.B.P., de la Cruz, M.T., Cabansag, J.B.P., Diaz, F.A., Diodoco, R.J.P., 2011. The sea cucumber fishery of Samar and Leyte, Philippines. Philippine Journal of Social Sciences and Humanities. 16.2: 35–48.

Hair, C., Foale, S., Kinch, J., Yaman, L., Southgate, P.C., 2016. Beyond boom, bust and ban: The sandfish (*Holothuria scabra*) fishery in the Tigak Islands, Papua New Guinea. Regional Studies in Marine Science. https://doi.org./10.1016/j.rsma.2016.02.001. 5: 69–79.

Hair, C., Foale, S., Daniels, N., Minimulu, P., Aini, J., Southgate, P.C., 2020. Social and economic challenges to community-based sea cucumber mariculture in New Ireland Province, Papua New Guinea. Marine Policy. https://doi.org/10.1016/j.marpol.2020.103940. 117: 1–11.

Hair, C., Militz, T.A., Daniels, N., Southgate P.C., 2022. Performance of a trial sea ranch for the commercial sea cucumber Holothuria scabra, in Papua New Guinea. Aquaculture. https://doi.org/10.1016/j.aquaculture.2021.737500. 547: 1–11.

Jontila, J.B.S., Monteclaro, H.M., Quinitio, G.F., Santander-de-Leon, S.M., Altamirano, J.P., 2018. Status of sea cucumber fishery and populations across sites with different levels of management in Palawan, Philippines. Ocean and Coastal Management. https://doi.org/10.1016/j.ocecoaman.2018.08.025. 165: 225–234.

Juinio-Meñez, M.A., Tech, E.D., Ticao, I.P., Gorospe, J.C., Edullantes, C.M.A., Rioja, R.A.V., 2017. Adaptive and integrated culture production systems for the tropical sea cucumber *Holothuria scabra*. Fisheries Research. https://doi.org/10.1016/j.fishres.2016.07.017. 186: 502–513.

Juinio-Meñez, M.A., de Peralta, G.M., Dumalan, R.J.P., Edullantes, C.M.A., Catbagan, T.O., 2012a. Ocean nursery systems for scaling up juvenile sandfish (*Holothuria scabra*) production: ensuring opportunities for small fishers, in: Hair, C.A., Pickering, T.D., Mills, D.J. (Eds.), Asia-Pacific tropical sea cucumber aquaculture. Proceedings of an international symposium held in Noumea, New Caledonia, 15–17 February 2011. ACIAR Proceedings No. 136. Australian Centre for International Agricultural Research: Canberra, pp. 57–62.

Juinio-Meñez, M.A., Paña, M.A.S., de Peralta, G.M., Catbagan, T.O., Olavides, R.D.D., Edullantes, C.M.A., Rodriguez, B.D.D., 2012b. Establishment and management of communal sandfish (*Holothuria scabra*) sea ranching in the Philippines, in: Hair, C.A., Pickering, T.D., Mills, D.J. (Eds.), Asia-Pacific tropical sea cucumber aquaculture. Proceedings of an international symposium held in Noumea, New Caledonia, 15–17 February 2011. ACIAR Proceedings No. 136. Australian Centre for International Agricultural Research: Canberra, pp. 121–127.

Mills, D.J., Duy, N.D.Q., Juinio-Meñez, M.A., Raison, C.M., Zarate, J.M., 2012. Overview of the sea cucumber aquaculture and sea-ranching research in the South-East Asian region, in: Hair, C.A., Pickering, T.D., Mills, D.J. (Eds.), Asia-Pacific tropical sea cucumber aquaculture. Proceedings of an international symposium held in Noumea, New Caledonia, 15–17 February 2011. ACIAR Proceedings No. 136. Australian Centre for International Agricultural Research: Canberra, pp. 22–31.

Purcell, S.W., Mercier, A., Conand, C., Hamel, J.F., Toral-Granda, M.V., Lovatelli, A., Uthicke, S., 2011. Sea cucumber fisheries: global analysis of stocks, management measures, and drivers of overfishing. Fish and Fisheries. https://doi.org/10.1111/j.1467-2979.2011.00443.x. 1–26.

Purcell, S.W., 2012. Principles and science of stocking marine areas with sea cucumbers, in: Hair, C.A., Pickering, T.D., Mills, D.J. (Eds.), Asia-Pacific tropical sea cucumber aquaculture. Proceedings of an international symposium held in Noumea, New Caledonia, 15–17 February 2011. ACIAR Proceedings No. 136. Australian Centre for International Agricultural Research: Canberra, pp. 92–103.

Purcell, S.W., Hair, C.A., Mills, D.J., 2012. Sea cucumber culture, farming, and sea ranching in the tropics: Progress, problems, and opportunities. Aquaculture. https://doi.org/10.1016/j.aquaculture.2012.08.053. 368–369: 68–81.

Purcell, S.W., 2014. Value, market preferences, and trade of beche-de-mer from Pacific Island Sea cucumbers. PLos ONE. https://10.1371/journal.pone.0095075. 9: 4. e95075.

Purcell, S.W., Polidoro, B.A., Hamel, J.F., Gamboa, R.U., Mercier, A., 2014. The cost of being valuable: predictors of extinction risk in marine invertebrates exploited as luxury seafood. Proceedings of the Royal Society B. https://doi.org/10.1098/rspb.2013.3296. 281: 20133296.

Purcell, S.W., Williamson, D.H., Ngalaufe, P., 2018. Chinese market prices of beche-de-mer: implications for fisheries and aquaculture. Marine Policy. https://doi.org/10.1016/j.marpol.2018.02.005. 91: 58–65.

Purcell, S. W., Tagliafico, A., Cullis, B.R., Gogel, B.J., 2021. Socioeconomic impacts of resource diversification from small-scale fishery development. Ecology and Society. https://doi.org/10.5751/ES-12183-260114. 26.1:14.

Robinson, G., Pascal, B., 2012. Sea cucumber farming experiences in south-western Madagascar, in: Hair, C.A., Pickering, T.D., Mills, D.J. (Eds.), Asia-Pacific tropical sea cucumber aquaculture. Proceedings of an international symposium held in Noumea, New Caledonia, 15–17 February 2011. ACIAR Proceedings No. 136. Australian Centre for International Agricultural Research: Canberra, pp. 142–155.

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

Schoppe S. 2000. Sea cucumber fishery in the Philippines. SPC Beche-de-mer Information Bulletin. 13: 10–12.

Uthicke, S., 2004. Overfishing of sea cucumbers: lessons from the Great Barrier Reef, in: A. Lovatelli, A., Conand, Purcell, S., Uthicke, S., Hamel, J.F., Mercier, A. (Eds.), Advances in Sea Cucumber Aquaculture and Management (eds), FAO Fisheries Technical Paper No. 463, FAO, Rome, pp. 163–171.

Villamor, J.L., de la Torre-de la Cruz, M., Diodoco, R.J.P., 2021. Spatial distribution patterns of sandfish juveniles released in a sea ranch area in Maliwaliw Island, Philippines. Aquaculture Research. https://doi.org/10.1111/are.15475. 52: 6132–6142.

Yin, R. K. 2016. Qualitative research from start to finish (2nd ed.). New York: Guilford.