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Impact of the COVID-19 Pandemic on the Management of Coral Aquaculture

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Abstract. This research aims to determine the impact of the COVID-19 pandemic on coral aquaculture businesses and management strategies in dealing with the pandemic. This research was a quantitative descriptive research. This research used the triangulation method (questionnaire, interview, and observation). This research was conducted at three coral aquaculture companies and a cultured coral transplantation site owned by a private company in Bali. The results showed that the COVID-19 pandemic had a more favorable impact on the coral aquaculture industry, such as the ability to become a source of income for the locals during the pandemic. The difficulties in conducting export activities and restricted mobility were some of the challenges encountered by coral aquaculture businesses during the pandemic. Additionally, the results showed that in order for coral aquaculture businesses to survive the pandemic, management strategies and adaptations are needed.

***Keywords*:** Coral Aquaculture; COVID-19 Pandemic; Impact; Management

I. INTRODUCTION

Coral reefs are one of the marine ecosystems in Indonesia with abundant biodiversity. Approximately 71% of the world's coral genus can be found in Indonesia [1]. The reason for the abundance of biodiversity in Indonesian coral reefs is that Indonesia is a part of the Coral Triangle [2]. Coral reefs have a variety of functions, such as protecting against coastal abrasion and being used by humans as underwater tourism objects [3].

Corals are sold as living ornaments in the aquarium trade. Initially, dead corals dominated the global coral trade. However, the trend in the market has gradually shifted towards live coral [4]. Live corals at the time were wild-caught, thus raising concerns regarding the disappearance of corals in the wild due to over-exploitation.

To meet the demand for live coral in the global coral trade, aquaculture has become an alternative source of live coral. Aquaculture can solve the problem of over-exploitation of wild animals that live in coral reef ecosystems and reduce the damage caused by capture fisheries without eliminating fishermen's source of income [5]. Since the late 1980s, Indonesia has become the largest ornamental coral exporter in the world.

Indonesia has consistently been a significant source of illegal corals over the last two decades [6]. The Fish Quarantine, Quality Control, and Fishery Product Safety Agency of Indonesia (or BKIPM) stopped issuing health certificates for corals and sea anemones in 2018[7]. The policy effectively halted all coral trade and coral aquaculture activities in Indonesia from 2018 to 2019[8, 9]. The Ministry of Marine Affairs and Fisheries of Indonesia resumed the coral trade in 2020 by re-issuing health certificates for corals and sea anemones [10].

A few months after KKP resumed the coral trade, the Indonesian government announced its first SARS-CoV-2 infection case [11]. In an attempt to reduce the spread of SARS-CoV-2 infections, the Indonesian government decided to implement several policies, such as the Large-Scale Social Restrictions (or PSBB) and Community Activities Restrictions Enforcement (or PPKM), from 2020 to 2021[12, 13]. Various industries and sectors in Indonesia have been directly and indirectly affected by the COVID-19 pandemic.

The COVID-19 pandemic has shown a variety of impacts on the marine and fisheries sector in Indonesia. The impact of the COVID-19 pandemic on the seaweed aquaculture industry in Bali was proven to be positive, as many workers in the tourism sector became seaweed

farmers to survive [14]. The impact of the COVID-19 pandemic on the capture fisheries industry in Bali was proven to be negative, as traditional fishermen have suffered losses due to the pandemic [15]. Coral aquaculture has been proposed as one of the solutions for people living in coastal areas to face the economic problems caused by the COVID-19 pandemic as ornamental coral exports continue [16].

Coral aquaculture was considered a potential industry during the COVID-19 pandemic. However, research on the relationship between the coral aquaculture industry in Indonesia and the COVID-19 pandemic is scarce. The purpose of this research is to determine the impact of the COVID-19 pandemic on coral aquaculture businesses and their management strategies in dealing with the pandemic. This research is relevant as it may act as a historical reference for stakeholders, investors, and governments if similar situations arise in the future.

II. METHODS

A. Research sites

This research was conducted in Bali. Field observations were conducted at coral aquaculture companies in Denpasar, Badung, and Buleleng and a cultured coral transplantation site in Jembrana (Figure 1).

Fig. 1. Research Locations

B. Data collection and analysis methods

This research used the triangulation method, which consists of a questionnaire section, an interview section, and a field observation section. The triangulation method helps to verify research findings using a variety of methods and theories [17].

This research used the purposive sampling method due to the specified nature of the research subjects. The questionnaire section was conducted with nine companies that were members of a local coral farmers group in Bali. However, only four companies were willing to fill out the questionnaire. Each company was represented by one voluntary respondent with a particular position within the company, such as owner or manager, to avoid confusion. The questionnaire section was carried out online via Google Forms. The types of questions on the questionnaire were the short answer, linear Likert scale, multiple choices, and checkboxes. The linear Likert scale questions used the format of negative to positive (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).

The interview section was conducted with four coral farmer informants, three of them were from the companies that filled out the questionnaire. All coral farmers represent four different regencies in Bali. In addition, the interview section was conducted with informants from Denpasar Coastal and Marine Resources Management Center (or BPSPL Denpasar). All collected data were analyzed descriptively.

III. RESULTS AND DISCUSSION

A. Coral trade during the pandemic

The questionnaire result showed a strong dependency on the international market (Figure 2). All informants stated that the domestic market had a minor contribution to the coral trade industry in Indonesia. One of the coral farmer informants stated that the strong dependence on the international market might happen since the purchasing power of local customers is not as substantial as international customers.

Strong dependence on the international market can threaten specific industries during the pandemic, as described by Plagányi et al on the tropical rock lobster fishery [18]. Although coral exports continued during the pandemic, exporting corals was challenging, as shown by the questionnaire results (Figure 3). The interview result matched the questionnaire result. One of the coral farmer informants added that coral export completely stopped during the first few months after the announcement of the COVID-19 pandemic in 2020. However, it gradually recovered. The identified challenges regarding coral exporting include the high cargo price, high shipment fee, limited cargo acceptance for non-priority goods, and border closures.

All coral farmer informants revealed that the demand for corals was high during the pandemic. Ornamental corals (Scleractinian and Alcyonacean corals) rank among the most exported live fishery commodities during the COVID-19 pandemic [19]. A similar result was reported by Rubini et al [20], which hypothesized that the high purchasing intention for coral is due to the consumers' focus on hobbies to cope with the COVID-19 pandemic. *Acropora, Euphyllia,* and Alcyonacean octocorals, such as *Sarcophyton*, were among the most popular corals during the pandemic.

Based on the interview results, the majority of buyers came from the United States of America and European Union countries. The decline in coral exports occurred for buyers from countries that closed their borders during the COVID-19 pandemic, such as Japan. The types of buyers are hobbyists and importers.

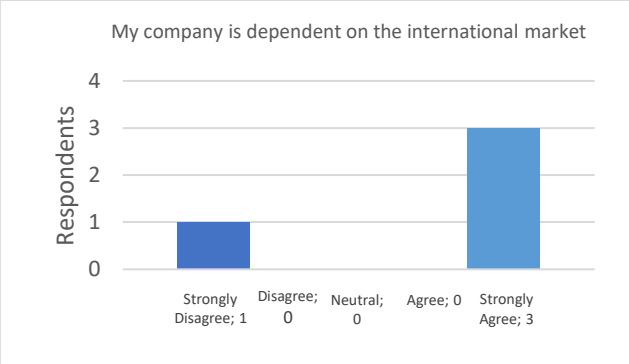

Fig. 2. Dependence on the international market

Revenue growth has been reported by all coral aquaculture companies during the COVID-19 pandemic (Table 1). The coral farmer informant from a coral aquaculture company in Denpasar stated that there was revenue growth, albeit it was not significant. The range of companies' clean surplus during the pandemic reported by the coral farmer informants was IDR 200.000.000 to IDR 350.000.000.

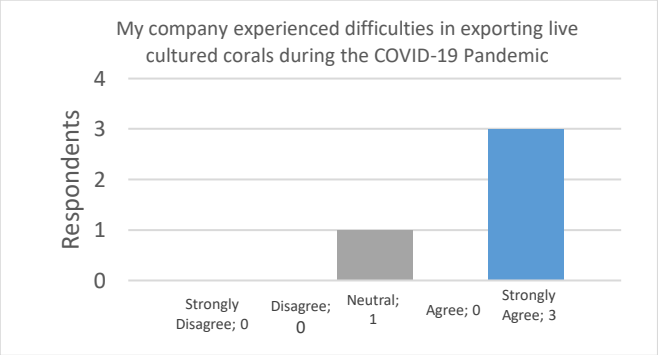

Fig. 3. Difficulty in exporting live cultured corals during the pandemic

B. Coral production during the pandemic

The observed coral aquaculture systems were in-situ (transplantation) and ex-situ (recirculation). The in-situ system was present in all sample coral aquaculture companies. The transplantation system is the most commonly used coral aquaculture system in Indonesia [21]. The ex-situ system was present in Denpasar, Badung, and Buleleng sample coral aquaculture companies, albeit all were still under development or in small-scale production. The ex-situ system is relatively new in Indonesia [22].

The questionnaire result showed a tendency towards increased coral production during the pandemic (Figure 4). The interview result matched the questionnaire and field observation results. The majority of coral farmer informants stated that the corals at their coral transplantation sites showed healthier and more colorful results compared to pre-pandemic. Additionally, one of the coral farmer informants reported there was minor or no presence of coral bleaching at their coral transplantation sites during the pandemic. Restricted human activities in coastal areas due to the COVID-19 pandemic may be the reason for the tendency to improve coral growth in nature, as described by Siahaya and Basir [23]. Coral transplantation sites near construction areas such as Gilimanuk Beach, however, showed sub-optimal coral growth, and the presence of coral pests infestation, such as *Convolutriloba retrogemma*.

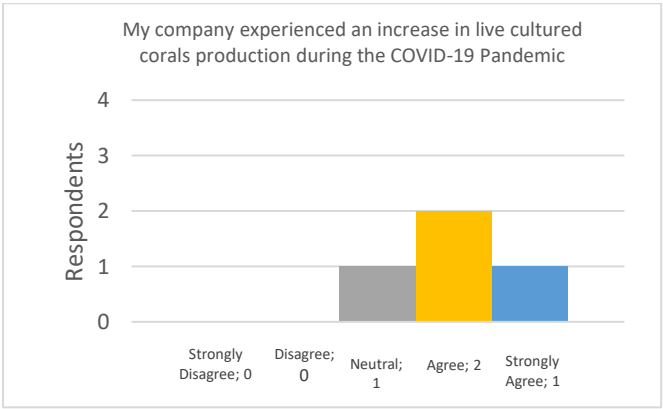

Fig. 4. Increase in live cultured coral production during the pandemic

A tendency towards increased export quotas during the pandemic (2020-2022) was found, albeit inferior to export quotas from pre-pandemic (Table 2). Some respondents answered the questionnaire with the estimated quotas. Nevertheless, close to the original quotas in all data or the combined export quotas (cultured and wild-caught coral) in the pre-pandemic data (2017). The export quota of each coral aquaculture company is determined based on the availability of coral stocks [24]. The decision to increase or decrease the export quota is based on the company's ability to meet the specified quota.

The workers at the main office were different from those at the coral transplantation sites. The main office area usually includes coral display tanks and ex-situ systems. The workers at the coral transplantation site are usually people who live around the coral transplantation site area. Based on the field observation results, most of the coral transplantation sites and the company's main office were not in the same area or regency. To illustrate this phenomenon, a coral aquaculture company in Badung could own coral transplantation sites at Serangan Beach, Denpasar, and Gilimanuk Beach, Jembrana. The identified activities that were affected due to the restricted mobility during the pandemic include field visits and inspections,

delivery of necessary equipment and materials from the main office to the coral transplantation site, moving the corals to the main office or other coral transplantation sites, and going to the sea.

Based on the interview and field observation results, limited access to equipment and materials could hurdle the coral production process in several regencies. Imported equipment and materials, such as coral foods used in the ex-situ aquaculture systems, were usually difficult to obtain during the pandemic, especially in remote and rural areas. Access to equipment and materials found in local shops, such as cement, was not a problem during the pandemic.

C. Human resource management during the pandemic

The questionnaire result showed that companies tend to keep their workers during the pandemic (Figure 5). The interview result showed similarity to the questionnaire result, as all coral farmer informants stated that workers' layoffs did not happen in their company. One of the coral farmer informants stated the ability to keep the workers was due to coral export activities which continued during the pandemic.

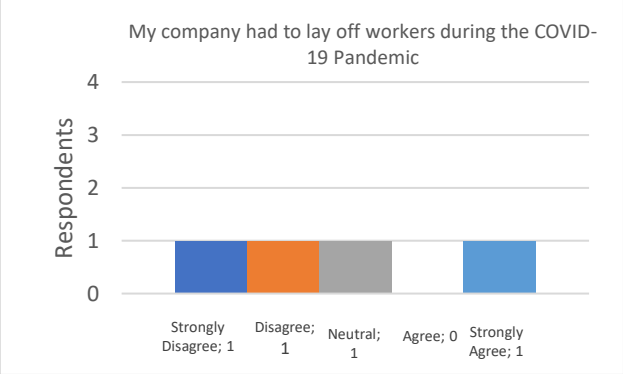

Fig. 5. The case of workers' layoffs during the pandemic

The cases of SARS-CoV-2 infections among workers in all sample companies were relatively low during the pandemic. The field observation results found that the majority of workers lived in company-provided housing, usually in the company's area. Thus, workers did not need to travel long distances. Additionally, health protocols were implemented in work areas (office and coral transplantation sites) and company-provided housing to minimize the spread of SARS-CoV-2.

The restricted mobility during the pandemic has forced companies and governments to utilize technology for field inspections and reporting-related activities, thus triggering digitalization. The inspection mechanism during the pandemic was done by recording videos or capturing photos of the corals at the coral transplantation site by field workers and then sending the results through a predetermined message group. Report submission was done online and only required a digital copy. All permits and licensing processes were done online by uploading the required documents to integrated digital service systems, such as e-SAJI (Fish Transport Permit) and OSS RBA (One Single Submission Risk Based Approach). The video recording-based coral inspection mechanism during the COVID-19 pandemic period was changed to the on-site inspection carried out by government-appointed personnel, meanwhile, the integrated digital service systems were still implemented as of December 2022.

D. Management strategies and adaptations during the pandemic

The identified management strategies and adaptations during the pandemic and the stopping of the health certificate issuance period are described in Table 3. The field observation results showed that several companies recruited new workers during the pandemic, especially graduates with educational backgrounds related to aquaculture or chemical studies. Recruitment of locals affected by the pandemic, such as workers from the tourism sector, was present in all sample companies. The results indicate that the coral aquaculture business becomes a source of income for the locals, especially those affected by the pandemic. Additionally, the recruitment of new workers with particular educational backgrounds and locals is based on the need for human resources to improve the existing coral aquaculture systems. One of the coral farmer informants, in addition, stated that the low human resources regeneration in the coral aquaculture industry threatens the industry's future.

One of the coral farmer informants reported that additional diving equipment was rented from another business affected by the pandemic, such as the recreational diving business. The recreational diving industry has been severely affected by the pandemic as outdoor activities are restricted [25].

The implementation of digital marketing was present in one sample company. Based on the field observation results, two sales models were observed, the B2B (Business-to-Business) model and the B2M (Business-to-Many) model. The B2B model tends to use established business connections and often does not require digital marketing. The B2M model, however, needs to diversify marketing strategies to reach broader audiences. The strategies include creating a company's website and engaging potential customers through social media.

Two coral farmer informants reported the implementation of a consolidated shipping method, as requested by customers, to reduce shipping costs during the pandemic. The consolidated shipping was done with other companies, usually from the same association, and under the condition of having the same shipping destination. Additionally, all management strategies from the stopping of the health certificate issuance period were

last effort strategies by coral aquaculture companies to avoid business closures. This was due to the loss of companies' main source of income during that period. The results indicate that crisis periods, such as the COVID-19 pandemic, have forced coral aquaculture companies to strategize to ensure business survivability.

IV. CONCLUSIONS

Based on the research results and discussion, the conclusions are as follows:

1. The impact of the COVID-19 pandemic on the coral aquaculture business showed a tendency towards positive impact, as it managed to become the source of income for the locals during the pandemic. However, several challenges were found, such as the difficulty in exporting coral during the pandemic.
2. The COVID-19 pandemic has forced coral aquaculture companies to develop management strategies and adaptations to ensure their business survivability during the pandemic.

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TABLE 1.
RANGE OF REVENUE GROWTH DURING THE COVID-19 PANDEMIC

Sample Companies	From 2020 to 2021, my company experienced an increase in revenue					Range of percentage in revenue growth (%)
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Denpasar			■			< 10%
Buleleng				■		31% - 60%
Badung					■	> 60%

Note: each region is represented by one sample company.

TABLE 2.
EXPORT QUOTAS (PIECES) OF SAMPLE COMPANIES

Sample Companies	Years			
	2017	2020	2021	2022
Denpasar	33.000	30.000	30.000	31.000
Badung	114.306	15.182	20.914	15.435
Buleleng	10.000	20.000	18.000	25.000

Note: each region is represented by one sample company.

TABLE 3.
MANAGEMENT STRATEGIES AND ADAPTATIONS

During the COVID-19 pandemic			
Aspects	**Management strategies/adaptations**	**Context**	**Reported by**
Social	Providing the workers' health protocols needs	To minimize infection case between workers	All sample companies/coral transplantation sites
	Recruitment of workers with certain educational backgrounds	To improve the ex-situ system during the pandemic	Denpasar and Badung
	Recruitment of the locals who live around the coral transplantation site area	To improve the in-situ system during the pandemic	All sample companies/coral transplantation sites
	Renting additional diving equipment from local recreational diving services	Happens when the workers need additional diving equipment	Jembrana
Economic	Doing digital marketing	To reach diverse audiences during the pandemic	Denpasar
	Using the consolidated shipping method	To reduce the shipping costs during the pandemic	Badung and Jembrana
	Using local ingredients to make coral foods as a substitute for the imported commercial coral foods	As a result of imported goods that were hard to get during the pandemic	Denpasar
Ecological	Increasing coral production by increasing the number of coral transplant tables at the coral transplantation sites	Taking advantage of the pandemic situation to increase coral production	All sample companies/coral transplantation sites
During the stopping of the health certificates issuance period			
Aspects	**Management strategies/adaptations**	**Context**	**Reported by**
Social	Allocating workers in the ornamental coral section to the ornamental fish section	To minimize workers' layoffs	Denpasar and Badung
Economic	Selling private assets	To ensure company's survivability	Denpasar
	Temporarily stop the ex-situ system	To reduce electricity costs	Denpasar
	Doing business diversification through selling non-coral commodities such as ornamental fish and crustacean	To replace corals as source of income thus preventing business closure	Denpasar and Badung