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MANAGEMENT OF THE SUSTAINABLE UTILIZATION OF ORNAMENTAL CORAL WILDLIFE ON PULAU KAUNG VILLAGE AS HOBBYIST TOURISM

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Abstract: The coral reef ecosystem is one of the biodiversity that the most significant component of coral reefs, namely corals, has been traded in various sizes. Not only beneficial for marine ecotourism, but the current trend is that ornamental coral has become a legal hobby. These hobbyists make coral one of the main components that decorate their aquariums because of their attractive shapes and colors. However, several types of hard corals are included in CITES Appendix II, so their permits and trading activities are stringent. Indonesia has more than 14% of the World's reefs and is known as the coral triangle area, where one of the centers for ornamental coral production is the Bali Strait. One of the suppliers established in 2015 is PT Lombok Samudera Abadi (PT LSA). PT LSA is a supplier of wildlife ornamental coral products in West Nusa Tenggara that fulfills orders from exporters who are members of the Indonesian Ornamental Coral Farmers Association (KPKHN) for exporters in Bali and Banyuwangi and the Association of Indonesian Ornamental Coral and Fish Association (AKKII) for exporters in Jakarta. The purpose of this study was to analyze the level of corals utilization at PT. LSA and its impact on sustainability. The study's results showed the level of utilization of corals by PT. LSA in Pulau Kaung Village delivered an average actual production of 1,862 individuals /month, which means it does not exceed the maximum production value (CMSY = 3,743 individuals/month) and JTB (2,995 individuals/month). The actual corals harvesting average of 133 trips is still below the optimum harvesting effort (EMSY = 211 trips), so this condition still shows that over-exploited has not occurred in the area with a utilization rate of 0.48 which is still in the moderate status, which means that utilization efforts can be increased. There are 36 hard corals and 9 soft corals taken from nature. Besides corals utilization, PT. LSA also engages in CSR activities by offering restocking from corals transplants in particular areas and training for academics or coastal communities. However, not all restocking is successful, primarily because of seasonal factors that can impact the corals' health. In light of this, more investigation is required.

Key words: Ornamental Reef, Maximum Sustainable Yield (MSY), reef trading, Corporate Social Responsibility (CSR), Hobbyist Tourism

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INTRODUCTION

Coral reefs are important ecosystems that support a variety of marine life and have a vital ecological function because they are home to 93,000 species of marine biota (Bellwood and Wainwright, 2002; CRITC Coremap-LIPI, 2016; Intyas et al., 2020; United States Environmental Protection Agency, 2022). Coral reefs are found in many tropical waters, including Indonesia, which has approximately 12,5% - 18% of the total worldwide (Karim et al., 2021; Susiloningtyas et al., 2018). Indonesia is also included in the corals triangle area, often referred to as the Amazon of oceans, because it has various types of coral reefs, around 69% of the species worldwide (Allen and Erdmann, 2013; Asian Development Bank, 2014; NOAA, 2015; Seascapes Working Group CTI-CFF, 2015). Coral reef ecosystems have an essential ecological, social, and economic role in the fisheries sector. From an ecological perspective, coral reefs are home to approximately 93,000 species of marine life and protect the coast from abrasion. Meanwhile, from a health perspective, it is a place to obtain supplementary materials and medicines. From a socio-economic perspective, it can increase the productivity of fishery

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resources, which are a source of income for the community, especially coastal communities (CRITC Coremap-LIPI, 2016; Intyas et al., 2022). The main components of the coral reef ecosystem are coral animals (corals) with a hard structure and containing lime which are in symbiosis with zooxanthellae algae plants. There are two types of coral: hard and soft (LIPI P2O, 2018). Because of its beauty, this coral is also traded globally but several types of coral are included in CITES appendix II (Biondo, 2017; CITES, 2023) so that their circulation is highly monitored and regulated by the World.

Currently, the beautiful and well-maintained coral reef ecosystem also has economic value as part of marine ecotourism. Coral reefs are a popular destination for tourists for various reasons, including those interested in marine ecology and horticulture. For example, Europeans and Americans have been watching television for about 7 hours per day as their favorite hobby, followed by outdoor hobbies such as gardening, hanging out with friends, going to cultural celebrations, and visiting museums, theatres, or concerts.

The trade-in ornamental coral reef wildlife, which includes the aquarium, jewelry, and curio trades, supports a multi-million dollar industry (Grey et al., 2005). Overall the aquarium industry is of relatively low volume yet very high value, thus potentially providing an incentive to conserve reef habitats and offering a livelihood to coastal communities often living in low-income areas (Wabnitz et al., 2003). But aquariums are already playing a key role by providing knowledge and expertise in coral reproduction and restoration techniques in natural habitats (Silva et al., 2019).

Over the last five years, the hobby of raising ornamental fish and corals has become a trend, especially during the pandemic, which requires people to stay at home and place restrictions on one another so that this hobby is an alternative to watching television. These hobbyists make coral one of the main components that decorate their aquariums. Even though it looks beautiful, maintaining ornamental coral requires money. So high-end consumers and the export market still dominate these hobbyists. Aquascaping is the art of decorating the shape and contents of an aquarium. According to Hariyatno et al. (2018), Aquascape is the art of arranging stone, coral, sand, wood, and aquatic plant components in an aquarium. Aquascape's main goal is to provide a view below the surface of the water in an aquarium so that the aquarium looks aesthetically as part of beautifying a room or a specific location. Currently, Aquascape is also one of the subjects that are in great demand by students. Children and adults alike are fascinated by the stunning beauty of ornamental coral, the primary component in an aquarium besides ornamental fish. Therefore, many tourist attractions, offices, and even airports have added aquariums with ornamental coral and ornamental fish using Aquascape, which has been positively received by those who see it. In 2012-2016, 153 countries traded ornamental coral in the global market, including Indonesia, the second largest after Japan (33.67%), with export growth of 5.25% per year.

The export value of Indonesia's ornamental coral in 2016 reached US$ 10.70 million, equivalent to 6.35 percent of the total world export value of ornamental coral (US$ 168.51 million, but the trade in ornamental coral during that period did not affect the damage to the existing coral in Indonesia (Riadi et al., 2018). Moratoriums on certain species, no-take reserves, tiered quota systems, and import and export restrictions, among others, provided examples of management successes. Bright spots in the marine aquarium trade include the quickly expanding trade in transplanted corals and improved fisheries management in small fisheries, which demonstrate that this trade can be a part of a larger strategy for reef conservation (Fattah et al., 2021; Rhyne et al., 2014). The increasing consumer concern that the trade in ornamental coral will not damage the ecosystem requires that this ornamental coral business have a clear traceability and legality system because some ornamental coral species included in CITES Appendix II are strictly monitored. Only a few areas have obtained permits to carry out domestic harvesting and distribution of ornamental coral taken from nature. According to Intyas and Abidin (2018), one of the policy directions for fisheries development since 2015 are fostering standardization, accreditation, and certification of fisheries, is to ensure certainty of the form, quality and standards of goods and services produced so that consumers (domestic and foreign) accept them so that they are able to compete in the global market. Based on Intyas et al. (2022), currently the block chain digitization system is also widely used related to traceability.

Based on information from 1153 coral reefs in Indonesia collected in 2019, 390 coral reefs (33.82%) were classified as bad, 431 reefs (37.38%) as sufficient, 258 reefs (22.38%) as good, and 74 reefs (6.42%) as very good (Hadi et al., 2020). Human activities (destructive and illegal fishing), bleaching conditions, and current waves can all contribute to the poor condition of coral reefs (Hadi et al., 2018; Swara and Intyas, 2021). Currently, research that has been conducted in Indonesia is only about monitoring and the condition of corals (Dutra et al., 2021; Johan et al., 2019; Koroy et al., 2014) but research on how often ornamental coral is harvested is still lacking. In order to prevent over-exploitation, it is important to monitor the utilization rate of corals harvesting such as a number of studies by (Auger et al., 2022; Costa and Anjos, 2021; Yanto et al., 2020; Zhang and Fong, 2021) that examined the utilization rate of fish resources being used sustainably in nature. It will be beneficial to take wildlife ornamental coral if it is sustainable, particularly in terms of the economy and the environment. One of the long-established ornamental coral producers is PT. Lombok Samudera Abadi (LSA). PT LSA was established in 2015 and obtained a permit to trade corals from wildlife and aquaculture (transplants) with fishing areas in West Nusa Tenggara namely in Labuan Jambu Village, Tarano District, and Pulau Kaung Village, Alas District, as stated in the recommendations from the West Nusa Tenggara BAPPEDA. Therefore, this research aimed to analyze the sustainable potential and utilization rate of wildlife corals by PT LSA.

MATERIALS AND METHODS

Corals in Indonesia are scattered from Sabang to the north of Jayapura. The distribution of corals is not evenly distributed throughout Indonesian waters, there are certain areas where corals does not grow well, and in other areas, it grows very well. The areas around Sulawesi, Maluku, Sorong, West Nusa Tenggara, and East Nusa Tenggara are good for corals growth (Suharsono, 2008). This research was conducted in January 2023 at PT LSA, which has a fishing area in the

waters of Pulau Kaung Village, Buer District, Sumbawa Besar, West Nusa Tenggara, Indonesia, where the majority of the population is the Bajo Tribe and work as fishermen. The type of research used is descriptive research. Nazir, (2003) defines descriptive research as finding facts with the proper interpretation that accurately describes the properties of several phenomena, groups, or individuals. The methodology of our research is below on Figure 1.

Based on Figure 1, using schaefer's model of resource potential for sustainable corals utilization is based on the Maximum Sustainable Yield (MSY) in Pulau Kaung Village. According to (Conrad and Clark, 1987), from the ecological and economic aspects of MSY, it has the meaning of the most significant number of fish catches (predators) that can be taken from stocks of a type of fish (prey) unlimitedly. Meanwhile, the MSY concept aims to maintain the size of the fish population at a maximum point, namely when the fish growth rate is maximum (the maximum catch rate that provides net economic benefits or benefits to society). Harvesting individuals and adding them to this population allows the population to remain productive. MSY (Maximum Sustainable Yield) is a guideline to manage fishery resources with economic utilization without reducing their population. MSY is often called the maximum value of fishing in waters in the maximum sustainable capacity or the maximum sustainable catch (Munica et al., 2016) MSY is a management parameter resulting from the wildlife assessment of fishery resources. Estimating these parameters requires annual production catch data (time series) (Widodo and Suadi, 2016). Adopted from (Sparre and Vennema, 1998), the following data analysis is used to estimate the sustainable potential and utilization rate of corals, namely :

a) CPUE (Catch per Unit Effort) analysis aims to determine the level of utilization of ornamental coral collection units based on the division of the total catch by effort, using the formula (Sparre and Vennema, 1998):

$$CPUEi = \frac{Ci}{Ei}$$

Ci: The result of taking the i (individuals)
Ei: Retrieval attempt to - i (trip)
CPUEi: The number of results taken per unit of retrieval efforts to-i (individuals/trip)

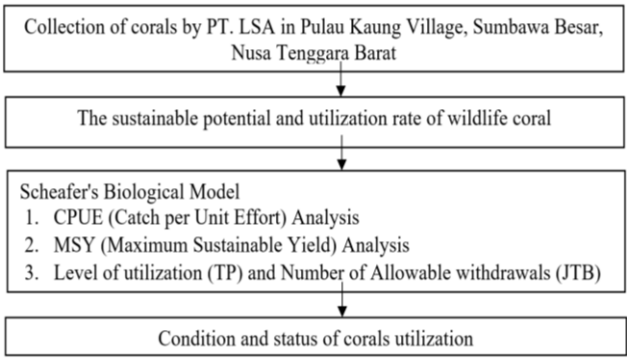


Figure 1. Research flowchart of Corals Utilization by PT. LSA

b) MSY (Maximum Sustainable Yield) analysis is to estimate the sustainable potential value of ornamental coral by analyzing catch and effort using the Schaefer production surplus method by calculating the estimation of maximum sustainable potential (C_{MSY}) and optimum harvest effort (E_{MSY}) by using the linear regression equation below (Sparre and Vennema, 1998):

$y = a - bx$ - y = dependent variable (CPUEi) in individuals/trip; x = independent variable (fi) in trip a and b = regression parameters, where the values of a and b are obtained from the following formula (Sparre and Vennema, 1998):

$$a = \sum\frac{xi}{n} - \sum\frac{yi}{n} \text{ and } b = \frac{n.\sum(xi)(yi)) - (\sum yi)}{n.\sum(xi^2) - (\sum xi)^2}$$

a = intercept; b = slope/variable Ei; xi = retrieval attempt i (fi); yi = retrieval result per unit of retrieval attempt i (CPUE); which is input into the Schaefer equation, namely CPUE = a – b(f)

This method can be applied if the value of b is negative, which means that each additional retrieval effort decreases CPUE. Furthermore, bio technic analysis determines the parameters r, q, k, and biomass under MSY conditions using the fox algorithm estimation model with the formula (Sparre and Vennema, 1998) :

$$x = \left[\left(\frac{z}{U_t}\right) + \left(\frac{1}{\beta}\right)\right], y = \left[\left(\frac{z}{U_{t+1}}\right) + \left(\frac{1}{\beta}\right)\right], \quad z = \left[\left(-\frac{a}{b}\right) - \left(\frac{U_t + U_{t+1}}{2}\right)\right], \quad r = \frac{kq^2}{\beta} \quad q = \left[\prod_{t=i}^{n} ln\left(\frac{\frac{x}{y}}{z}\right)\right]^{1/t}, \quad k = \frac{\alpha}{q}$$

Based on Sparre and Vennema (1998), the estimated value of biomass (x_{MSY}) = $\frac{k}{2q}$, maximum sustainable potential (C_{MSY}) = $\frac{r.k}{4}$ and optimum retrieval effort (E_{MSY}) = $\frac{r}{2q}$

c) Then, an estimation of the level of utilization (TP) and the number of allowable withdrawals (JTB) is carried out in Pulau Kaung Village. TP estimation presents the amount harvested in a particular year with the maximum sustainable potential value (C_{MSY}). The TP formula is (Sparre and Vennema, 1998):

$TP = \frac{Ci}{C_{MSY}} x\ 100\%$ While the JTB formula = 80% x MSY (Anna, 2016; BPS, 2018)

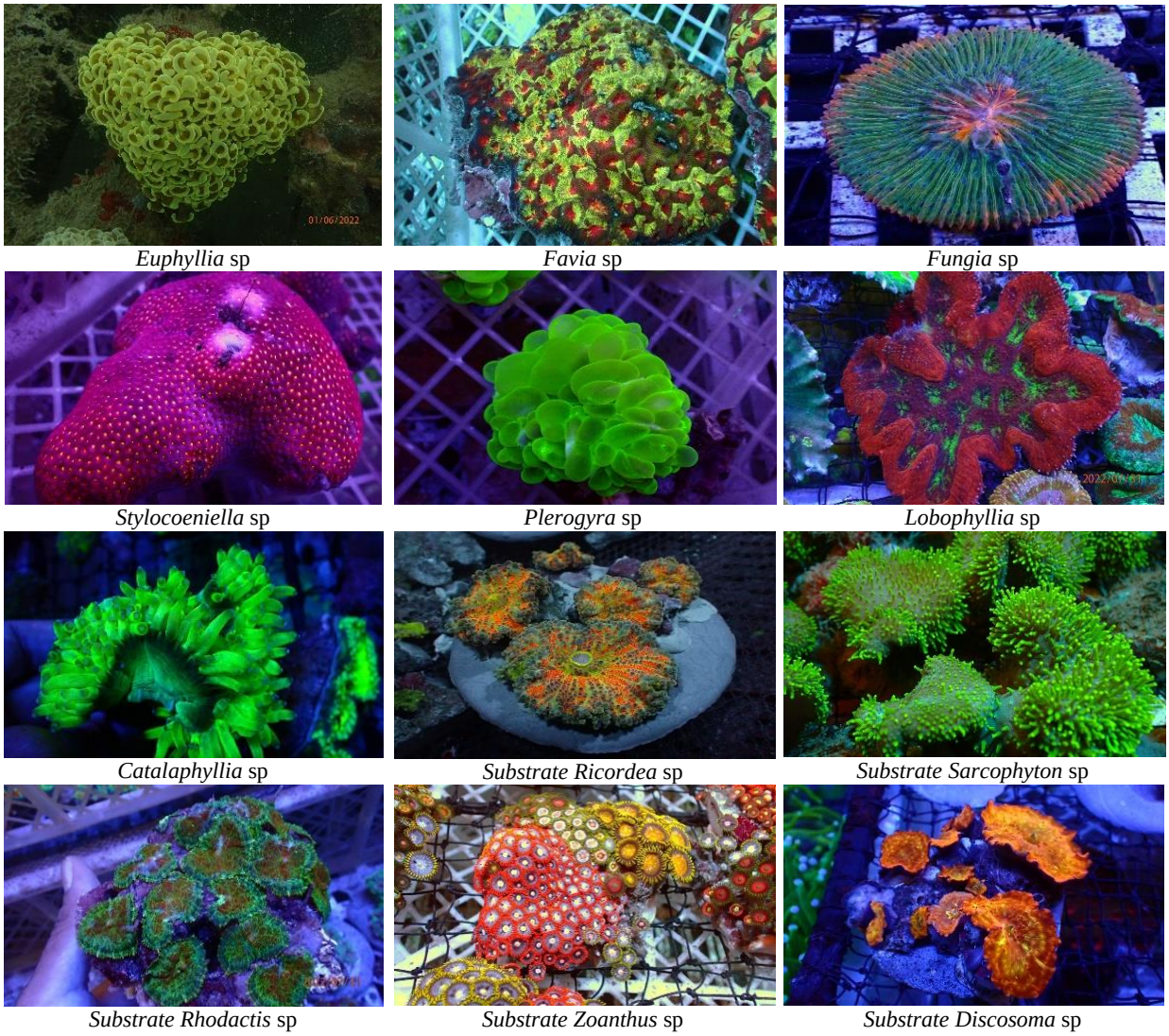
RESULTS AND DISCUSSION

Table 1. Level of Utilization category
(Source: Kepmen KP No. 50, 2017 annex 4)

Index value	Category
TP < 0,5	Moderate
0,5 ≤ TP < 1	Fully exploited
TP ≥ 1	Over exploited

The collection of wildlife corals by PT LSA is a request from an exporter who is a member of the Indonesian Ornamental Coral Farmers Association (KPKHN) in Bali and Banyuwangi and the Association of Indonesian Ornamental Coral and Fish Association (AKKII) for exporters in Jakarta. Based on recommendations from the use of ornamental coral that are not protected by law, they must meet the requirements to be outside the conservation area/ protected area set by central and regional agencies and be carried out with caution to avoid damage to the coral reef ecosystem. During 2020 – 2022, PT SLA took 46 types of corals divided into 37 types of hard corals, with the most species being *Euphyllia* sp and 9 types of soft corals, with the most species being Substrat *Ricordea* sp. The types of corals are mostly taken because their corals patterns and shapes are the most preferred by consumers. The harvest period for hard corals consists of 3 periods, namely 4 months (13.51%), 8-12 months (70.27%), and 24 -30 months (16.22%). The types of corals that are

mostly taken are presented in Figure 2. The results of wildlife corals harvesting conducted by PT LSA in May 2020 - December 2022 were 59,490 individuals on 133 trips with an average monthly corals harvest of 1,862 individuals.



Euphyllia sp | *Favia* sp | *Fungia* sp

Stylocoeniella sp | *Plerogyra* sp | *Lobophyllia* sp

Catalaphyllia sp | *Substrate Ricordea* sp | *Substrate Sarcophyton* sp

Substrate Rhodactis sp | *Substrate Zoanthus* sp | *Substrate Discosoma* sp

Figure 2. Dominant corals species taken by PT. LSA in Pulau Kaung Village (Source: Primary Data, 2023)

The highest corals harvest was in October 2020 at 8,237 individuals, while the lowest was in May 2022 at 98 individuals. The taking of wildlife corals decreases every year due to restrictions on corals harvesting quotas from the government, which support sustainability. Moreover, the growth period and season also affect the harvest time, which is usually low in March-May and high in October-November for three years (2020–2022) as can be seen in Figure 3.

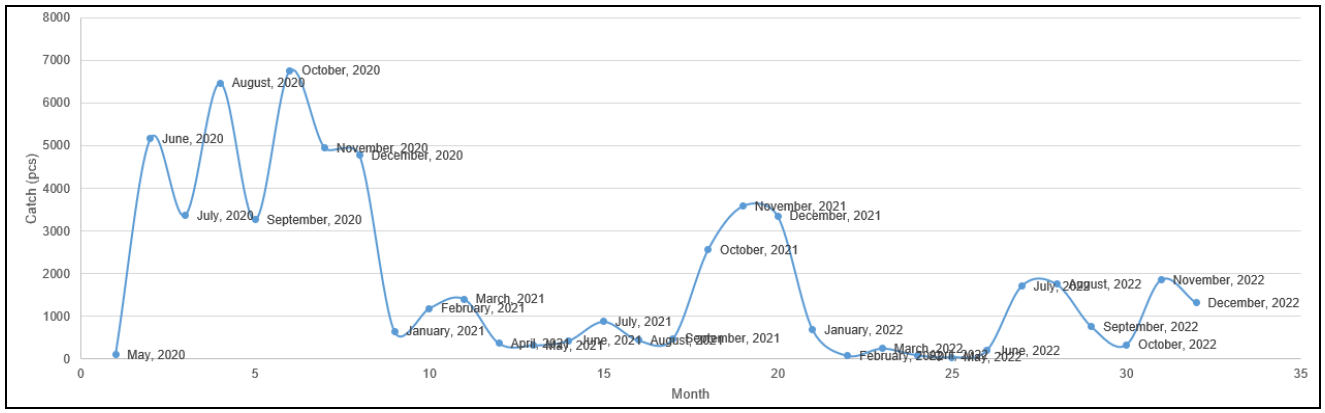


Figure 3. Results of PT LSA Corals Harvesting from May 2020 – December 2022

Based on the Catch Per Unit Effort (CPUE) calculation, the value of ornamental coral from May 2020 – December 2022 is represented in Figure 4.

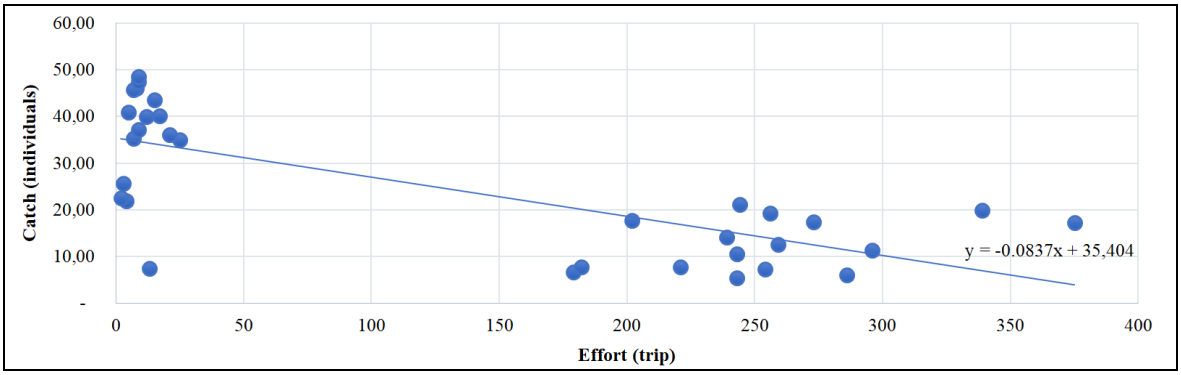


Figure 4. Relationship between Effort and CPUE of Wildlife Ornamental Coral PT. LSA in Pulau Kaung Village in May 2020 – December 2022

Table 2. Analysis of Scheafer's Biological Model

Data	Value	Analysis	Value
a	35.404	x_{MSY}	5,160
b	-0.0837	C_{MSY}	3,743
R^2	0.5484	E_{MSY}	211
P-value	0,0000126	JTB	2,995
r	1.11	TP	0.48
q	0.003		
k	10,319.9		

The relationship between effort and PT LSA's Wildlife Ornamental Reef CPUE in Kaung Village in May 2020 – December 2022 in Figure 3 showed an increase in the number of corals taken (effort) per ship, which led to a decrease in corals yields per ship (CPUE). The varied CPUE values indicated that there had been an increase and decrease in corals harvesting but tended to decrease. Furthermore, the results of biotechnical, bioeconomic, and utilization rates are presented in Table 2. Based on the graph in Figure 4 and Scheafer's biological model in Table 2, the regression equation is as follows: y = 35,404 – 0.0837x This equation shows that: The regression coefficient (b) of -0.0837 states that there is an inverse relationship between production and effort (trips) and that the addition of 10 taking trips means that production will decrease by 0.837 individuals/month, and vice versa. If the trip value is zero, the production is 35,404 individuals/month. The coefficient of determination (R^2) is 0.5484 or 54.84%, indicating that CPUE is affected by the total effort (trip) of 54.84%. In comparison, the remaining 45.16% was influenced by other factors such as fishing ground, type gear, stock, weather, or did not address in the model. Biological parameters include intrinsic growth rate (r), gear coefficient (q), and the carrying capacity of the aquatic environment (k). The intrinsic growth rate (r) is 1.11 which means that corals resources grow naturally without any disturbance from natural phenomena or human activities of 1.11 individuals/month. The gear coefficient (q) of 0.003 indicates that each increase in the unit of harvesting effort will have an effect of 0.003 individuals per trip. The carrying capacity of the environment (k) is 10,319.9, indicating that the ability of the ecosystem to support the production of corals resources is 10,319.9 individuals/month from biological aspects, including food abundance, population growth, and fish size. The maximum sustainable potential is obtained by biomass (x_{MSY}), which is 5,160 individuals/month. The maximum sustainable potential (C_{MSY}) is 3,743 individuals/month, and the optimum harvesting effort (E_{MSY}) is 211 trips. Degradation analysis was carried out to determine how much the degradation rate occurred due to resource extraction (Sobari et al., 2009). Generally, the average actual production (1,862 individuals/month) is less than the maximum sustainable potential (C_{MSY}). In addition, the actual corals harvesting effort (133 trips) is also smaller than the optimum harvesting effort (E_{MSY}). This condition indicates that overfishing has yet to occur because both the number of corals taken (catch) and the actual level of effort (effort) have not exceeded the level of potential and sustainable harvesting efforts (MSY). These conditions can also be seen in Figure 5.

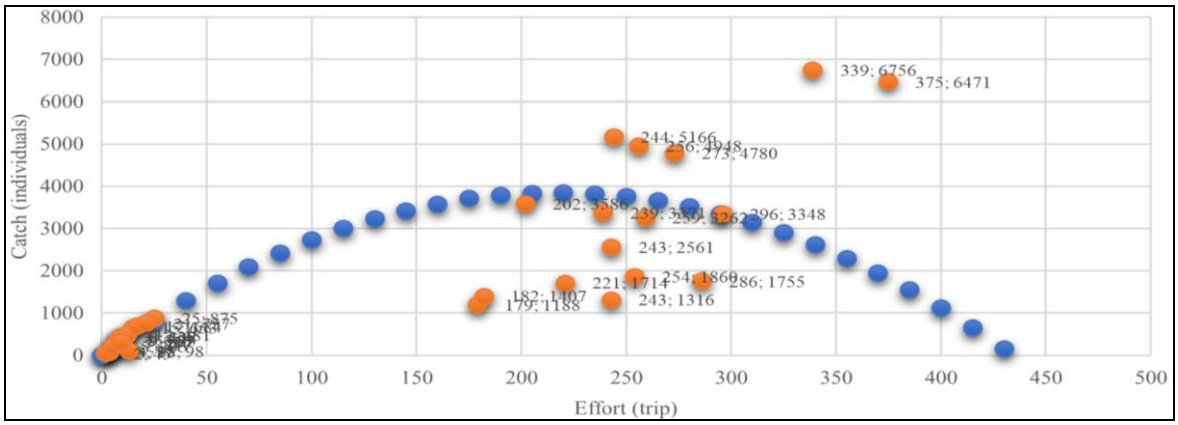


Figure 5. Coral Maximum Sustainable Yield Curve in Kaung Village

Referring to Kepmen KP No. 50, 2017, the Ministry of Maritime Affairs and Fisheries provides standards for the utilization of fish resources in the fisheries management area of the Republic of Indonesia. Based on the MSY estimation analysis, this study showed a utilization rate of 0.48 which was included in the moderate category because it was in the range TP < 0.5 , which means that corals harvesting efforts can be increased. In addition, the number of corals harvests allowed (JTB) is 2,995 individuals, whereas the average actual corals production/taken was 1,862 individuals/month, which means that

PT LSA takes corals still on the JTB boundary. The difference between the actual average corals harvest and JTB was 1,133 individuals (37.83%). So that this condition is still safe for corals harvesting, although policies are still needed regarding corals harvest quotas, especially corals species included in CITES appendix II. To support sustainability, PT LSA also conducts corals transplantation (aquaculture), which is traded on the export market. In addition, PT LSA conducts Corporate Social Responsibility (CSR) activities in collaboration with POKMASWAS and related stakeholders for restocking coral transplants in several areas of West Nusa Tenggara annually and conducting training for academics and coastal communities. Restocking is carried out not in coral collection areas but in areas with a high level of corals damage or beach tourism areas that require improving coral conditions. Figure 6 and 7 illustrates PT LSA's CSR activities from 2020 to 2022.

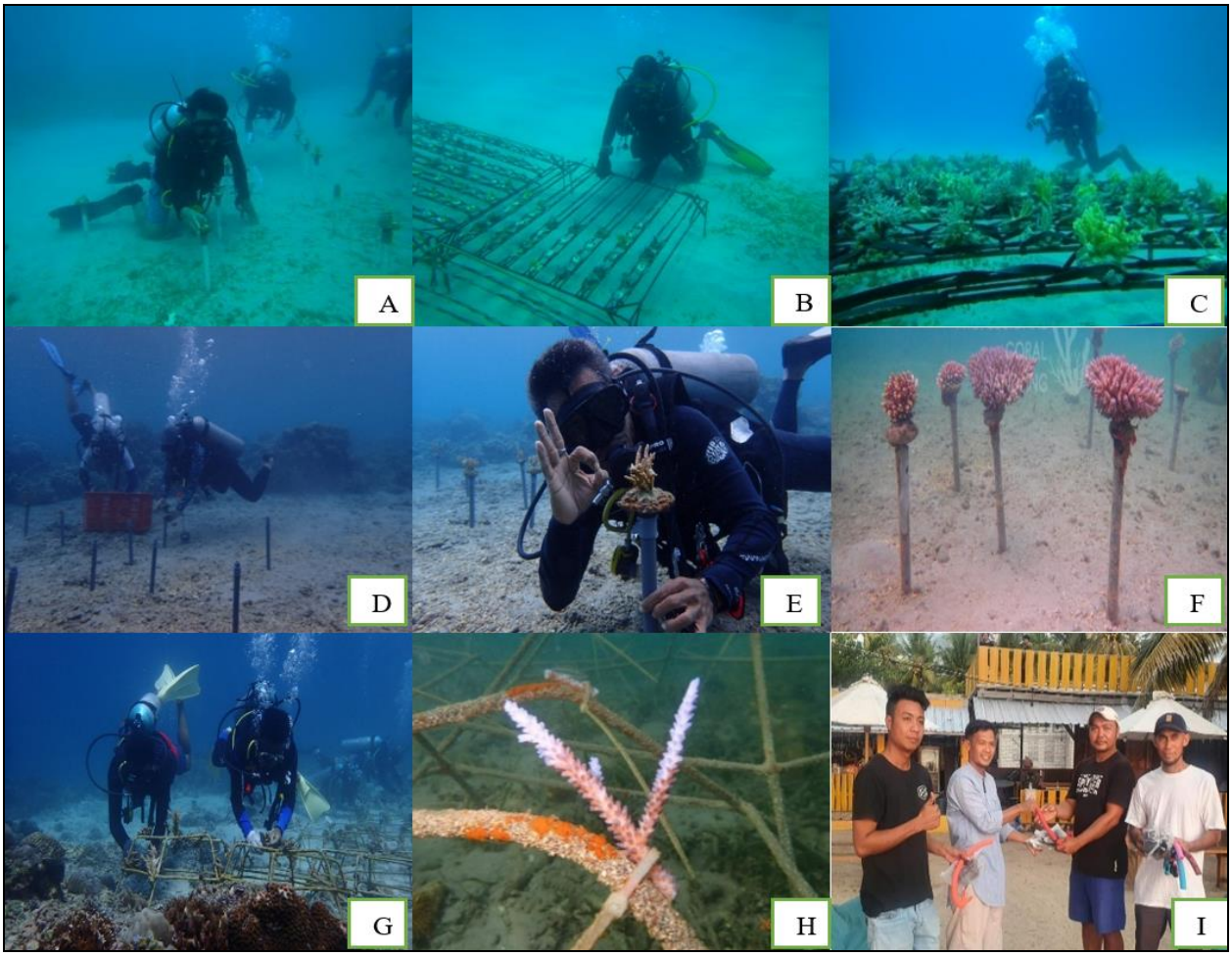


Figure 6. Restocking Corals (Corals Transplantation) on 2020–2022
(A–C) at Pandanan Beach, North Lombok, in 2020: planting corals in shelves [A], planting corals with the peg method[B], and only corals in shelves surviving within two months [C]. On November 21, 2020, at Moyo Island Beach, Sumbawa Besar, planting corals with the peg method of 50 stakes on a sandy rubble substrate area [D–E] and checking on December 4, 2021, it was found that 17 stakes had survived, and the corals were developing quite well [F]. (G) planting corals on shelves on Gili Meno Beach, North Lombok, in 2021. (H-I) planting corals on Mutiara Beach, Pulau Kaung Village in 2022 (Source: Primary Data, 2023)

Figure 7. Corals Transplantation (Aquaculture) Training and Assistance
(A – B) for teachers is scheduled for October 12th–17th, 2020, at the PT LSA Office in Pulau Kaung Village. This training includes material on how to cultivate corals, identification, and regulation, as well as practice on how to plant both hard and soft corals and good coral harvesting methods. There were two schools on the figure namely Teachers of Seteluk 1 Public Vocational School, Sumbawa Regency [A] and Teachers of Alas 1 State Vocational School, Sumbawa Regency [B]. (C) assisted community groups from Natural Resources Conservation Center (BKSDA) Sumbawa on 13th December 2021 (Source: Primary Data, 2023)

CONCLUSION

The commerce in decorative corals as hobby tourism is becoming a global trend that is thriving during the pandemic with the growth of Aquascape, which is not only a hobby at home but also tourist sites, airports, offices, and hotels. PT LSA collected 36 types of wildlife ornamental coral, including hard corals, with the most species being *Euphyllia* sp, and 9 types of soft corals, with the most species being substrate *Ricordea* sp.

The research results show that the average actual production is 1,862 individuals/month, which means it does not exceed the maximum production value (C_{MSY} = 3.743 individuals/month) and JTB (2,995 individuals/ month). The actual coral harvest of 133 trips still below the optimum harvesting effort (E_{MSY} = 211 trips). So this condition still indicates that overfishing has not occurred in this area. The level of corals utilization in Pulau Kaung Village has a value of 0.49 or is in a moderate condition, which means utilization efforts can be increased. In addition to using corals, PT LSA also carries out CSR activities by providing restocking from corals transplants resulting in certain areas and training for academics or coastal communities. However, not all restocking goes well, mainly due to seasonal conditions, which also affect the condition of the corals. In light of this, more research is required.

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REFERENCES

Allen, G.R., & Erdmann, M.V. (2013). Reef Fishes of The East Indies. *Journal of Fish Biology*, *83*(5), 1483–1484. https://doi.org/10.1111/jfb.12248

Anna, Z. (2016). Pengelolaan Perikanan Tangkap Berkelanjutan Waduk Cirata : Pendekatan Model Bio-Ekonomi Logistik [Sustainable Capture Fishery Management in The Cirata Reservoir: A Bio-Economic Modelling Approach]. *J. Sosek KP*, *11*(2), 161–172. http://dx.doi.org/10.15578/jsekp.v11i2.3688

Asian Development Bank. (2014). *State of the Coral Triangle: Indonesia*. http://coraltriangleinitiative.org/sites/default/files/resources/SCTR-IN.pdf. http://hdl.handle.net/11540/771

Auger, P., Kooi, B., & Moussaoui, A. (2022). Increase of maximum sustainable yield for fishery in two patches with fast migration. *Ecological Modelling*, *467*. https://doi.org/10.1016/J.ECOLMODEL.2022.109898

Bellwood, D.R., & Wainwright, P.C. (2002). The History and Biogeography of Fishes on Coral Reefs. In P. F. Sale (Ed.), *Coral Reef Fishes Dynamics and Diversity in a Complex Ecosystem*. Academic Press.

Biondo, M.V. (2017). Quantifying the trade in marine ornamental fishes into Switzerland and an estimation of imports from the European Union. *Global Ecology and Conservation*, *11*, 95–105. https://doi.org/10.1016/j.gecco.2017.05.006

BPS. (2018). *Proporsi Tangkapan Jenis Ikan yang Berada Dalam Batasan Biologis yang Aman [Proportion of Catch of Fish Species Within Safe Biological Limits]*. Pilar Lingkungan Indikator Pembangunan Berkelanjutan. https://www.bps.go.id/indikator/indikator/view_data/0000/data/1586/sdgs_14/1#:~:text=Jumlah tangkapan yang diperbolehkan adalah,maximum sustainable yield – MSY)

CITES. (2023). *Convention On International Trade In Endangered Species Of Wild Fauna And Flora Appendices I, II and III*. Convention on International Trade in Endangered Species of Wild Fauna and Flora. https://cites.org/eng/app/appendices.php

Conrad, J., & Clark, C. (1987). *Natural Resource Economics, Notes and Problem*. Cambridge University Press.

da Costa, M.I.S., & dos Anjos, L. (2021). Maximum sustainable yield and species survival: Insights from effects of prey harvest saturation on dynamic predator–prey models. *Ecological Modelling*, *461*. https://doi.org/10.1016/J.ECOLMODEL.2021.109764

CRITC Coremap-LIPI. (2016). *Tentang Terumbu Karang [About Coral Reefs]*. CRITC Coremap-LIPI. http://coremap.oseanografi.lipi.go.id/berita/520

Dutra, L.X.C., Haywood, M.D.E., Singh, S., Ferreira, M., Johnson, J.E., Veitayaki, J., Kininmonth, S., Morris, C.W., & Piovano, S. (2021). Synergies between local and climate-driven impacts on coral reefs in the Tropical Pacific: A review of issues and adaptation opportunities. *Marine Pollution Bulletin*, *164*(February), 111922. https://doi.org/10.1016/j.marpolbul.2020.111922

Fattah, M., Intyas, C.A., Utami, T.N., Sofiati, D., & Abdillah, K.I. (2021). Pemetaan Posisi Keunggulan Ekowisata Bee Jay Bakau Resort [(The Advantages Position Mapping of "Bee Jay Bakau Resort" Ecotourism]. *Jurnal Penelitian Sosial Dan Ekonomi Kehutanan Vol.*, *18*(2), 129–139. https://doi.org/10.20886/jpsek.2021.18.2.129-139

Grey, M., Blais, A.M., & Vincent, A.C.J. (2005). Magnitude and trends of marine fish curio imports to the USA. *Oryx*, *39*(4), 413–420. https://doi.org/10.1017/S0030605305000967

Hadi, T.A., Abrar, M., Giyanto, B.P., Johan, O., Budiyanto, A., Dzumalek, A.R., Alifatri, L.O., Sulha, S., & Suharsono. (2020). The status of Indonesian coral reefs 2019. In *Research Center for Oceanography-Indonesian Institute of Sciences, Jakarta*.

Hadi, T.A., Giyanto, Prayudha, B., Hafizt, M., Budiyanto, A., & Suharsono. (2018). *Status Terumbu Karang Indonesia 2018 [The status of Indonesian coral reefs 2018]*. Pusat Penelitian Oseanografi – Lembaga Ilmu Pengetahuan Indonesia.

Hariyatno, H., Isanawikrama, I., Wimpertiwi, D., & Kurniawan, Y.J. (2018). Membaca Peluang Merakit "Uang" Dari Hobi Aquascape [Reading the Opportunity to Build "Money" From the Hobbyist Aquascape]. *Jurnal Pengabdian Dan Kewirausahaan*, *2*(2), 117–125. https://doi.org/10.30813/jpk.v2i2.1364

Intyas, C.A., & Abidin, Z. (2018). *Manajemen Agribisnis Perikanan [Fisheries Agribusiness Management]*. UB Press.

Intyas, C.A., Putritamara, J.A., & Haryati, N. (2022). *Dinamika Agrobisnis Era VUCA (Volatility, Uncertainty, Complexity, Ambiguity) [Agribusiness Dynamics of the VUCA Era (Volatility, Uncertainty, Complexity, Ambiguity)]*. UB Press.

Intyas, C.A., Susilo, E., & Indrayani, E. (2022). *Modal sosial dan Kemiskinan Nelayan*. UB Press.

Johan, O., Yulius, Salim, H.L., Ardi, I., Abrar, M., & Daulat, A. (2019). Keberadaan Karang Hias Dalam Perbedaan Kondisi Tutupan Karang Hidup Di Teluk Saleh, Nusa Tenggara Barat [The Existence Of Ornamental Coral In Different Live Coral Coverage Condition In Saleh Bay, West Nusa Tenggara]. *Jurnal Segara*, *15*(2), 99–108. http://dx.doi.org/10.15578/segara.v15i2.6592

Karim, I., Wulandari, E., Arsal, A., & Mandasari, N.F. (2021). The Causality Model of Maize Farmers' Income: Integrating Social Capital, Supply Chain, and Competitive Advantage. *International Journal on Advanced Science, Engineering and Information Technology*, *11*(1), 252–258. https://doi.org/10.18517/ijaseit.11.1.8275

Kepmen, K.P. (2017). Keputusan Menteri Kelautan dan Perikanan Republik Indonesia Nomor 50/Kepmen-Kp/2017 Estimasi Potensi, Jumlah Tangkapan yang Diperbolehkan, dan Tingkat Pemanfaatan Sumber Daya Ikan di Wilayah Pengelolaan Perikanan Negara Republik Indonesia [Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia, Number 50/Kepmen-Kp/2017, Estimation of Potential, Amount of Allowed Catch, and Level of Utilization of Fish Resources in the Fisheries Management Area of the Republic of Indonesia]. *Keputusan Menteri Kelautan Dan Perikanan Republik Indonesia Nomor 50/Kepmen-Kp/2017*, 6.

Koroy, K., Nurafni, & Husain, N. (2014). Tutupan Karang Lunak Di Perairan Desa Pandanga Kabupaten Pulau Morotai [Soft Coral Coverage In Pandanga Village Waters, Morotai Island Regency]. *Jurnal Enggano*, *5*(1), 53–63. https://doi.org/10.31186/jenggano.5.1.53-63

LIPI P2O. (2018). Status Terkini Terumbu Karang Indonesia 2018. *Lipi*, *November*, 1. http://lipi.go.id/siaranpress/lipi:-status--terkini-terumbu-karang-indonesia-2018-/21410

Munica, D., Triarso, I., & Pramonowibowo. (2016). Analisis Bioekonomi Sumberdaya Ikan Gabus (*Ophiocephalus striatus*) Model Gordon Schaefer Di Perairan Rawa Pening Kabupaten Semarang [Resource Bioeconomic Analysis Fish Cork (*Ophiocephalus Striatus*) Gordon Schaefer Model In Rawa Pening Water, Semarang District]. *Journal of Fisheries Resources Utilization Management and Technology*, *5*(4), 88–97.

NOAA. (2015). *The Coral Triangle – The Amazon of the Seas*. Start1.Org. https://start1.org/news/the-coral-triangle-the-amazon-of-the-seas/

Rhyne, A.L., Tlusty, M.F., & Kaufman, L. (2014). Is sustainable exploitation of coral reefs possible? A view from the standpoint of the marine aquarium trade. *Current Opinion in Environmental Sustainability*, *7*, 101–107. https://doi.org/10.1016/j.cosust.2013.12.001

Riadi, S., Wahyudin, Y., & Arkham, M.N. (2018). Literatur Review: Kebijakan Pelarangan Perdagangan Karang Hias Dan Anemon Oleh Kementerian Kelautan Dan Perikanan [Review Literature: Policy Of Backing For Trading Ornament Corals And Anemon By The Ministry Of Marine And Fisheries Affairs]. *Coastal and Ocean Journal*, *4*(2), 83–90. https://doi.org/10.29244/COJ.2.2.83-90

Seascapes Working Group CTI-CFF. (2015). *Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security*.

Silva, R., Da Pearce-Kelly, P., Zimmerman, B., Knott, M., Foden, W., & Conde, D.A. (2019). Assessing the conservation potential of fish and corals in aquariums globally. *Journal for Nature Conservation*, *48*, 1–11. https://doi.org/10.1016/J.JNC.2018.12.001

Sobari, M.P., Diniah, & Isnaini. (2009). Kajian Bio-Ekonomi dan Investasi Optimal Pemanfaatan Sumberdaya Ikan Ekor Kuning di Perairan Kepulauan Seribu [Bio-Economic Studies and Optimal Investment Utilization of Yellowtail Fish Resources in the Perairan Seribu Islands]. *Jurnal Mangrove Dan Pesisir*, *IX*(2), 56–66.

Sparre, P., & Vennema, S.C. (1998). *Introduction to Tropical Fish Stock Assessment.* Food and Agriculture Organization of The United Nations.

Suharsono. (2008). *Jenis-Jenis Karang Indonesia*. LIPI Press.

Susiloningtyas, D., Handayani, T., & Amalia, A.N. (2018). IOP Conference Series: Earth and Environmental Science The Impact of Coral Reefs Destruction and Climate Change in Nusa Dua and Nusa Penida, Bali, Indonesia. *IOP Conf. Series: Earth and Environmental Science*, *145*, 12054. https://doi.org/10.1088/1755-1315/145/1/012054

Swara, S.E., & Intyas, C.A. (2021). *Value Chain performance of the three developing Mangrove Ecotourism in East Java*. *27*, 360–365. http://doi.org/10.53550/EEC.2022.v28i03.051

United States Environmental Protection Agency. (2022). *Basic Information about Coral Reefs* |. United States Environmental Protection Agency. https://www.epa.gov/coral-reefs/basic-information-about-coral-reefs

Wabnitz, C., Taylor, M., Green, E., & Razak, T. (2003). *From Ocean to Aquarium: The Global Trade in Marine Ornamental Species*. UNEP-WCMC.

Widodo, Y., & Suadi. (2016). *Pengelolaan Sumberdaya Perikanan Laut [Management of Marine Fisheries Resources]*. Gajah Mada University Press.

Yanto, F., Susiana, & Muzammil, W. (2020). Tingkat Pemanfaatan Ikan Umela (*Lutjanus vitta*) di Perairan Mapur yang didaratkan di Desa Kelong Kecamatan Bintan Pesisir Kabupaten Bintan [Utilization Rate of Brown Strip Red Snapper (*Lutjanus vitta*) on Mapur waters that landing in Kelong Village, Bintan Pesisir Sub District, Bintan Regency]. *Journal of Tropical Fisheries Management*, *4*(2), 1–9. https://doi.org/10.29244/jppt.v4i2.31955

Zhang, Z., & Fong, K. (2021). Estimation of key population parameters and MSY-based reference points for sidestripe shrimp (*Pandalopsis dispar*) in the Fraser River Delta, British Columbia. *Fisheries Research*, *238*. https://doi.org/10.1016/J.FISHRES.2021.105893

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