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Analysis of Ecological and Social Relationships as the Basis for Sustainability of Giant Clams (*Tridacnidae*) Conservation in the Thousand Islands National Park, DKI Jakarta

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ABSTRACT

This research was conducted to determine the community structure of giant clams in the Thousand Islands National Park in the core zone and protection zone including giant clam abundance, giant clam uniformity and clam dominance, and analyze the social behavior of the community towards giant clams in the core and protection zones. Data collection on clam habitat conditions was carried out at 5 locations namely Corn Island, The Netherlands, Kayu Angin Bira, Nyamplung and West Penajliran. Data retrieval using the belt transect method with modified underwater visual census (UVC). Assesment of habitat conditions refers to the parameters of salinity, brightnesss, acidity and temperature. The results showed that the waters of the core and protection zones at the 5 locations contained 2 types of clams, namely *Tridacna squamosa* and *Tridacna crocea*. Overall, the observation sites have low diversity, abundance and uniformity values. The dominance of *Tridacna crocea* has a high value and that of *Tridacna squamosa* has a low dominance value. Social behavior data collection in TNKpS was carries out by in-depth interview method with snowball sampling technique in TNKpS community. The results of the analysis of the social behavior of the TNKpS community show that *Tridacna squamosa* is still being hunted for its meat for consumption, especially on Eid holidays. The recommendation given to the Area manager is the establishment of a clam conservation area that is more focused on the core zone and protection based on the community structure of the clam.

1. Introduction

Giant clams are a mollusk that belongs to the family *Tridacnidae* and is a macrozoobentos that lives in coral reef ecosystems. They are widely distributed with a high level of diversity in the Indo-Pacific region. Thousand Islands National Park (TNKpS) has a logo with Giant Clams elements. High biodiversity in the Thousand Islands is found in coral reef

ecosystems, which are the habitat of Giant Clams. As an area that is primarily aquatic, and there are various kinds of biota and ecosystems in it. TNKpS emphasizes various focuses on the development of conservation, cultivation, and tourism.

Giant Clams are one of the biota used by coastal communities; all parts of giant clams can be used and can be a source of food that is very easy to take from nature. Since 1983, CITES (Convention on International Trade In Endangered Species) has classified clams as protected marine life, but clams are traded as aquarium animals, their shells as jewelry, and their meat can be consumed and exported abroad.

Giant Clams are still difficult to cultivate, but domestication efforts and hatchery engineering have been carried out to prevent overexploitation in nature. One of the ten natural resources that are the focus of conservation in TNKpS based on the Decree of the Head of the Thousand Islands National Park Office No. K.35/BTNKpS-1/2014 concerning Important Natural Resources is clam conservation.

One of the efforts to maintain the survival of clams in nature is in-situ conservation in TNKpS, which has been applied to the core zone and protection. The core and protection zones play a role in maintaining and preserving all marine life contained in them and prohibit various utilization activities in the area to maintain the presence of marine life in the area (Sadili *et al*. 2015).

Currently, the existence of clams in coral reef ecosystems in the Kepulauan Seribu is under a lot of potential pressure, so it can experience a drastic population decline. One of the causes of this is human activity and the environment. Social and ecological factors have relationships that can be analyzed as the basis for the sustainability of Giant clam conservation in TNKpS. Based on this, Giant clam conservation is expected to succeed and remain sustainable in TNKpS, especially in the core and protection zones.

2. Methods

The study was conducted in the Thousand Islands National Park on October 13–20, 2020. Data collection was carried out in the core zone (Kayu Angin Bira, Penjaliran Barat, and the Netherlands) and protection zones (Jagung and Nyamplung Island).

Table 1. Observation sites

Location	Zone	Coordinate
Kayu Angin Bira Island	Core	5º60'73.87''S - 106º57'22.95'' E
Penjaliran Barat Island	Core	5º46'70.57''S - 106º56'13.01'' E
Belanda Island	Core	5º60'73.59''S - 106º60'13.85'' E
Jagung Island	Protection	5º47'93.48''S - 106º52'92.68'' E
Nyamplung Island	Protection	5º50'30.88''S - 106º53'62.38'' E

The method used in this study is the survey method, which produces primary and secondary data. After the data is obtained, an analysis of conservation suitability, carrying capacity, and identification of various internal and external factors is carried out to determine a strategy plan for more effective management of clam conservation.

Clam data collection using the Belt Transect method with Underwater Visual Census (UVC) modification at a depth of 3–10 meters with one point on each island is determined based on purposive sampling. Stationary point counts are individual calculations in the UVC method, researcher counts individual clams in cylindrical space at a radius based on transect length, which is 100 meters in an area selected by purposive sampling for 90 minutes, consisting of 30 minutes of snorkeling and 60 minutes of diving (Samoilys, 1997). Data collection includes the type, number, and size of clams that are in the transect dimensions on the right and left sides and records habitat conditions.

Meanwhile, data collection of physical-chemical parameters is taken in situ at each station, including salinity, acidity (pH), water temperature, and brightness.

Social data collection for primary data using the snowball sampling method In its implementation, an interview was conducted first with a group or a relevant respondent, and then the person concerned was asked to name the next prospective respondent who had a specialization in the same field (Djamba & Neuman, 2002).

Data from observations are processed and analyzed with several formulas;

a. Clam abundance based on Odum (1996)

$$Ki = \frac{ni}{A}$$

b. Diversity of Clam based on Shannon Wiener index

$$H' = -\sum (Pi \ln Pi)$$

$$Pi = \frac{ni}{N}$$

c. Clam uniformity index based on Odum (1971)

$$E = \frac{H'}{Hmax}$$

$$Hmax = Ln\ S$$

d. Clam domination index based on Simpson (1949)

$$D = \sum_{t=0}^{n} (\frac{ni}{N})^2$$

3. Result

3.1 Physical and Chemical Conditions of Waters

The values of temperature, salinity, brightness and pH at the research site are generally within the range of marine life quality standards KEPMEN LH No. 51 of 2004 (Table 2).

The temperature of the waters is generally 30°C, in accordance with the optimal temperature criteria for clams, which range from 25°C to 32°C. The brightness of the waters obtained mostly has a visibility of more than 5 m; by default, the quality of the brightness of the waters is included in the criteria that are suitable for marine life and for clams. The salinity of seawater is an important factor in the distribution of marine life, and this affects the distribution of benthos animals such as Bivalves, especially clams, because marine organisms can only tolerate small and slow changes in salinity. Some observation sites with high salinity have a small number of clam individuals, such as on Nyamplung, Belanda, and Harapan Island.

Table 2. Physics-chemical parameter values of observation sites

Parameter	Island				
	Belanda	Kayu Angin Bira	Penjaliran Barat	Jagung	Nyamplung
Salinity	37 ppt	36 ppt	33 ppt	32 ppt	38 ppt
Clarity	4,35 m	6,3 m	6,2 m	7,4 m	8 m
pH	8,5	8,5	8,1	8,0	8,3
Temperature	30°C	30°C	30°C	30°C	30°C

The salinity of the waters shows a range of 32–38 ppt, in accordance with the criteria of good salinity for clams according to Jameson (1976), which is in the range of 25–40 ppt.

The acidity of the waters at the sites is generally in accordance with the quality standards of marine life, and the pH value of Pulau Harapan exceeds the standard value of

water quality (7.0–8.5), which is 8.6. Waters with pH <5 and pH >9 create unfavorable conditions for most macrobenthos organisms (Sadili, Ramli, et al., 2015).

3.2 Types and Abundance of Clams

Clams identification is carried out by observing the size of the shell, shell shape, and substrate found in the observation location by referring to the clam monitoring guidelines (Sadili, Sarmintohadi, et al., 2015).

The most common type of clam found is the hole clam (*Tridacna crocea*) because at the observationsites there are many habitat substrates for hole clams, namely massive corals and on these substrates hole clams are attached to the mantle involved (KKP. go. id, 2021). Scaled clam (*Tridacna crocea*) was only found at the observation site on Corn Island in as many as four individuals.

The results of the analysis of the length of the clamshell show that there are more hole clams in the adult phase than clams in the juvenile and post-juvenile phases. All individuals of scales found are in the post-juvenile phase with a size of 10–20 cm. A low number of daughter phases indicates a high failure rate in the recruitment process of clam larvae. Failure of larval recruitment can be caused by various factors related to species traits, genetic patterns, habitat conditions, and other environmental factors (Hernawan, 2010). From secondary data based on 2020 clams inventory data covering 14 islands, the abundance value of clams was obtained as in Table 5.

Table 3. Clams data at the observation sites

Island	**Species**	
	Tridacna squamosa	*Tridacna crocea*
Belanda	-	8 ind
Kayu Angin Bira	-	10 ind
Penjaliran Barat	-	45 ind
Jagung	4 ind	37 ind
Nyamplung	-	8 ind
Total	4 ind	110 ind

Table 4. Phases of Clams growth

Species	**Growth phase**	**Size criteria**	**Lokasi Pengamatan**
T. squamosa	Juvenile	<10 cm	-
	Post-Juvenile	10-20 cm	4 ind
	Adult Hemaphrodite	>20 cm	-
T. crocea	Juvenile	<2 cm	1 ind
	Post-Juvenile	2-4 cm	4 ind
	Adult Hemaphrodite	>4 cm	105 ind

Table 5. Abundance of Core Zone Clams and TNKpS Protection (2020 Clams Inventory)

No	Island	Zone	Abundance (Ha)	Species
1	Gosong Rengat	Core	60	ts,hh
2	P.Gosong Rengat	Core	40	ts
3	Penjaliran barat	Core	80	ts,tc
4	Penjaliran timur	Core	200	ts,tc
5	Peteloran barat	Core	320	ts,tc
6	Peteloran timur	Core	160	tc
7	Pulau belanda	Core	120	ts,tc
8	Kayu Angin bira	Core	40	ts,tc
9	Bira Besar	Core	40	tc
10	Rengit	Protection	140	ts,tc
11	Jagung	Protection	40	ts,tc
12	Sebaru Besar	Protection	140	tc
13	Dua timur	Protection	440	ts,tc,td,hh
14	Dua Barat	Protection	80	ts,tc,hh

Notes:
tc : *Tridacna crocea*, ts : *Tridacna squamosa*, tm : *Tridacna maxima*
hh: *hipopus hipopus*, tg :*Tridacna gigas*, td : *Tridacna derasa*

The clams abundance data obtained by the 2020 clams inventory includes two management zones, namely the core and protection zones, with the highest abundance on Dua Timur Island with a value of 440 ind/Ha, followed by the abundance on Peteloran Barat Island with a value of 320 ind/Ha, and Penjaliran Timur Island with a value of 200 ind/Ha.

The abundance of individuals below 1 ind/m2 falls into the category of low abundance (Planes et al., 1993). The abundance of clams in the Thousand Islands National Park is in a low category, indicating an imbalance in environmental conditions and various other factors based on ecological and social analysis, with the influence of community activities being the biggest factor. This is also supported by 2020 Clams inventory data, which shows that the average abundance in the core and protection zones covering 14 islands has been valued at *Tridacna squamosa* (18.89 ind/Ha), *Tridacna crocea* (62.22) ind/Ha, *Tridacna maxima* (12.22 ind/Ha), and *Hippopus hypoppus* (14.44) ind/Ha. In terms of the abundance of Clams on each island, there is no abundance with a value exceeding 1 ind/m2 from both primary and secondary data.

3.3 Clams Dominance

Simpson's dominance index value has an index value ranging from 0 to 1, and the closer it is to 1, the higher the dominance is said to be. Overall, the highest dominance value was from the *Tridacna crocea* type, with a dominance index value of 1 at each observation location except Jagung Island, which was valued at 0.85.

The lowest overall dominance is found in the *Tridacna squamosa* type with values ranging from 0 – 0.17 thus indicating that dominance is low.

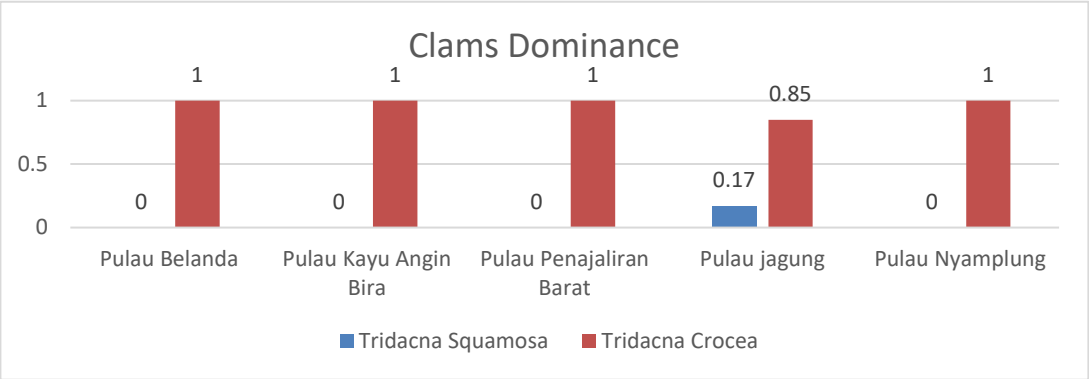

Figure 1. Clams dominance graphic

The dominance of *Tridacna crocea* is also supported by 2020 Clams inventory data. The results of the clams inventory show that the species with the largest dominance of the 14 islands is *Tridacna crocea* with dominance on 10 islands; *Tridacna squamosa* on 3 islands; and *Tridacna derasa* on 1 island.

Table 6. Core Zone Clams Dominance Value and TNKpS Protection (2020 Clams Inventory)

No	Island	Zone	Dominance	Species
1	Gosong Rengat	Core	66,67 %	ts
2	P.Gosong Rengat	Core	100,00 %	ts
3	Penjaliran barat	Core	75,00 %	ts
4	Penjaliran timur	Core	80,00 %	tc
5	Peteloran barat	Core	87,50 %	tc
6	Peteloran timur	Core	100,00 %	tc
7	Pulau belanda	Core	80,00 %	tc
8	Kayu Angin bira	Core	50,00 %	tc
9	Bira Besar	Core	100,00 %	tc
10	Rengit	Protection	66,67 %	tc
11	Jagung	Protection	50,00 %	tc
12	Sebaru Besar	Protection	100,00 %	tc
13	Dua timur	Protection	47,83 %	td
14	Dua Barat	Protection	50,00 %	tc

3.4 Clams Diversity and Uniformity Index

The higher the diversity index value, the higher the diversity of the number of species. The diversity value obtained is 0.15, which indicates that diversity is low (H'<1). Communities in environments that are affected by periodic human and natural disturbances have lower species diversity than communities in stable environments (Odum, 1996).

From the value of the diversity index obtained, the value of the clams uniformity at the observation location is 0.2. This value shows that the uniformity value obtained is relatively low (E < 0.4). An evenness index close to 0. Tends to indicate a community that is less stable and in a depressed state due to environmental pressures. The difference in the evenness index value at the third station is thought to be caused by environmental factors that are more suitable to support the life of clams (Rachimi et al., 2019).

3.5 The relationship of community activities to clams conservation

Coastal communities in the Thousand Islands National Park Area are one of the important factors for the sustainability of clams and the reduction of clams. These interview points include clams as a protected animal, ongoing clam hunting, clams as a food ingredient, and public awareness of clams conservation. Interviews were conducted with seven respondents who can be trusted as sources for interview respondents (Table 7).

Table 7. Interview respondents

No	Name	Information
1	Mr. Gogo	Harapan island community and TNKpS honorary
2	Mr. Saudin	Harapan island village secretary
3	Mr. Syahrul	Harapan island community
4	Mr. Herman	Harapan island fisherman
5	Mr. Ari	TNKpS staff
6	Mr. Salafi	Harapan island community and TNKpS honorary
7	Mr. Dul	Harapan island head neighborhood

Clams are a sensitive issue for some Thousand Island people, based on interviews from all respondents who said that Clams are a source of food that for decades has been a food for the people of Thousand Islands at the celebration of Eid. From this, it can be concluded that clam-eating activities have long been a culture and tradition for the people of the Thousand Islands; generally, clams are eaten together with ketupat (Javanese and Sundanese rice cake). Along with the huge hunting of clams, the Indonesian government has designated clams as a protected species through Government Regulation Number 7 of 1999 concerning the Preservation of Plant and Animal Types because they are rare, endangered, have slow growth (2–12 cm/year), and are experiencing population decline. Since 1983, the World Conservation Organization (IUCN) has listed clams on the IUCN red list as vulnerable, and the Convention on International Trade in Plants and Wildlife (CITES) has listed all species of clams in Appendix II (kkp.go.id, 2021).

Clam hunting activities as a food source are still running. Even though there are regulations on the protection of clams in Indonesia, this is strengthened by the remains of scale clam shells found in as many as 5 shells, namely 20–40 cm long scale clam shells (Figure 2). Clams are hunted by taking its flesh and then throwing its shells into the sea. It can be concluded that the clam hunted is a type of large-sized clam, and the large-sized clam left in the Thousand Islands is the scaled clam (*Tridacna squamosa*). The giant clam (*Tridacna gigas*) can no longer be found in the nature of the Thousand Islands at this time; only its shells are stored in the TNKpS office, and based on respondents as TNKpS staff, there is no documentation of giant clams in the nature of the Thousand Islands.

Figure 2. Scaled Clam Shells found at the Observation Site (Source: Personal Documentation. 2021)

Fishermen entering the core and protection zones are generally compressor fishermen from Panggang Island, known for frequently violating by using destructive fishing gear, entering the core and protection zones, and hunting clams. This was confirmed by all respondents and reinforced by

documentation of compressor fishermen's activities encountered when data collection was carried out on Jagung Island. Fishermen took fish and scale clams from Jagung Island, which is a protection zone where there should be no utilization activities at all (Figure 2).

(a) (b)

Figure 3. (a) Compressor fisherman, (b) New holes from gouging clams (Source: Personal documentation, 2021)

From the fishermen's activities that are still being carried out and based on all respondents statements that clams are still hunted as food, it strengthens the analysis that one of the biggest factors in not finding many scale clams in TNKpS clams conservation is the impact of clam hunting activities. Environmental factors in clam habitat are also important things that affect the effectiveness of clam conservation. In some core zones and areas of protection, there are still quite a few hole clam individuals, which means that it still have the potential to multiply in number.

The culture of people consuming Clams on Eid is difficult to change. According to respondents who are communities on Harapan Island, the status of clams protected by the community is already known, but public awareness of clams is still relatively lacking, and law enforcement for perpetrators is still less firm and clear, which causes fishermen to still violate, which has an impact on the ineffectiveness of clam conservation.

3.6 Analysis of social and ecological relationships

Studies of social and ecological relationship analysis can be applied as a sustainable basis for clam conservation in TNKpS to determine the pattern of social and ecological interaction with clams. This analysis is based on data on the abundance and dominance of clams that influence the behavior of clam fishing communities in TNKpS (Figure 4).

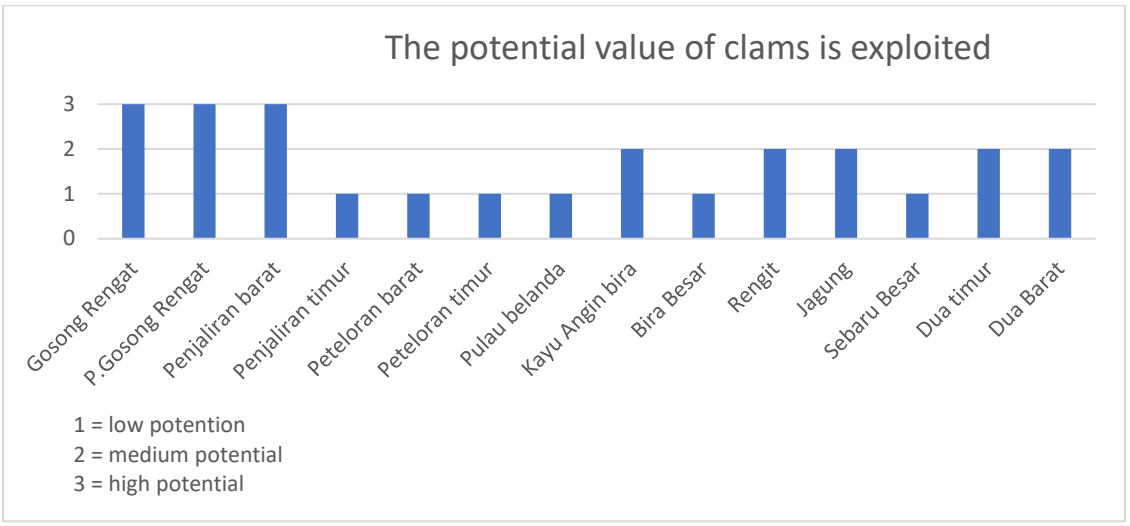

Figure 4. The potential value of clams exploited graphic

From the social and ecological analysis, the exploitation activities of clam fishermen have great potential to be carried out in 3 core zones, namely Penjaliran Barat (West Penjaliran/Gosong Island), and medium potential to be carried out in 4 protection

zones, namely Rengat Jagung Island, Dua Timur, and Dua Barat.

The results of the analysis are expected to help in understanding how the challenges of clam conservation management affect their ecological and social relationships. Further studies are needed to explore the activities of clam fishermen to determine their direct and comprehensive influence on the presence of clams in TNKpS, especially on scale clams (*Tridacna squamosa*). In addition, it is necessary to evaluate countermeasures and actions related to the activities of clam fishermen that are still ongoing.

7. Conclusion

In the study, two types of clams were obtained at the observation site, namely *Tridacna squamosa* and *Tridacna crocea*. Overall, based on the abundance, diversity, and uniformity of clams, this research has a low value, even though the value of aquatic habitats from clams has sufficient quality standards. The dominance of clams at observation sites, core zones, and protection is dominated by *Tridacna crocea*. The islands dominated by *Tridacna squamosa* are Gosong Rengat, P. Gosong Rengat, and Penjaliran Barat.

The social behavior of the TNKpS community is one of the big factors in the declining clams population because clam hunting activities for consumption still continue on Eid al-Fitr. Although the community's understanding of protected clams is thorough.

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