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RESEARCH ARTICLE **OPEN ACCESS**

Biodiversity of Bivalvia Tridacnidae in Marine Conservation Area : Lesson Learned from Abang Island, Kepulauan Riau Province-Indonesia

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Abstract. Kima (local name) is known as a giant clam of a group of bivalve mollusca belonging to the Tridacnidae family that live in coral ecosystems zhich are considered as endangered species (CITES: Appendix II). This study aims to determine the biodiversity and ecological index of Tridacna in Abang Island waters, as well as determine the status of its presence in this area. A field survey was conducted on the type, number and distribution of tridacnae at each location by SCUBA equipment dive using the sweept area method on the transect lines. The transect wasplotted at 2-5 m in depth parallel to the shoreline at each observation station with covering observation area as far as 2.5 meters both on the left and 2 right side of the observers. The results showed 5 species of Kima with a total of 75 individuals, namely *Tridacna maxima, T. Squamosa, T. crocea, T.derasa* and *H. hipppus.* The densitywas maximal for *T.maxima* 0.014 individu/M^2 folowing by *T.squamosa* (0.009/M^2), *T.crocea* (0.006/M^2), *T.derasa* (0.003/M^2), *H.hipppus* (0.001/M^2). While the relative density were *T.maxima* (44%), *T.squamosa* (26.7%), *T.crocea* (18.7%), *T.derasa* (8.0%), and *H.hipppus* (2.7%). The diversity index (H ') was 1.33 with representing a medium diversity category, dominance index (D) equal to 0.70 and Uniformity (E') equal to 0.82. *T. maxima, T. squamosal*, and *T. crocea* were found abundantly in the study area while *T.derasa* and *H. hippopus* were hard to find and *T. gigas*wasabsences presumably due to local extinction and functional extinction. Protectionof Tridacna in natural habitats is a must to maintain the ecological function and sustainability of Tridacn awith strict and controlled management.

Keywords: Tridacna, indeks ecological index, giant clam, bivalvia, biodiversity, Kima

Introduction

Kima is known as a giant clam, a group of bivalve mollusk belonging to the Tridacnidae family that living in coral ecosystems throughout the Red Sea and the Indo-Pacific region (Ellis, 1999; Andréfouët *et al.*, 2014; Arias-ruiz *et al.*, 2017), with populations in nature declining due to overcrowding and habitat destruction in coral reef ecosystems throughout the Indo-Pacific and Oceania experiencing rapid decline. This condition has lead the local extinction of the Tridacna which was impacted on significant functional extinction (Pasaribu, 1988; Tisdell and Menz, 1992; Apte *et al.*, 2010; Waters *et al.*, 2013; Mohamed *et al.*, 2016). Recently, *T. maxima* serve as a suitable bioindicator in the environmental biomonitoring program (Métais *et al.*, 2012) while *T. squomosa* can confirmly reflect environmental changes from rising temperatures and rainfall due to La Nina's extreme weather within 2016-2011 in Sulawasi-Indonesia (Arias-ruiz et al., 2017).

According to Othman *et al.*, (2010) there are ten members of the Tridacnidae clam family i.e. *T. gigas* (Linnaeus, 1758), *Hippopus hippopus* (Linnaeus, 1758), *T. maxima*, *T. derasa*

(Roding, 1798), *T. crocea*, *T. squamosa* (Lamarck, 1819), *H. porcellanus* (Rosewater, 1982), *T. teveroa* (Lucas, Ledua & Braley, 1991), *T. rosewateri* (Sirenko & Scarlato, 1991) and *T. costata* (Richter, Roa-Quiaoit, Jantzen, Al-Zibdah & Kochzius, 2008). Recent reports that based on the genetic and morphological description of *T. noae* have been separated from *T. maxima* (Su *et al.*, 2014a). *T.maxima* has the largest distribution range, with geographical reach extending from the western Indian Ocean to Polynesian (Lucas, 1988; Soo and Todd, 2014). *T. crocea*the smallest of a giant clam species, grows to a length of about 15 cm. This species is similar to *T. maxima*, but smaller, less asymmetrical and with blurred scales except near the top edge of the shell. Life by sinking into rocks and coral reefs (Lucas, 1988; Panggabean, 1990). All of these giant clams are settled in coral reefs in shallow waters and live in symbiotic photosynthesis with xanthophyllae algae (symbiodinium) grown in mantle tissue (Griffiths and Klumpp, 1996; Boglio and Lucas, 1997; Soo and Todd, 2014).

The Convention on International Trade of Endangered Species (CITES) classifies this group of animals in Appendix II, which means groups of species thought to be endangered by uncontrolled trade, considered vulnerable under the threatened species list of the Global Union for Conservation of Nature (Waters *et al.*, 2013). The high price and habit of consuming high Tridacna shellfish from the community is also one of the causes of uncontrolled consumption, even within conservation areas. Tridacna become a very popular in aquascape hobbies. The *T. maxima* species measuring 2 inches and have good and attractive colors sell for US $ 40/individufor used as an ornamental animal in aquarium (Ambariyanto, 2007). Rizal *et al.*, (2014) reported that the utilization of Tridacna by local communities in Taka Bonerate National Park is limited only for their self-needed. A number of case studies highlighting excessive exploitation for international trade are considered as one of several anthropogenic factors that potentially affect the biological status of the wild taxa in question. There may be local trade and additional threats, such as habitat loss, pollution, invasive species and climate change, which can coincide with the impact of harvesting in nature (Smith *et al.*, 2011; Andréfouët *et al.*, 2014).

Abang Island waters is the core zone of the Regional Marine Conservation Area (RMCA) Batam City which is a group of small islands including Dedap Island, Racers, Sepintu, Udik, Sawang. Tridacna shellfish is one of the biodiversity of coral reef ecosystem in Abang Island waters which directly or indirectly become target in utilization by society. Information on the existence of Kima biodiversity in this region is not known in detail, but taking in nature is still ongoing. Therefore, this study aims to determine the biodiversity and ecological index of Tridacna shells in RMCA Abang Island waters of Batam Island, through the value of the index of diversity (H '), density (K), relative density (KR), dominance (D) and, E), as well as determine the status of its presence in this area.

Material and Methods

The study was conducted in October-December 2015 at six location points on the RMCA area of Batam City Abang Island Waters (Figure 1.). Locations are determined based on information of the community allegedly there are many kima. As for locations are 1). Pulau Udik, 2). Pulau Pengalap (Tjg. Tok), 3). Pulau Dedap, 4). Sawang Island, 5). Pulau Sepintu Kecil, and 6). Pulau Sepintu Besar.

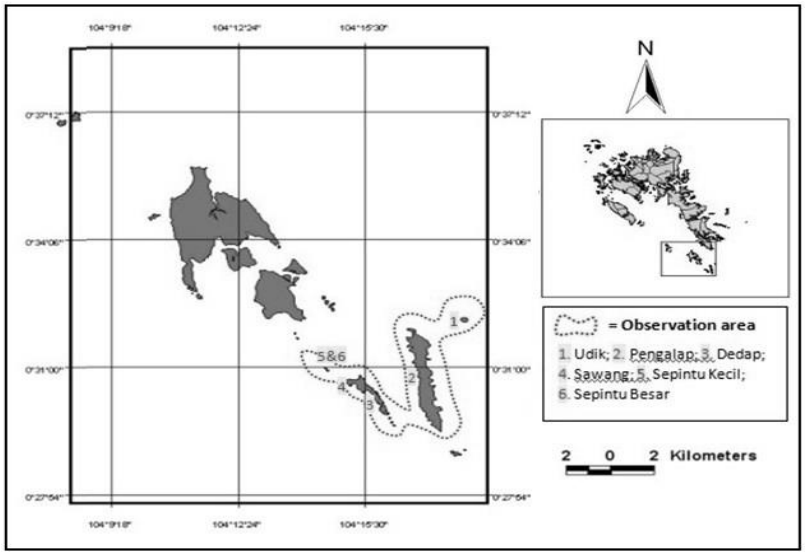

Figure 1. Map of Research Locations

Data collection

Data collection was conducted by conducting field survey on the type and number of tridacnae shells and spreading at each location by dive using the sweept area method on the transect line within a certain area. The transect is made by drawing a line of meter along the length determined along the coral reefs parallel to the shoreline at each observation station. Furthermore, divers dive the types of clones found along the transect by limiting the observation space as far as 2.5 meters on the left and 2.5 meters right of the transect line at an average depth of 2-5m (at sea tides). Such a method is also carried out by Apte *et al.*, (2010) that the assessment of the size of the giant clamfish population so far follows various techniques such as the transect method in addition to remote sensing. The introduction and identification of Tridacna shells refers to Lucas, (1988), Hernawan, (2012); Su *et al.*, (2014b); Neo *et al.*, (2015).

The data analysis was calculated based on Shannon-Wienner's quantitative ecological value (1949) in Ludwig and Reynolds (1988). This analysis aims to construct a description of the quantitative ecological value of Tridacnae shells in terms of the index value of diversity (H '), density, relative density, dominance (D) and, uniformity of species (E). All the data that didapaat presented in the form of tables and graphs. According to Apte *et al.*, (2010) for rapid assessment of trident population, the use of relative indexes rather than absolute estimates is often wiser within time limits and logistical limitations.

Results and Discussion

The results showed 75 individuals from 5 species of Tridacna in Abang Island waters with an area of 2300 m2. Pulau Udik Station found 2 species with 9 individuals, Pulau Pengalap (Tjg. Tok) 3 species with 35 individuals, Dedap Island 3 species with 23 individuals, Sawang Island 2 species of 2 individuals, Pulau Sepintu Kecil 2 species of 6 individuals and on Sepintu Besar Island not found. Tridacna scallop species found are *T. squamosa, T. derasa, T. crocea, T. maxima, H. hipppus*. Population density of each species was presented in Table 1.

Tabel 1. Number of species and individual Tridacna shells in the area of observation at each location in the KKLD Area of Batam City, Riau Islands-Indonesia

Site	Observed area (m^2)	Species number	Abundance
Pulau Udik	750	2	9
Pulau Pangalap (Tjg. Tok)	250	3	35
Pulau Dedap	750	3	23
Pulau Sawang	150	2	2
Pulau Sepintu Kecil	250	2	6
Pulau Sepintu Besar	150	0	0
Number	**2300**		**75**

The type and density of Tridacna shellfish populations recorded in the Abang Island watershed area RMCA is different compared with those reported previously. Yusuf *et al.,* (2009), reported that the survey found 106 individuals in the Thousand Islands of three tridacna species, *T. squamosa* (40 indv.), *T. maxima* (25 indv.) And *T. crocea* (41 indv.), and Manado waters found 61 individuals from four species of *T. squamosa* (40 indv.), *T. maxima* (3 ind.), *T. crocea* (17 ind.), and *T. gigas* (1 ind.). Other surveys conducted by Pada *et al.,* (2013), in the waters of Venu Island recorded four species present: T. *crocea, T. maxima, T. squamosa* and *T. gigas* from a total of 88 individuals found. Furthermore, Tisera *et al.,*(2012) reported that in the Alor archipelago (Pura Island, Ternate, Batang and Alor) there are four species identified as *T. crocea, T. maxima, T. squamosa* and *H. hippopus* with *T. crocea* and *T. maxima* as the most common in all locations. The density of the shells ranged from 0.33 ind./250 M^2 to 19.250 M^2. Tridacna crocea is found abundantly in Batang Island with a density of 19 individuals / 250m2 and 63% of whom are adolescents (range in size: 2.1-4.6 cm).

Meanwhile, Guest *et al.,* (2008) reported that *H. hippopus* was not found in a 9670m2 survey, suggesting that the species was extinct locally. Only one *T. maxima* specimen was found, suggesting that the species was functionally extinct. The density of *T. crocea* was slightly higher (0.07 per 100 M^2). Cappenberg, (2007), reported on the island of Derawan found 4 types of clams as many as 411 individuals. *T. crocea* was found in a relatively dominant number of individuals, as many as 308 individuals and was present at all observation sites, followed by *T. maxima* 82 individuals; *T. derasa* 14 individuals and *T. squamosa* 9 individuals. The high number of individuals allegedly closely related to the way of life attached to the strong bysus and buried the entire body / shell in the crevices of the rock, making this type difficult to take except by breaking / destroying the rocks where his life (Cappenberg, 2007; Guest *et al.,* 2008).

In this study the largest shell length was obtained on 48cm *T. squamosa* that lived on the dead coral fault. *T. maxima* and *T. crocea* are the smallest species found in 4 cm that live to immerse themselves in living or dead massive corals and are commonly found in Tjg. Tok Pulau Pengalap. Each location of observation has dominance of a certain type. The results also show that there are differences in population at each location. *T. maxima, T. squamosa* and, *T. crocea* were found abundantly in the study area. *T.derasa* and *H. hipppus* are hard to find and *T. gigas* is not found at all. Against these three species of *T.derasa, H. hipppus* and *T. gigas* are suspected to have experienced local extinction and functional extinction as well. According to Lucas, (1988); Soo and Todd, (2014) that *T. maxima* has the largest distribution range with a geographical range extending from the western Indian Ocean to Polynesia.

The density value of the kima species found from the highest is *T. maxima* (0.014/M^2), *T. squamosa* (0.009/M^2), *T. crocea* (0.006/M^2), *T. derasa* (0.003/M^2), *H. hipppus* (0.001/ M^2). The relative density (KR) of Kima for all research stations in RMCA area in Abang Island waters was *T. maxima* (44%), *T. squamosa* (26.7%), *T. crocea* (18.7%), *T. derasa* (8.0%), *H.hipppus* (2.7%). Briefly the density and relative density values of kima can be seen in Table 2.

Table 2. Population Density of Tridacna Clams at RMCAAreas in Abang Island Waters, Batam City Riau Islands-Indonesia

Spesies	Number	Density (population/m^2)	Relative density (RD) %
Tridacna maxima	33	0.014348	44.0
Tridacna squamosa	20	0.008696	26.7
Tridacna crocea	14	0.006087	18.7
Tridacna derasa	6	0.002609	8.0
Hippopus hipppus	2	0.000870	2.7
Total (N)	**75**	**0.032609**	**100.0**

Tridacna density value in this study is not much different from that reported by other researchers. Average density value at location Thausand Islands were *T. squamosa* (0.026 ind./M^2), *T. maxima* (0.016 ind./M^2), *T. crocea* (0.028 ind./M^2) whereas at Manado location, *T. squamosa* (0.021 ind./M^2), *T. maxima* (0.0005 ind./M^2), *T. crocea* (0.0085 ind./M^2) and *T. gigas* (0.002 ind./ M^2). These results indicate that the Kima density at the two study sites is still lower than some locations in Indonesia and abroad (Yusuf *et al.*, 2009) . Meanwhile, Neo and Todd (2012) reported that the survey covered nearly 10.000 M^2 but only 23 individual shells of three species (*T. squamosa* = 14, *T. crocea* = 7, and *T.maxima* = 1) were found (equal to average density 0.24 per 100 m2). In a larger and detailed survey (29 reefs = 87.515 M^2) conducted in 2009 and 2010, recorded a much reduced density of only 0.067 per 100 M^2, and two species of *T. crocea* and *T. squamosa* emerging. Recent surveys have confirmed the absence of *T. gigas, H. hippopus* and *T. maxima*, while *T. squamosa* and *T.crocea* are present only in low numbers.

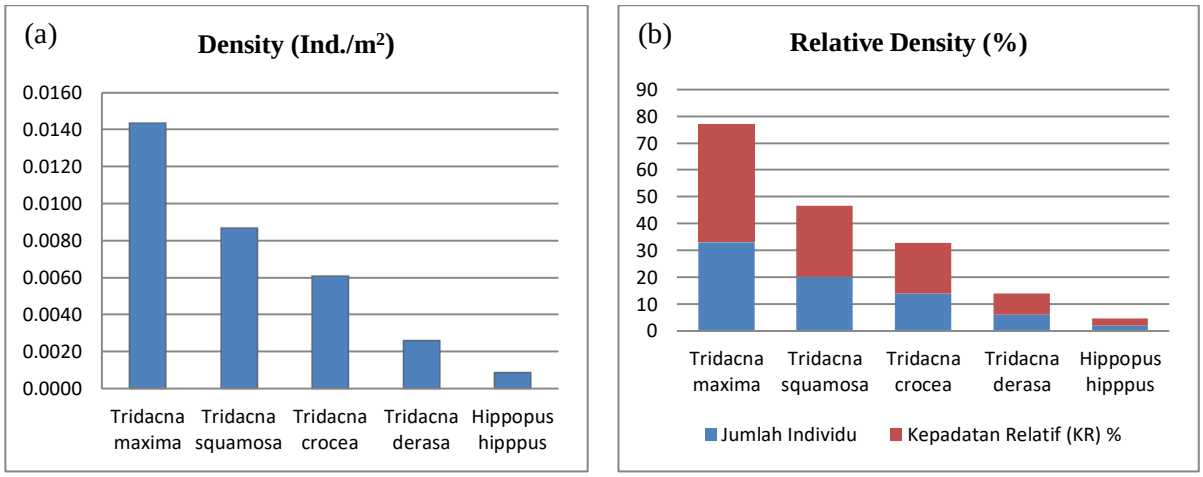

Figure 2. (a) Population Density of Kima, (b) Relative Density

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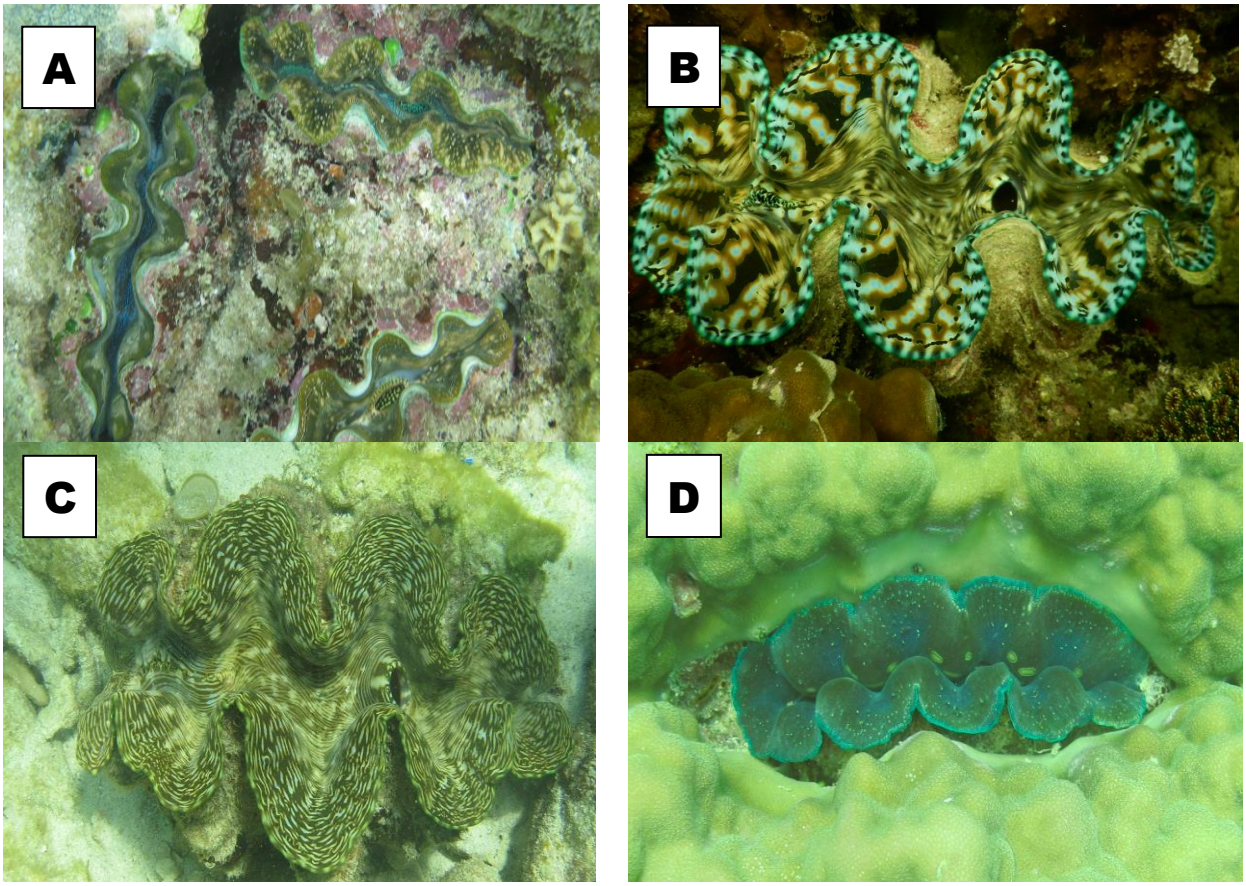

Figure 3. Some *Tridacna spp* found in Pulau Abang water: (a) *T. maxima,* (b) *T. squamosa,* (c) *T. derasa,* and (d) *T. crocea*

In this study, there is a diversity index (H') of 1,326, which shows that this area has a category of medium diversity in the biodiversity category range 1 <H' <3 (Odum, 1971). While the dominance index (D) of 0.703) and Uniform type obtained value (E ') of 0.824. The value of the index obtained indicates that the management of the clams and their habitat should be taken seriously.

Table 3. Kima ecology index in the RMCA area in the waters of Abang Island, Batam City

Diversity Index (H')	Dominancy (D)	H_{max}	Eveness (E')
1.326	0.703	1.609	0.824

It is predicted that the impact of a massive population of giant clams simultaneously occurring in the extinction of ecological functions is illustrated by (Neo *et al.*, 2015) that some of the negative consequences can be predicted, eg, biomass and carbonate production, surface area for epibion, and water filtration, all estimated will decrease with the abundance of giant shell abundance.

Conclusion

Five species of Kima were found with 75 individuals: T.*maxima, T. squamosa, T. crocea, T.derasa* and, *H. hipppus*. The density value for *T. maxima* was 0.014/M^2, *T. squamosa* 0.009/ M^2, *T. crocea* 0.006/ M^2, *T. derasa* 0.003 /M^2, *H. hipppus* 0.001 / M^2. While the relative density for*T. maxima*was 44%, *T. squamosa* 26.7%, *T. crocea* 18.7%, *T. derasa* 8.0%, *H.hipppus* 2.7 %

respectively. There are different types of locations and dominance in locations with high populations. The value of diversity index (H ') is 1,326 with medium diversity category, dominance index (D) equal to 0,703 and Uniformity (E') equal to 0,824. *T. maxima*, *T. squamosa* and, *T. crocea* were found abundantly in the study area. *T.derasa* and *H. hipppus* are hard to find and *T. gigas*was not found. Against these three species, *T.derasa*, *H. hipppus* and *T. gigas* are suspected to have experienced local extinction and functional extinctio1n as well. Protective measures against tridacna shells in natural habitats are still an option to maintain the ecological function and sustainability of Tricana with strict and controlled management.

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