The density of blood cockle (*Tegillarca granosa*) population in the river estuary of industrial area

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Abstract. Blood cockle (*Tegillarca granosa*) has a high value so that it can be utilized as a source of community income. *T. granosa* could be easily found in the coastal area, which is the location of its collection activity. However, fishing activities are thought to be a trigger for the decrease in production of *T. granosa*. Intensive *T. granosa* collection activity has serious impact upon the resources existence. This research aims to identify the density of *T. granosa* in the waters around an industrial area. Swept area was carried out in the sampling process. Purposive sampling method was used to determine the sample. In each zone, there were 3 stations with 5 repetitions in each zone per month (total 3 month research process). This study also measured the water quality by adding HNO_3 to the water sample until the pH reached <2. The result showed fluctuations in the *T. granosa* population, in January was 0.69 ind m^{-2}; in February was 0.44 ind m^{-2}; and in March was 0.5 ind m^{-2}. Measurement of water quality illustrated the absence of varied changes between parameters (temperature, salinity, pH, brightness, dissolved oxygen, suspended solids, and sediments). Shellfish collection and water quality are becoming factors that affect the density of *T. granosa*. The disposal of industrial waste also inhibits the growth of *T. granosa*. Proper monitoring of *T. granosa* collection activity and water pollution is needed for balance ecosystems of *T. granosa* living areas.
Key Words: population density, water quality, fishing effect, shell growth.

Introduction. Blood cockle (*Tegillarca granosa*) is one of the biological resource that has been widely used as a source of protein (Dharma 1988). *T. granosa* cultivation activities could be a solution for abrasive land use and for economic problems of the surrounding communities (Sony & Rejeki 2014). However, the number of *T. granosa* population continues to decrease (Dinas Perikanan dan Kelautan Jawa Timur 2014). The decrease is due to intensive *T. granosa* fishing activities (WWF Indonesia 2015). The use of shellfish catching tool (*garit*) without good management could reduce the number of shellfish and causing damage to the ecosystem.

The highest diversity of shellfish species is located in the southern China regions, Indonesia, Northeastern Australia, and Central America (Crame 2000). Shellfish production in Sidoarjo Regency from year 2003 to 2006 showed an increase: 2,869 tons (2003), 12,991 tons (2004), 16,348 tons (2005) and 18,896 tons (2006). Whereas, in 2013-2014, shellfish production decreased by 534 tons, i.e. 1,695.6 tons (2013) and 1,061.6 tons (2014) (Dinas Perikanan dan Kelautan Jawa Timur 2014). This phenomenon is in line with the increase in the number of *garit* as many as 125 units (in 2013) and 6,074 units (2014) (Dinas Perikanan dan Kelautan Jawa Timur 2014). Based on the latest data, shellfish production in 2016 in Sidoarjo shellfish catchment area was only 1,434,700 kg (Statistics of Sidoarjo Regency 2017).

Continuous capture of *T. granosa* is feared to cause a negative effect on the sustainability of the population in the future (Ruth et al 2014). In addition, river bank area is located near the industrial area that has the potential to produce destructive waste to the water (Herawati et al 2007; Wibowo 2012). The use of river as a waste dump also worsens this condition (Alfionita et al 2018). Polluted water conditions can affect *T. granosa* population (Komala et al 2011). *T. granosa* are osmoconformers that respond to a decrease in water salinity (Davenport & Wong 1986). This decrease is also caused by hypoxic conditions over a long period of time (Nakano et al 2017). Based on this phenomenon, this study was conducted to identify population density of *T. granosa* and the factors that influence the decline of this population.

Material and Method

Description of the study sites. The research was conducted at the Dadapan River Estuary, Sidoarjo, East Java, from January to march 2017. The research location zone of Dadapan River estuary was divided into three stations, i.e. (1) the distance from river bank of 1.5 km to the coordinates of S7° 19,523' E112° 51,242'; (2) the distance from river bank of 1.75 km at the coordinates of S7° 19,538' E112° 51,431'; and (3) the distance from river bank of 2 km at the coordinates of S7° 19,557' E112° 51,631'.

The density test required swept area data, i.e. the method used to estimate the magnitude of the potential of shellfish resources using fishing gear by sweeping in an area of water (Sandria et al 2014). Data retrieval was done by purposive sampling method. The material used in this study was *T. granosa* which were collected using *garit* fishing gear. Retrieval distance was carried out every 5 m for five times using a boat with a speed of 3.5 km/h. Sampling was done 1 time per month from January to March 2017, so that a total of 30-time *T. granosa* collection was performed.

Sea water samples were taken using a water sampler at a depth of 30 cm below the surface of the water as much as ±100 mL and stored in a bottle. The sea water sample was then added to HNO_3 until the pH reached <2. Water samples were tested for water quality, including temperature, dissolved oxygen (DO), salinity, and pH.

The collection of environmental data for the Dadapan river estuary was obtained through the Meteorology, Climatology and Geology Agency in January, February, and March 2017 which included current velocity, wind speed, and wave height.

Data calculation. Shellfish population density was calculated using the formula of Sparre & Venema (1999) as follows:

$$D = Vxt$$

Where: D: sweep length (m); V: withdrawal speed (km/h); t: withdrawal time (hours)

From the formula, the area of garit sweep was obtained as follows:

$$a = D\ x\ h$$

Where: A: broad sweep area; D: length of sweep (m); h: garit length

Furthermore, population density was calculated using the formula:

$$Q = \frac{Cw/a}{ef}$$

Where: Q: density per sweep area (ind/m^2); Cw: shellfish haul per sweep area (individual); a: sweep area (m); e: breakout factor (0.4)

Statistical analysis. The density data obtained were then analyzed descriptively to discover the relationship between *T. granosa* population density and water quality (temperature, DO, salinity and pH), sediment, oceanographic conditions, and water pollution.

Results. The results of the observations from study location showed that there was some polluting residues at each station. This condition may be caused by a lack of attention from the surrounding community towards waste disposal that could affect the shellfish ecosystem. At stations 1 and 2 it was also seen that some fishermen were catching *T. granosa*. In addition, the observation showed that the average population density of *T. granosa* obtained in January was 0.69 ind/m^2, in February 0.44 ind/m^2 and in March 0.5 ind/m^2 (Table 1).

Table 1

The average population density of blood cockle (*Tegillarca granosa*)

Month	*Population Density (ind/m^2)*			
	Station 1 (1,500 m)	*Station 2 (1,750 m)*	*Station 3 (2,000 m)*	*Mean ± SD*
January	0.43	0.9	0.74	0.69±0.41
February	0.16	0.48	0.68	0.44±0.30
March	0.64	0.57	0.28	0.5±0.49

Water quality. Water quality measurements showed several stable parameters that are important to support shellfish life. The results illustrated the absence of varied changes between parameters (temperature, salinity, pH, brightness, dissolved oxygen (DO), total suspended solids (TSS) and sediments (Table 2).

Table 2

The water quality parameters

Parameter	*Unit*	*Score*		
		January	*February*	*March*
Temperature	^{o}C	28	29	29
Salinity	ppt	29	29	29
pH	-	8	8.2	8.1
Brightness	Cm	40	45	40
Dissolved Oxygen	mg/L	5	5	5
Suspended Solids	mg/L	19	7.5	7.5

The results from the three stations showed that the sediment of mud type was very dominant. Each station had high percentage of mud type substrate. The high percentage of mud at the station is caused by the condition of muddy mangroves that are still in good condition, in which large amounts of mud are carried during tide at that location (Table 3).

Table 3

Sediment types

Station	*Sediment types*			*Sediment type*
	Pebble (%)	Sand (%)	Mud (%)	
1500 m	1.91	9.43	88.67	Mud
1750 m	1.99	9.12	88.89	Mud
2000 m	2.54	9.73	87.73	Mud

In addition, oceanographic conditions indicated differences in the current, wind, and water wave height (Table 4).

Table 4

Data on current flow speed, wind speed and wave height

Month	*Station*	*Current flow speed (cm/s)*	*Wind speed (knot)*	*Wave height (m)*
January	1,500 m	10.84	2.8	0.76
	1,750 m	10.64	3.1	0.79
	2,000 m	8.38	3.5	0.81
February	1,500 m	13.84	8.1	1.54
	1,750 m	15.82	8.4	1.53
	2,000 m	13.75	8.6	1.51
March	1,500 m	12.95	4.5	0.91
	1,750 m	11.91	4.9	0.88
	2,000 m	14.89	5.3	0.83

Source: BMKG 2017.

Discussion. The density of *T. granosa* populations has decreased from January (0.43 ind m^{-2}) to February (0.16 ind m^{-2}). This happened because the speed of the water flow was 10.84 cm per second, wind speed 2.8 knots, and the wave height 0.81 meters in January. In February, the velocity of water flow was 13.84 cm per second, the wind speed 8.1 knots and the wave height 1.54 meters, that condition causing the transfer of *T. granosa* to different locations. Increased fishing activities in January caused a decline of *T. granosa* population in February. However, the increase in density occurred in March (0.64 ind m^{-2}). The decrease of water flow's velocity (12.95 cm per second), wind speed (4.5 knots) and wave height (0.91 meters) caused this increase. Decreasing water flow, wind, and wave height did not cause displacement of *T. granosa* to different locations. In addition, the possibility of juvenile *T. granosa* that escaped during arrest in January which then experienced growth. The growth of individual juvenile *T. granosa* into adults takes approximately 3 months (Satrioajie et al 2013).

The decrease in average population density of *T. granosa* also occurred at station 3 in every month (January=0.74 ind m^{-2}; February=0.68 ind m^{-2}; and March=0.28 ind m^{-2}). This occurs because there was an increase in the water flow velocity in January to March (January=0.38 cm per second; February 13.75 cm per second; and March 14.89 cm per second). The increase of water flow can cause shift of *T. granosa* to a different location due to being carried by the water flow.

The environmental condition of stations 1 to 3 tended to be dominated by the mud. Mud and other dissolved materials at the river banks are thought to determine the level of the *T. granosa* population (Rochmady & Tandipayuk 2011). *T. granosa* and several other types of shellfish can be found in a large quantities in the muddy mangrove area (Ashton et al 2002). Shells and other mollusks are often found in the mangrove area (Ashton et al 2002). The live population of shellfish is strongly influenced by water salinity (Eizzati et al 2018). Based on the results of measurements of temperatures, salinity, pH, and dissolved oxygen, there were no varied changes occurred. Shellfish have a high level of sensitivity to salinity (Khade & Mane 2012). Shellfish will find difficulties to regulate it's osmolarity fluctuations in water with low salinity. However, *Anadara* sp. can still grow well with temperatures supporting around 5^oC to 25^oC (Sugiura et al 2014). In addition, the high content of organic matter from waste causes the decrease the density of *T. granosa* because of the low dissolved oxygen (Lyndawaty et al 2016). The water flow also has an impact on the distribution of industrial and household waste (Din & Ahamad 1995). In addition, the brightness level of a water is strongly influenced by the content of total suspension solids (TSS). The findings showed that the brightness of water was influenced by the contribution of suspended substances from the river that had been carried along the river. Poor water conditions trigger the death of shellfish within 48 hours (Davenport & Wong 1986). The obstruction of sunlight is caused by large number of suspended particles floating on the surface of the water, especially by sedimentary material that enters through the river flow (Satrioajie et al 2013). However, after the rainy season, shells are more commonly found due to high water flow and salinity (Khade & Mane 2012). High rainfall causes an increases in the amount of clean water that has an impact on the environment, especially the increase in shellfish population (Yurimoto et al 2014).

Conclusions. Population density of *T. granosa* is caused by changes in water flow's velocity, wind speed, and the wave height. Water quality and type of location also have an active influence in the growth and breeding of *T. granosa*. The highest density of *T. granosa* was obtained in January (0.69 ind m^{-2}) and the lowest density was obtained in February (0.44 ind m^{-2}). Proper monitoring of *T. granosa* collection activity and water pollution is needed so the balanced ecosystem of *T. granosa* living area can be achieved.

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