Environmental factors impact on the length-weight relationships of dog conch (*Laevistrombus canarium*) in the coastal waters of Bangka Island, Indonesia

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Abstract. Dog conch (*Laevistrombus canarium*) is one of Bangka Island's most important economic marine biological resources. Tin mining activities in Bangka Island's coastal waters produce tailings with very low nutrient content and microorganisms. The tailings cover the sediment's surface, thereby affecting the metabolism and growth of *L. canarium*. The study aims to determine the length-weight relationship and factor conditions of *L. canarium* in several habitats of Bangka Island. The method of this research is purposive sampling based on the presence of *L. canarium* in a different habitat. The results showed that the length-weight relationship of *L. canarium* from five stations (Romodong Beach, The Cupat Beach, Semulut Beach, Nanas Island, and Anak Air Island) is negative allometric (b<3). At the same time, Tukak Beach results are positive allometric (b>3). The condition factor (K) value of *L. canarium* in Cupat Beach is <1.0 (0.97±0.18) and indicates a very thin condition, with the C-organic sediment content at Cupat Beach ranging from 0.47±0.10 (very low category). The condition factor (K) value from Romodong Beach, Semulut Beach, Nanas Island, Anak Air Island is around 1.0 (1.01±0.21, 1.02±0.20, 1.01±0.19, 1.01±0.13) and classified as thin, while Tukak Beach values are >1.0 (1.21±0.46). The C-organic content of Tukak Beach sediments was 2.46±0.86 (moderate category). Low C-organic sediment is an indicator of a lack of substrate fertility and eventually affects the condition of *L. canarium*. The government can use the research results to manage the habitat of *L. canarium* in the coastal waters of Bangka Island.

Key Words: Kelabat Way, South Bangka, tin mining, water characteristics.

Introduction. Marine biological resources in Bangka Island's waters consist of minerals, fish, and dog conch (*Laevistrombus canarium*), which all have significant economic values. Dog conch is a marine natural resource with high protein, of around 46.65% (Muzahar 2013). The habitats of *L. canarium* in the waters of Bangka Island are Kelabat Bay, Tukak Beach, Anak Air Island, and Lepar Pongok (Dody & Marasabessy 2007; Dody 2011; Siddik 2011; Supratman & Syamsudin 2018). *L. canarium* is not abundant all year, only between February and August, and is commonly found in littoral and sublittoral zones (Dody & Marasabessy 2007). The growth of dog conch is likely affected by the physicochemical condition of the water, so it can be considered as a bioindicator. Tin mining activity in the waters off the coasts of Bangka Island alters the physicochemical growth condition of dog conch.

Tin mining in the coasts of Bangka Island is done by local people and produces material waste (sand) with a low nutrient content, called tailing (Dariah et al 2010; Sukarman & Gani 2017). Tailing reduces the quality of the coastal waters' environment (Borja et al 2000; Wahyuni et al 2013) because it leads to high suspended particles and turbidity. Tailing will be deposited on the base substrate of the waters. Dog conch is a deposit feeder that collects food by sucking all sediment at the bottom of the waters, e.g., detritus and microorganisms (Cob et al 2014). Organic materials, detritus and microorganisms can influence the length-weight and condition factors of *L. canarium*. Information on the length, weight, and condition factor of *L. canarium* is essential to determine the condition of dog conch in some habitats in the waters off the coasts of Bangka Island. Therefore, the length-weight relationship and condition factor of *L. canarium* in the waters off the Bangka Island coasts was studied. The length-weight relationships could determine conditions during growth, thus indicating the aquatic animal's health (Blackwell et al 2000). The condition factor (K) then could be used to predict the condition of *L. canarium*, which is a gastropod in an ecosystem (Ariyanto et al 2018). Then the government could use the information in making policies to manage the habitats of *L. canarium* in the waters of the coasts of Bangka Island.

Material and Method

Description of research location. The study was performed in July 2019 in the waters of the coasts of Bangka Island, covering four stations in Kelabat Bay, i.e., station 1 (Romodong Beach), station 2 (Cupat Beach), station 3 (Semulut Beach), station 4 (Nanas Islands), and stations in the waters of South Bangka Regency, i.e., station 5 (Tukak Beach) and station 6 (Anak Air Island) (Figure 1). From each research station, sample collection was iterated three times at three sampling spots. The research stations were determined by purposive sampling, i.e., based on *L. canarium* habitat.

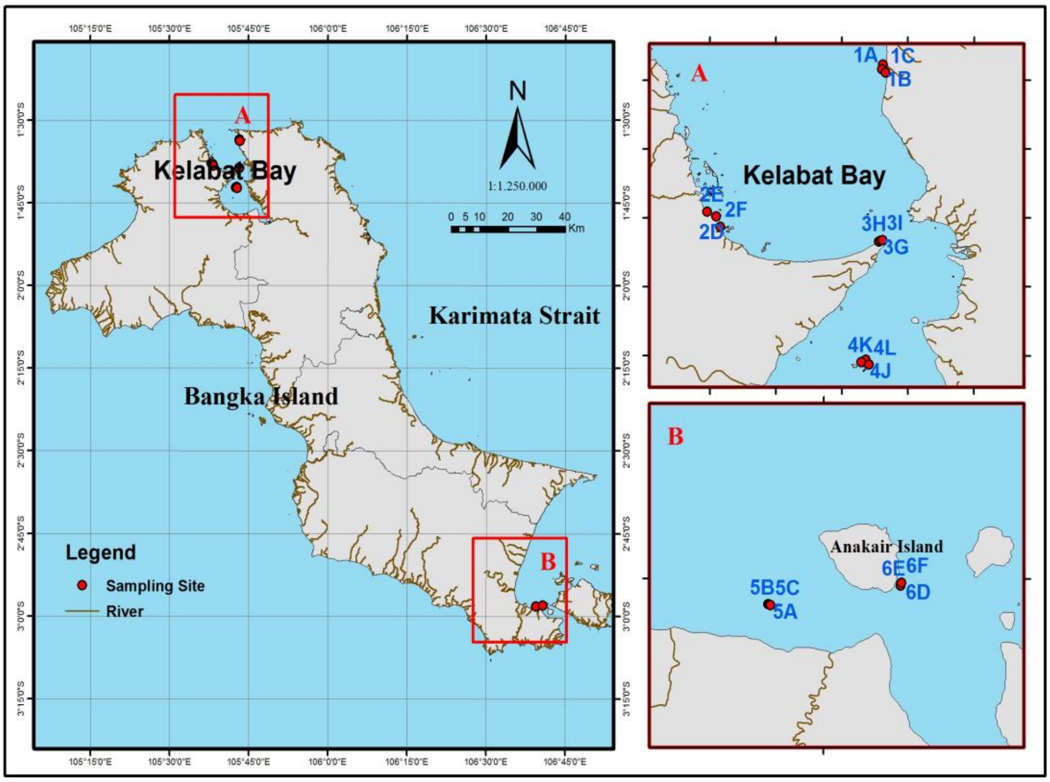

Figure 1. Sampling location of *Laevistrombus canarium* in Kelabat Bay's waters (Central Bangka and West Bangka Districts) and South Bangka Regency, Bangka Island, Indonesia.

Data collection. *L. canarium* sampling was performed at low tide at depths of 0.5-1 m using 1 m x 1 m quadrat transect. Each station had three line transects as iteration, with each line having one transect and each transect is 10 m from each other (English et al 1997). *L. canarium* samples were collected and put in an open container to keep them alive. Then, they were taken to the laboratory to be properly identified and have their length and weight measured. *L. canarium* was identified in the zoological laboratory, LIPI Cibinong.

Sediment and water. In each line transect, sediment was collected using a corer (5 cm diameter) at 10 cm from the substrate surface (English et al 1997). The sediment was then stored in zip plastic bags inside a cool box (at ±4^{O}C) for sedimentary C-organic and fraction analyses in the laboratory. Sedimentary C-organic analysis was based on the combustion method by Carbon Hydrogen Nitrogen (CHN) analyzer (Meyers 2003; Kauffman & Donato 2012) in the Plant Ecology laboratory of P2B LIPI Cibinong. Sedimentary texture size analysis used sieving and pipetting methods by Wibisono (2005). Total suspended solids (TSS) analysis used gravimetric method (Suryantini et al 2011; Saputra et al 2016), while pH, dissolved oxygen (DO), current velocity, salinity and temperature were measured on site with a pH meter, DO meter, current meter, refractometer, and thermometer.

Seagrass percent cover. Seagrass data was collected using the line transect method (English et al 1997). Each research station is set by three lines transect with a length of 50 m, and the distance between line transects was of 10 m, so that the total area is 20x50 m^2. The calculation of the seagrass percent cover carried out in quadrat transects of 1x1 m.

Data analysis. *L. canarium* samples were collected, and total length and weight were measured. The length was measured using a digital caliper with 0.1 mm accuracy and the weight using an electric scale with 0.1 mg accuracy. Then, the length-weight relationships of the dog conch were calculated.

Length-weight relationship with allometric equation. The length-weight relationship is explained with an allometric growth equation and is illustrated in two forms, i.e., isometric and allometric (Jamabo et al 2009; Ariyanto et al 2018), using the following equation:

$$W = a\ L^b$$

where:
W - weight of *L. canarium* (g);
L – total length of *L. canarium* shell (mm);
a and b – regression constants.

The equation used the logarithmic form:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

with parameters a and b for simple linear regression analysis with Log W (y or dependent variable) and Log L (x or independent variable) so that the regression equation:

$$Y = a + b\ X$$

Suppose the rate of weight increases more than the length, it means the growth is allometric positive (b≥3). If the rate of length increases more than the weight, it means the growth is allometric negative (b<3); if the increase in length is equal to the increase in weight, the growth is isometric (b=3) (Widowati et al 2005). b1 is the length-weight relationship (b) and then b0=3 and Sb1 are the coefficient deviation. The t count was compared to the t table with 95% confidence interval for determining of growth pattern:

$$T_{count} = \frac{b1 - b0}{Sb1}$$

where:
allometric - $t_{count} > t_{table}$
isometric - $t_{count} < t_{table}$

Condition factor. The condition factor of *L. canarium* was calculated based on the result of calculation of the length-weight relationship with an allometric growth equation for *L. canarium* (Ariyanto et al 2018).

$$K = \frac{W}{a.\, L^b}$$

where:
K - condition;
W - weight of *L. canarium* (grams);
L - total length of *L. canarium* (mm);
a, b - regression constant;

Distribution of environmental characteristics of coastal waters. The environmental parameters of coastal waters, including current velocity, temperature, salinity, TSS, pH, DO, depth, C-Organic, sedimentary texture, sedimentary heavy metal such as lead (Pb), cadmium (Cd), tin (Sn), zinc (Zn), copper (Cu) and research stations were analyzed using Principal Component Analysis (PCA) (Bengen 2000).

Results and Discussion

Results. The total of *L. canarium* samples found in six stations on Bangka Island's coastal waters in July 2019 was 732 individuals. The dominant frequency of the size was 54.70 – 58.70 mm found in 202 individuals, while there is one individual with an uncommon size range between 79.3-83.3 mm (Figure 2). The frequency distribution of the length of *L. canarium* in Bangka Island's waters in July was suspected to be the adult size.

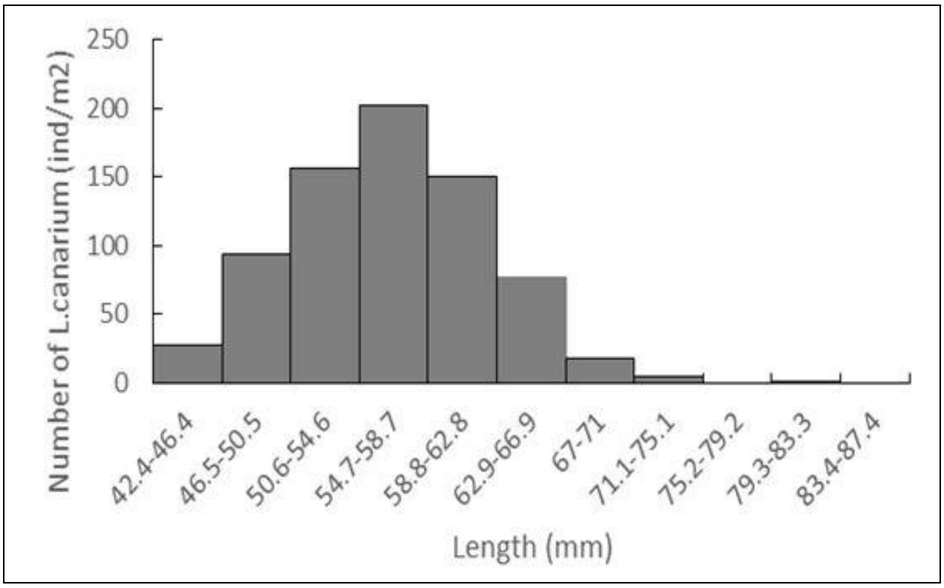

Figure 2. The frequency distribution of the total length of *Laevistrombus canarium* in the coastal waters of Bangka Island, Indonesia.

Length-weight relationship of L. canarium with allometric equation*.* The total sample of L. canarium: station 1 with 128 individuals, station 2 with 111 individuals, station 3 with 151 individuals, station 4 with 111 individuals, station 5 with 108 individuals, and station 6 with 123 individuals. The average lengths of *L. canarium* from stations 1, 2, 3, 4, 5, and 6 were 55.542±5.930 mm, 52.214±4.217 mm, 57.473±5.049 mm, 59.263±4.353 mm, 61.369±4.988 mm, 53.191±4.349 mm and the average weights were 24.477±6.289 g, 20.672±4.750 g, 25.876±6.207 g, 26.563±5.891 g, 27.096±8.940 g, 24.780±5.781 g. The regression analysis result showed that the length-weight relationship with allometric equation *L. canarium* from six stations was allometric negative (b<3), i.e., length increase was faster than weight gain (Figure 3).

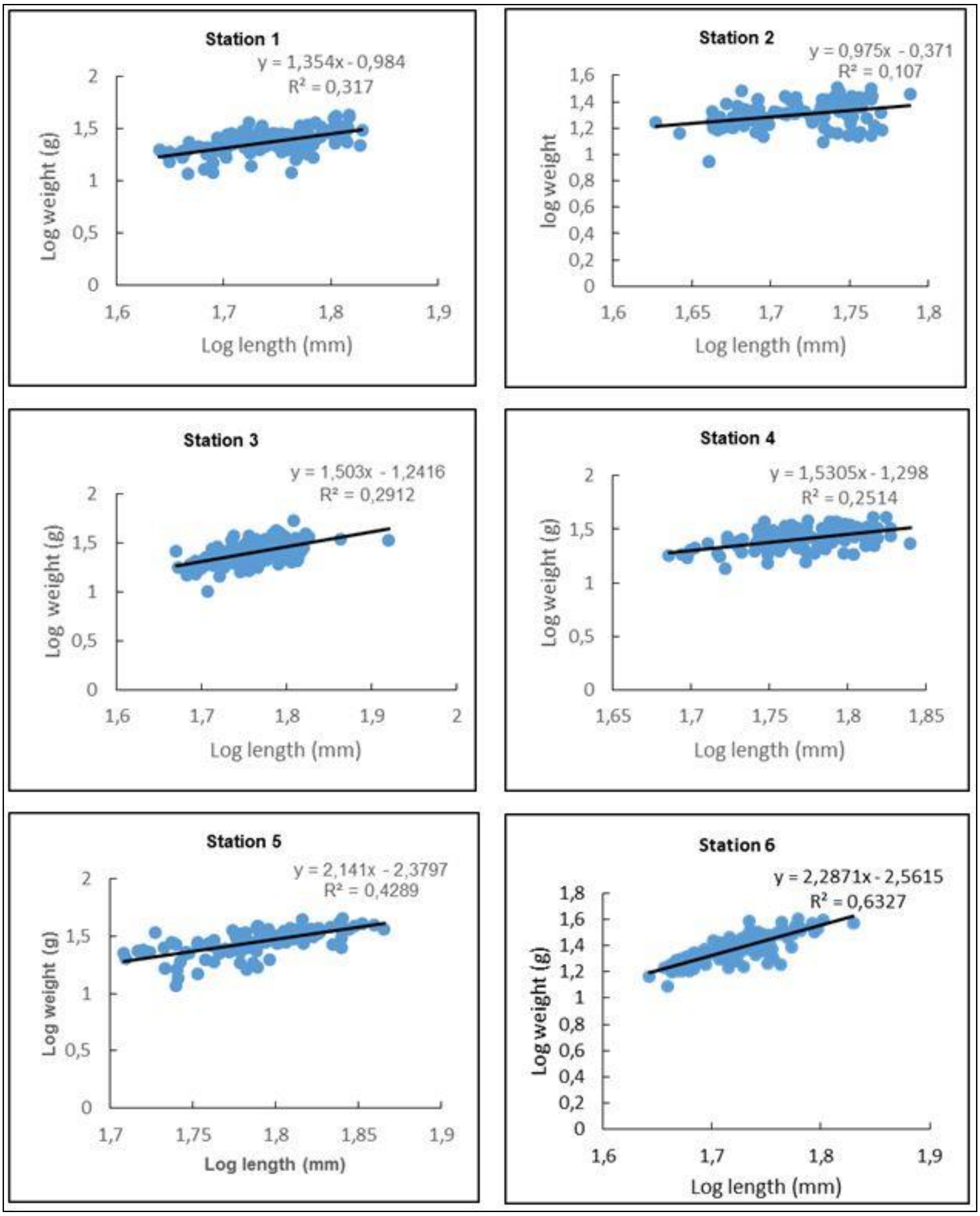

Figure 3. Length-weight relationship of *Laevistrombus canarium* from six research stations in the coastal waters of Bangka Island, Indonesia

Based on the length-weight relationship analysis of L. canarium in stations 1, 2, 3, 4, 5 and 6, each has correlation coefficients (r^2) of 0.564, 0.327, 0.539, 0.501, 0.654 and 0.795, respectively. $r^2>0.5$ in five stations showed a quite strong correlation, i.e., if length increased, the weight of L. Canarium would be affected. However, station 2 has a correlation coefficient (r^2) of 0.327. $r^2<0.5$ showed a weak relationship between length increase and weight gain of L. canarium. Environmental parameters also could cause a low correlation (r^2) in station 2, as indicated in Table 1.

Condition factor. Analysis of the condition factor can be used to indicate the biological condition of a biota. Condition factor analysis is an important indicator of growth. The condition factor analysis of *L. canarium* showed very similar conditions at six stations (Figure 4). The "K" values of *L. canarium* from stations 1, 2, 3, 4, 5, and 6 were 1.022±0.209, 1.025±0.219, 1.020±0.203, 1.019±0.196, 1.018±0.193, and 1.010±0.138. The "K" values of *L. canarium* from six stations based on Effendie's (2002) criteria were thin.

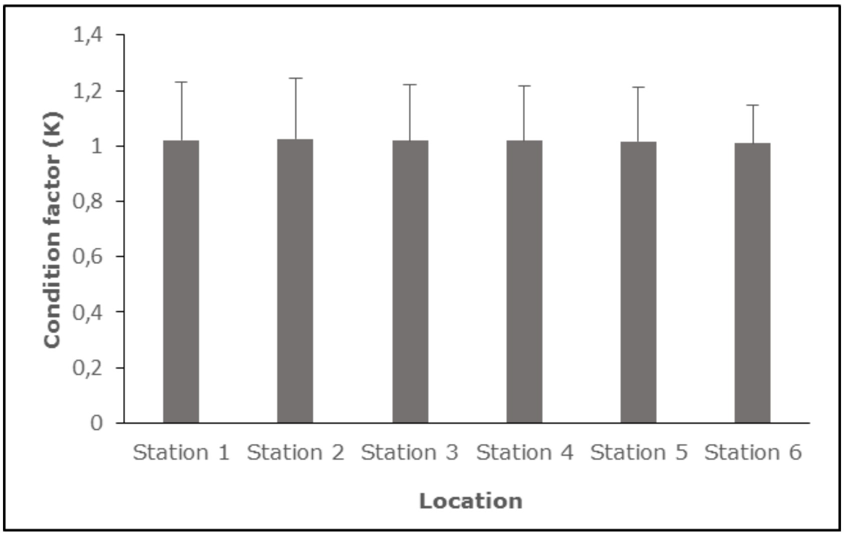

Figure 4. The value of the condition factor (K) of the six *Laevistrombus canarium* habitat stations in the coastal waters of Bangka Island, Indonesia

Table 1

The average value of the environmental parameters of *L. canarium* habitat in coastal waters of Bangka Island, Indonesia

Parameters	*Station 1*	*Station 2*	*Station 3*	*Station 4*	*Station 5*	*Station 6*	*Quality standards*
Temperature (°C)	29.67± 0.58	30.33±0.58	30.33±0.58	29±0.00	29.33±0.58	29.33±0.58	28-30*
Depth (cm)	101.67±10.40	96.67±20.81	61.67±17.55	45±0.01	80±17.32	88.33±25.65	-*
Current (ms^{-1})	0.35±0.09	0.17±0.03	0.06±0.01	0.057±0.02	0.9±0.17	0.97±0.21	-
TSS (mg L^{-1})	30.33±3.43	233.53±21.00	79.67±13.01	28±1.77	29.1±3.00	28.13±1.36	<20*
pH	7.885±0.08	7.13±0.06	7.16±0.05	7.13±0.14	7.77±0.07	7.63±0.10	7,0-8,5*
Salinity (°/oo)	31±0.00	30.33±0.58	30±0.00	30.33±0.71	34±0.00	34±0.00	33-34*
DO (mg L^{-1})	4.51±0.01	3.57±0.06	4.13±0.06	4.79±0.03	6.13±0.06	6.17±0.06	>5*
C-Organic (%)	0.89±0.17	0.47±0.10	0.97±0.06	0.70±0.01	2.46±0.86	1.06±0.14	
Texture sediment :							
Sand (%)	54.13±1.74	48.59±1.33	72.55±2.35	53.82±3.01	53.07±2.28	39.28±4.17	-
Silt (%)	16.44±2.79	42.93±2.16	11.18±1.81	12.74±1.05	12.99±0.74	16.66±8.19	-
Clay (%)	29.42±4.51	8.48±0.84	16.26±3.08	33.44±1.96	33.93±2.80	44.06±4.13	-

*Decision of Minister of Environment Number 51 of 2004 (MNLH 2004).
** Canadian Council of Minister of the Environment (CCME 2002).

Distribution of environmental characteristics of coastal waters. The result of principal component analysis (PCA) on the characteristics of the coastal waters environment by research station was focused on two main axes (F1 and F2) with a total variety of 64.10 % (Figure 4). High current velocity, pH, salinity, DO, C-organic, sedimentary Zn, and clay fraction characterized Stations 5 and 6 (substations 1, 2, 3). Meanwhile, stations 2 and 3 (substations 1, 2, 3) were characterized by high temperature, TSS, sedimentary Pb, sedimentary Cd, and sedimentary Cu. Station 1 (substations 1, 2, 3) was characterized by high depth, sludge fraction, and sedimentary Sn.

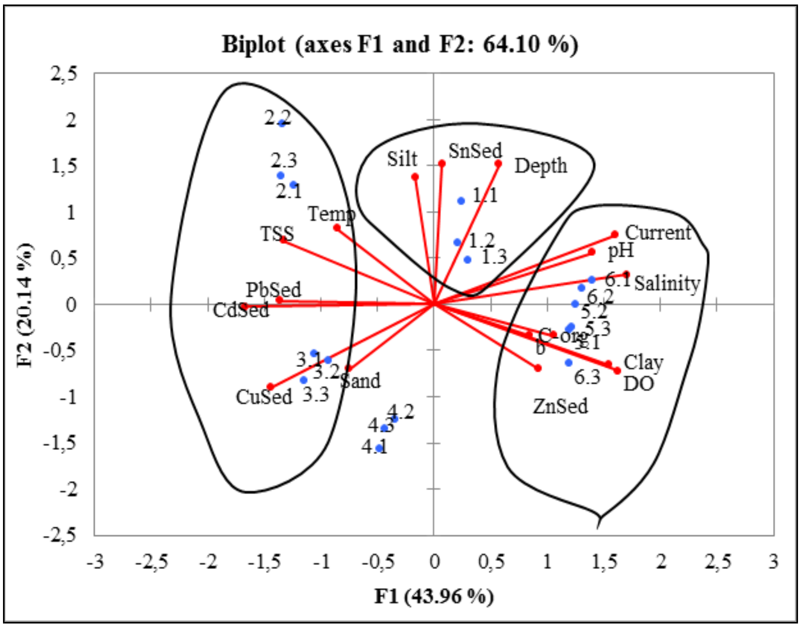

Figure 5. The results of the Principal Component Analysis (PCA) parameters of the coastal waters environment and the value of b based on the research station on axis 1 (F1) and axis 2 (F2).

Discussion. Based on the regression analysis of the length-weight relationship of *L. canarium* in stations 1, 2, 3, 4, 5 and 6, b values<3, i.e., 1.354, 0.975, 1.503, 1.531, 2.141, and 2.287. The b values<3 showed negative allometric growth. Such a growth pattern is affected by ecological factors or environmental conditions (Froese 2006; Abelha & Erivelto 2008; Ramesha et al 2009; Clemente 2011; Tamsar et al 2013; Taunay 2013), e.g., coastal waters environment parameters. Similar parameters included sandy substrate, C-organic content, temperature, salinity, and DO (Table 1). Based on the regression analysis, the length-weight relationship of *L. canarium* in six stations showed the same growth pattern (b<3). However, the b value of each station is significantly different. The b value was shown by *L. canarium* in station 2, with a coefficient value of r^2<0.5 around 0.327. It showed a weak relation between length growth and weight growth of *L. canarium*. Station 2 showed more extreme conditions than other stations because it was near a tin mine, so that muddy sand waste from the mine (tailing) spread and settled above the substrate around stations 1 and 2 (Figure 5). Tailing has very low C-organic matter, nutrients, and microorganisms (Dariah et al 2010; Sukarman & Gani 2017), affecting the growth, and condition factor of *L. canarium*.

The analysis result of the condition factor (K) of *L. canarium* from six stations showed similar conditions (Figure 5), i.e., categorized as criteria 1 and, according to Effendi's (2002) criteria, they were thin. The low condition factor (K) values are determined by the fact that the five stations had predominantly sandy substrate and low nutrients, e.g., sedimentary C-organic matter. Sedimentary C-organic matter in stations 1, 2, 3, 4, and 6 were 0.89±0.17, 0.47±0.10, 0.97±0.06, 0.70±0.01, and 1.06±0.14, respectively, which are very low, and in station 5 it was 2.46±0.86 or of moderate value (Eviati & Sulaeman 2012). C-organic matter in station 5 was higher than in other stations because station 5 has residential areas, rivers, and fish auction location, so that many organic matters entered station 5. The C-organic matter from the six stations proved to be too low to meet the growing needs of *L. canarium*, affecting the condition factor (K).

Low C-organic matter and microorganisms will affect the relationship between the length-weight relationship with allometric equation and condition of *L. canarium* in Bangka Island's waters. They represent food for *L. canarium,* and food availability is one factor affecting the length-weight relationships (Alunno-Bruscia et al 2001).

Sedimentary C-organic matter shows the fertility of a substrate, thus affecting the life of *L. Canarium*, e.g., the length-weight relationship with allometric equation and condition factor*.* Morphologically, *L. canarium* in station 5 was larger than in the other five stations, but the condition factor (K) analysis showed a similar condition with the other five stations. Similar condition factor (K) of *L. canarium* in all stations might be due to lack of availability and low food quality in the waters (Abelha & Erivelto 2008). In station 5, there was seagrass, but with low coverage (13.96%), consisting of *Halodule uninervis*, *Halophila minor*, *Halophila ovalis*, *Thalassia hemprichii*, *Enhalus acoroides*, *Cymodocea rotundata*, and *Cymodocea serrulata*. Similarly, in station 6, *Halodule uninervis*, *Halodule pinifolia*, and *Halophila minor* had 18.44% coverage. The seagrass did not significantly increase K value because *L. canarium* is not a grazer but a deposit feeder. The study of Supratman and Syamsudin (2016), shows that dog conch from the waters of Tukak Beach and Anak Air Beach has the highest food index, i.e., detritus (66.08%), sand (23.35%) and the rest was plant fragments and microalgae.

Another environmental parameter that affected the condition factor could be the heavy metal concentrations. Pb and Sn contents in the sediment of station 2 were also higher than in the other five stations (Table 1). TSS content also exceeds the quality standard for biota (MNLH 2004) because it caused high turbidity, thus lowering water quality and affective the life of *L. canarium*. This is because there is a relation between heavy metal contents and TSS, i.e., fine particles will bond with heavy metal (Henny & Susanti 2009; Mlayah et al 2009; Luis et al 2011; Agustina 2014, Riani et al 2017; Suteja et al 2020), settling at the bottom of the waters and then accumulating and affecting benthic biota life (Weber 2006; Mohamed 2008; Riani 2011; Takarina et al 2013; Riani et al 2014; Suteja & Dirgayusa 2018; Agustriani et al 2020). *L. canarium* in the bottom waters is a deposit feeder (Cob et al 2014), and sucks sediment contents using its proboscis, thus allowing the heavy metals from the sediment to accumulate and influence to the growth of L. canarium. Heavy metals entered the body and bonded with the protein-containing sulfhydryl (-SH) and reduced enzymatic work, disturbing the metabolism of *L. Canarium.* It caused the length-weight relationship to have a negative allometry ($b<3$) and not to be strongly correlated (r2 <0.5). Besides the length-weight relationship to have negative correlation allometry ($b<3$), it also affected the condition factor (K) of *L. canarium*, being in the 1 category with condition described as "thin".

The correlation coefficients of *L. Canarium* from stations 1, 3, 4, 5 and 6 were strong ($r^2>0.5$), at 0.564, 0.539, 0.501, 0.654 and 0.795. The r^2 coefficients of stations 5 and 6 were bigger than the other three stations. Based on PCA, spatially stations 5 and 6 were characterized by the distribution of current velocity, pH, salinity, DO, C-organic, clay sediment, sedimentary Zn, and b value (Figure 5). It might be because station 5 was close to a residential area, fish auction, and river, and had seagrass, so that there was a lot of seagrass litter and organic matter input. It increased C-organic matter content in the sediment and b value (length-weight relationship with allometric equation of *L. canarium*). Moreover, high b values in 5 and 6 stations were also supported by the waters' DO, i.e., 6.13±0.06 mg L^{-1} and 6.17±0.06 mg L^{-1} (Table 1). DO>5 mg L^{-1} was appropriate for biota life (MNLH 2004). High DO in both stations was due to photosynthesis of seagrass that produces oxygen, supported by low TSS and turbidity (Table 1), so that oxygen from the atmosphere easily entered the waters.

Conclusions. The length-weight relationship with allometric equation of *L. canarium* have strong correlations and display negative allometry ($b<3$). The condition factor (K) was category 1 and "thin" at six stations. One of the factors affecting this is the sand-dominant substrate with low C-organic matter content.

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Conflict of Interest. The authors declare no conflict of interest.

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