Population growth model of *Anadara granosa* based on correlation between dimension of shell with the weight at the water environment of Sunda Strait

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**Abstract.** Exploitation of shellfish resources can affect its growth which can be seen from changes in the size of the shell dimensions including length, width and height. The study was conducted to determine the relationship between the dimensions of the shell with its total weight as a description of growth patterns, and to determine the environmental factors that affect shell growth. Descriptive method with direct observation technique was carried out at 3 observation stations in the Sunda Strait waters. Data were analyzed using power regression, while the correlation of environmental parameters were analyzed using PCA. The results show that the correlation between the dimensions of the shell and the total weight of the shell is allometric negative ($b < 3$), which is an unbalanced growth between the dimensions of the shell and the weight of the shell, so that the shell growth pattern is indicated by the increase in width, length and height that was faster than the body weight. The parameters that affects the dimensions of the shell and weight are NH$_3$-N, NO$_2$-N, BOD, salinity, depth, TOM, brightness, Pb, Cd, Hg and temperature.

1. **Introduction**

The aquatic environment is a habitat for various organisms, one of which is the *Anadara granosa* which is an important resource in the marine ecosystem [1]. Ecologically, shellfish acts as bioindicator to prove the supply of nutrients and detritus, and indicators of pollutants as a sign of a change in the environment in which they live [2]. The economic role of shellfish is as a source of protein and minerals in meeting the needs of the general public [3]. There is a circumference that can be used to determine the growth, age of shellfish, and environmental conditions in which it grows [4,5]. The relationship between the dimensions of the shell and its body weight can be used to study growth in nature. Dimensions of the shell are the size includes length, width, and the height of the shell [6]. Anadara spp lives scattered in several coastal waters [1,5] including in the Sunda Strait waters, which lies between the islands of Sumatra and Java which was suspected to have an impact on the growth of *A. granosa* shellfish. Intensive exploitation of shells by fishermen without proper management can lead to growth disturbance and even to the extinction of the organism. Research on growth patterns needs to be done to determine the condition of the population as a basis for efforts to conserve potential water resources.
2. Materials and methods

Samples of *A. granosa* shells were collected from 3 observation stations as clam catchment areas, namely Bama Beach, Panimbang Beach and Suladengan Beach from March to April 2017. Sampling of shellfish were conducted using scratches that were pulled by motorboats, sampling was repeated three times using the area sweep method. Data taken includes morphometrics and body weight of shellfish. Morphometric measurements include the length of the shell measured from the dorsal margin to the ventral margin. The width of the shell is measured from the anterior to the posterior side of the shell, while the height of the shell was measured from the distance between the right-side umbo and the left side umbo shell. Weight measurement by weighing the overall weight of the shell with the shell. Measured environmental parameters includes temperature, salinity, turbidity, brightness, depth, dissolved oxygen, BOD, nitrate, nitrite, orthophosphate and ammonia, pH, TOM, TSS, and TDS.

Growth patterns based on the relationship of the dimensions of the shell and weight were analyzed through the power regression analysis, which is described in isometric and allometric form with the equation \( W = aL^b \). To get a linear equation, the equation was used \( \ln(W) = \ln(a) + b \ln(L) \). If the value of \( b = 3 \), then growth shows isometric growth, \( b < 3 \) value shows negative allometrics, and \( b > 3 \) value indicates positive allometrics [7–9]. Variation of environmental parameters between observations was analyzed using multivariable statistical analysis based on Principal Component Analysis (PCA) [10].

3. Results and discussion

3.1. Catches and size class

Based on the research, total catches of 2725 *A. granosa* were obtained which spreads in zone 1 (1167), 2 (433) and 3 (1125). The dimensions of each shell consist of 13 class intervals. With the lowest and highest value for each dimension.

| Shell dimension | Minimum size (mm) | Maximum size (mm) |
|-----------------|-------------------|-------------------|
| Length          | 0.66 – 4.13       | 42.42 – 55.89     |
| Width           | 1.14 – 3.49       | 29.10 – 31.42     |
| Height          | 1.13 – 3.38       | 27.70 – 29.90     |

3.2. Growth patterns and the relationship of the dimensions of the shell to the weight

From the regression analysis of the length, width and height of the shell correlation with the weight, these equations were generated: \( W = 0.052L^{1.2964} \), \( W = 0.1747W^{1.0414} \), \( W = 0.6222H^{0.6095} \). From this equation, the value of \( b < 3 \) so that the growth pattern of the dimensions of the shell with weight is classified as negative allometric, while the value of the dimension correlation coefficient with weight shows \( r \) values of 0.6139; 0.5478 and 0.4626

![Figure 1. Graph of the relationship of length shell dimensions to weight.](image-url)
3.3. Environmental parameters that affect the growth pattern of shellfish

The result of results of environmental parameters measurement are still in the normal range, the temperature ranges between 27-31.6 °C, turbidity 128-5.66 NTU; depth 1.75-4.55 m; pH 6-8; salinity 28-32 ppt; TDS 16,372-30,476 mg/l; TSS (15-92 mg/l; DO 6.5-7.62 mg/l; BOD 3.02-5.25 mg/l; TOM 13.27-27.47 mg/l; nitrite <0.02 mg/l; nitrate 0.003-0.888 mg/l; ammonium 0.208 -0.561 mg/l; orthophosphate 0.01-0.601 mg/l; Pb 0.031-0.039 ppm; Cd < 0.001 ppm; and Hg<0.01 ppm. The parameters that affects the dimensions of the shell and weight are NH$_3$-N, NO$_2$-N, BOD$_5$, salinity, depth, brightness, TOM, and temperature.

The number of catches were high because *A.granosa* is a type of shellfish which is able to adapt in several places and weather, has a high adaptation to the type of sand substrate, spreads in tropical and subtropical waters, on a beach that is based on mud or sandy mud and fine sand, and has red blood pigment (haemoglobin) so that it can live in conditions of relatively low oxygen levels [3,11]. Cockles are ideal candidates for species because of its fast growth rate, continuous reproduction throughout the year, and high population abundance [4]. The existence of size variations indicate that the population is still classified as normal. The abundant interval classes of shell dimensions in this research illustrates the abundance of groups in a population. The difference in the maximum shell size obtained can be due to several possibilities, such as the difference in location, size of the samples taken, and the likelihood of high capture stress [6]. The total length of blood shells in good environmental conditions can reach up to 49.5 mm [5]. Several factors can influence the soft tissue weight relative to the length of the shell. These may be influenced by biological and ecological factors such as water temperature, density and beach conditions [4].

Figure 1, 2, and 3 in general shows that the growth pattern of *A. granosa* shells in the Sunda Strait are negative allometric (b <3), which means that the shells are thin. In example, unbalanced growth
between the length, width, and height of the shell with the total weight of the shell, so it can be indicated that the length, width, and height of the shell are growing faster than the body weight. Shell morphological changes due to phenotypic variation also has the ability to influence soft tissue weight relative to the shell lengths between locations [7,12].

Food availability can affect tissue growth, storage, and utilization, which has the ability to change the ratio of total weight to shell length [13,14]. Correlation coefficient (r) between dimensions of length, width, and height of shell with the weight is 0.6139; 0.5478 and 0.4626. This value shows a moderate and close relationship [15]. The difference in value of b can be caused by differences in the number and variation of shell size observed, differences in species and environmental factors [16] also due to different shell stock in the same species, the stage of shell development, sex, gonadal maturity level, time difference in the day due to changes in stomach contents [17], differences in life strategies, and environmental conditions [6]. The basic substrate is a factor influencing the composition and distribution of benthic organisms and as a food source of zoobentos [5]. Sunda Strait temperature ranges from 27-30°C. This temperature is suitable for A.granosa shells that live in tropical and sheltered areas in mangroves with a temperature range in mud between 26–37.5°C [1], BOD concentration of 3.02–5.25 mg/l indicates that the waters are not mildly or moderately polluted by organic matter [2].

4. Conclusion
The relationship of the dimensions of the shell with the total weight of the shell shows a negative allometric growth pattern (b <3), which is an unbalanced growth between the dimensions of the shell and the weight of the shell, so that the increase in width, length and height is faster than the body weight. The parameters that affect the dimensions of the shell and weight are NH₃-N, NO₂-N, BOD, salinity, depth, TOM, brightness, humidity, Pb, Cd, Hg and temperature.

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