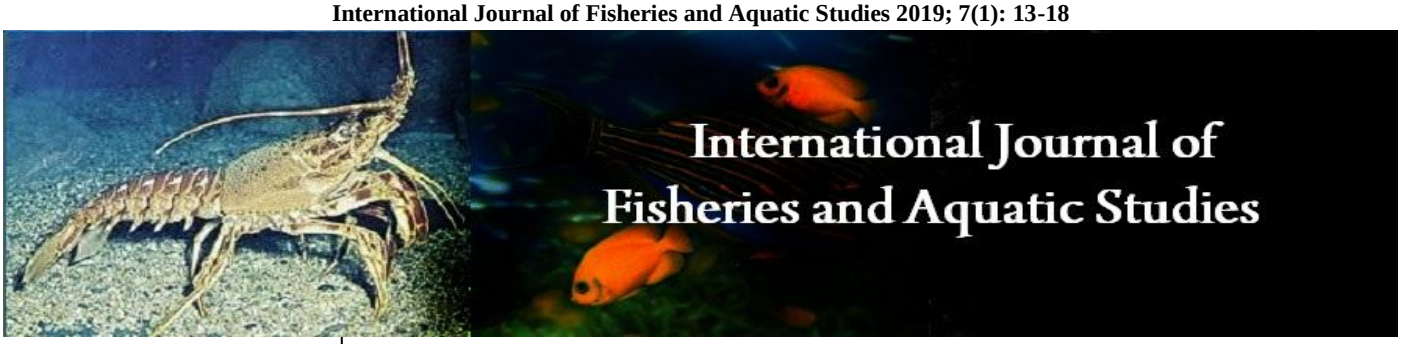

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Population structure and growth pattern of wild oyster (*Ostreidae*) in Banda Aceh City, Aceh Province, Indonesia

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Abstract
The aim of the study was to analyze population structure, growth patterns and determine the environmental conditions of wild oyster habitat that grows in Banda Aceh City, Indonesia. The study was conducted from April to May 2017 in three locations that represent the wild oyste habitat in Banda Aceh City, Indonesia. The study locations are Alue Naga, Gano and Gampong Pande. The methode that has been used to collect sampling in this study was square transect. Results revealed that, there was five oyster species in the Banda Aceh, namely *Saccrostrea cucullata*, *Crasosstrea irredelei*, *Crasosstrea gigas*, *Oestrea edulis*, *Crasosstrea virginica*. The most common oyster species was *Crasosstrea irredelei*. The highest density was observed in the Gampong Pande waters and the lowest in the Gano waters, respectively. The pattern of oyster distribution was found in clustered and formed oyster reef. The negative allometric growth pattern was observed in the oyster species. The environmental conditions consisted of plankton abundance and chemical-phisical parameters of the waters of Banda Aceh City have a normal carrying capacity for oysters to grow.

Keywords: Oysters, Population structure, Growth patterns

1. Introduction
Oyster the member of the family Ostreidae, which are widely consumed by people in the coastal region. Oyster shells are usually oval, have a rough, irregular and pear shaped (Silulu *et al*. 2013) [18]. Dance (1974)[8] reported that oysters consist of 3 genera, namely *Crassostrea*, *Ostrea*, and *Lopha*. They have an important role as ecosystem formers (Peterson *et al*. 2003 [15]; Grabowski *et al*. 2005 [12]; Coen *et al*. 2007 [7]; Fulford *et al*. 2010) [10], in the nutrient cycle (Fulford *et al*. 2007) [9], and the link between benthic-pelagis (Porter *et al*. 2004). In addition, an increase in oyster populations has an effect on reducing impact of anthropogenic eutrophication (Pringgenies 1994; Cerco 2007; Fulford *et al*. 2010) [16, 5, 10].
Oysters commonly found in the waters of Aceh Province consist of 3 genera, namely *Crassostrea*, *Ostrea* and *Saccrostrea* (Octaviana, 2014). The habitat area of the oysters in the Banda Aceh rever including Krueng Lamnyong river in Alue Naga Village (Rahayuni, 2013) [17] and brackish waters of Gampong Jawa (Asmah, 2015) [1]. The activity of catching wild oysters by fishermen continues to occur in Banda Aceh in order to fulfill the oyster consumer demand. The location of wild oyster capture in Banda Aceh City are in Gampong Alue Naga, Gampong Tibang, Gampong Gano, Gampong Pande. Catching oysters was done by fishermen by collecting oysters using traditional techniques. They have lack of knowledge when catching wild oyster without any consideration to select the proper size of wild oyster. Catching oyster in reproductive size conditions contributes to decrease oyster population.
Study of population structure of wild oyster in Banda Aceh city is considered important to be done in order to maintain the oyster sustainability and support the development of oyster culture in Banda Aceh city. The objectives of this study are to analyze the population structures, growth patterns and environment conditions in oyster habitat.

2. Methods
This research was carried out on three brackish waters which often become the wild oyster capturing area in Banda Aceh, namely: Alue Naga Waters Syiah Kuala District, Gano Waters Syiah Kuala District, and Gampong Pande Waters, Kota Raja District, Banda Aceh City. Data

collection of this research was conducted from April to May 2017. The location of the study shown in Figure 1.

2.1 Determination of Stations and Sampling

The research area was divided into 3 stations, namely Station 1 of the Aquatic area of Alue Naga Village, Syiah Kuala District, Station 2, Gano Aquatic Area, Syiah Kuala District, and Station 3, Gampong Pande District, Kota Raja District. The method used to collect data sampling was the Quadrate Transect Method.

At each station a transect line was drawn on the right, center and left of the brackish water parallel to the coastline, and a sampling plot of 1m x 1m was determined. Each transect line was assigned 9 side plots randomly placed on the right, middle and left side of brackish water. Sampling of oysters, water and substrate at each station was done by using the purposive method of sampling, with 3 replications on the right, middle and left edges of the estuary at low tide. Samples include oyster and substrate samples, carried out every week during 2 (two) months. Stages of research include observations, field sampling, measurements, and analysis in the laboratory. Identification of oysters was done by using a book of mollusk identification (Dance, 1974; Kozlof, 1987) [8, 13].

2.2 Data Analysis

2.2.1 Population Density and Oyster Size Distribution

Oyster density was analyzed using the formula Brower *et al*. (1977) [3], taking into account the number of individuals per area of transect (ind / m2). The formula used to determine the distribution pattern of an organism in the habitat is the Morisita Index formula (Id) (Brower and Zar 1977) [3].

Id = q (∑ni ^ 2-N) / (N (N-1))

if Morisita Index (Id) < 1 means the distribution patterns of individual types are uniform, if Id = 1 means Individual distribution patterns are random and if Id > 1 means distribution patterns of individual types are grouped.

2.2.2 Growth Patterns and Growth Parameters

The oyster growth pattern determine with the relationship of shell length to body weight (wet weight) which was analyzed through the equation relationship as follows:

$$W = a\ L^b$$

Oyster growth parameters including asymptotic shell length (L∞), growth coefficient (K), and theoretical age when oysters have a size of zero (t0) were analyzed using the Electronic Lengths Frequency Analysis program (ELEFAN I) accommodated in FiSAT II based on data shell length frequency.

3. Results and Discussion

3.1 Population Structure - Population Density

Most of the oysters found at the study site were oyster species which fall into the category of oysters which are generally spread in the West and Central Pacific waters where Aceh waters are included in the scope. The population of oysters in the three research stations had different densities, according to the following Table 1:

There were five species of oysters that grow and develop at the observation site: *S. cucullata, C. irredelei, C. gigas, C. virginica* and *O.a edulis* (Table 1; 2; 3),) Station 1 (Waters of Alue Naga) has four species of oysters (*S.; C. irredelei; C. gigas; O. edulis*), while station 2 (Gano waters) has five species of oysters (*S. cucullata; C. irredelei; C. gigas; C. virginica; O. edulis*) and Station 3 found 4 species of oysters (*S. cucullata; C. irredelei; C. gigas; C. virginica*).

In Alue Naga waters, the highest and lowest density of oyster was observed in *C. irredelei* (31-62 Ind/m^2) and *C. gigas* (1-7 Ind/m^2). Furthermore, *S. cucullata* (34 ind/m^2) and *C. gigas* (1-6 Ind/m^2) was reported highest and lowest density of oyster in the waters of Gano, respectively., Also, Gampong Pande revealed the highest and lowest density of oyster in *C. irredelei* (49- 97 Ind/m^2) and *C. virginica* (1-3 Ind / m^2).

Oysters found in the waters of Banda Aceh City consist of 3 genera, namely *Crassostrea*, *Sacrostea* and *Oystrea*. Species found were *S. cucullata*, *C. irredelei*, *C. gigas*, *O. edulis* and *C. virginica*. The total samples collected were 1,514 individuals, consisting of *S. cucullata* 617 individuals, *C. irredelei* 671 individuals, *C. gigas* 142 individuals, *O. edulis* 84 individuals and *C. virginica* 69 individuals. Most of the oysters spesies found at the study site were oysters species generally spread in the West and Central Pacific waters.

Table 1: Density and morphometric species at Station 1 (Alue Naga). 2 (Gano) and 3 (Gampong Pande) (Ind / m^2)

Species	Density (ind/m^2)	Lenght (mm)	Width (mm)	Total Weight (mg)	Muscular Weight (mg)
Station 1					
S. cucullata	20-66	25.3-59.8	18.1-38.1	31.6-146.9	2.0-13.7
C. irredelei	31-62	24.4-67.2	15.3-45.4	21.3-164.6	2.0-9.1
C. gigas	1-7	25.3-59.8	23.6-33.8	36.4-86.1	2.6-4.9
O. edulis	2-14	25.4-45.1	21.7-36.1	24.8-71.3	3.4-5.2
Station 2					
S. cucullata	29-48	24.3-55.7	18.5-34.0	30.7-186.0	4.5-24.2
C. irredelei	29-50	32.9-71.4	15.8-48.4	23.8-268.6	4.5-64.5
C. gigas	1-6	42.4-52.9	25.4-40.5	103.7-123.6	6.3-17.0
O. edulis	2-13	30.0-49.1	24.2-30.8	50.3-83.3	4.5-7.0
C. virginica	3-5	29.3-47.9	24.5-32.1	7.5-120.6	2.4-17.1
Station 3					
S. cucullata	31-93	30.6-48.3	15.5-38.3	44.5-178.2	2-24.6
C. irredelei	49-97	19.5-56.3	8.3-19.3	53.6-265.6	8.5-32.1
C. gigas	2-11	52.1-59.1	36.9-44.2	152-210.3	33.4-89.5
C. virginica	1-3	40.0-54.4	25.3-35.1	77.8-205	12.8-37.5

Table 2: Value b of several studies on oysters

Species	b	References
Crassostrea madrasensis	1.06-2.07	Nagi *et al.* (2011)
Crassostrea gryphoides	0.76-1.99	Nagi *et al*. (2011)
Ostreae Crassostrea gigas	1.27-1.87 2.353-2.074	Octavina (2014) Siregar (2017)

Table 3: Species and Plankton Abundance

Station 1 (Alue Naga)				
No	**Plankton Spesies**	**Density**		
		1	**2**	**3**
1.	*Rhizosolenia pungens*	3.302	2.547	2.453
2.	*Pseudo-nitzschia Lineola*	189	660	0
3.	*Leptocylindrus minimus*	0	189	0
4.	*Nitzschia longissima*	0	418	0
5.	*Navicula distans*	0	94	0
6.	*Proboscia alata*	0	94	0
7.	*Tetraselmis*	0	0	94
Station 2 (Gano)				
No	**Plankton Spesies**	**Density**		
		1	**2**	**3**
1.	*Rhizosolenia pungens*	1.793	2.264	1.510
2.	*Peridinium sp.*	94	0	0
3.	*Chaetoceros tetrachon*	0	189	0
4.	*Ceratium hexacanthum*	0	189	0
5.	*Nitzschia sicula*	0	283	0
6.	*Guinardia deliculata*	0	0	94
7.	*Pseudo-nitzschia lineola*	0	0	94
8.	*Coronosphaera mediterranea*	0	0	94
9.	*Branianus plicatilis*	0	0	94
10.	*Trichocerca sp.*	0	94	0
11.	*Nitzschia longissima*	0	0	94
12.	*Rhizosolenia styliformis*	0	0	94
13.	*Thalassiosira punctigera*	0	0	3.208
Station 3 (Gampong Pande)				
No	**Jenis**	**Density**		
		1	**2**	**3**
1.	*Tetraselmis*	1.038	566	1.132
2.	*Rhizosolenia pungens*	3.397	3.302	3.019
3.	*Pseudoguinardia recta*	1.89	377	283
4.	*Nitzschia longissima*	94	188	189
5.	*Navicula distans*	94	0	0
6.	*Proboscia alata*	94	0	0
7.	*Rhizosolenia styliformis*	94	94	0

3.2 Distribution Pattern and Oyster Size Distribution

The distribution pattern of oysters in the waters of Banda Aceh City was clustered. The pattern of grouped distribution found a Morisita (Id) index value greater than 1 (>1). The clustered oyster distribution pattern was also found in previous studies (Octavina, 2014) [14].

The long-size distribution of oysters in the waters of Alue Naga has 7 to 9 size classes, *C. irredelei* has 9 classes with the shortest size 24.40 mm and the longest 67.20 mm, the highest frequency obtained at sizes 33.94-38.70 mm as many as 62 individuals. *Saccrostrea cucullata* has 9 classes with the shortest size of 25 mm and the longest is 60.40 mm, the highest frequency is obtained in sizes 36.82-40.75 mm as many as 56 individuals. *Crassostrea gigas* has 7 classes with the shortest size of 25.30 mm and the longest of 59.80 mm, the highest frequency is obtained in sizes 35,17-40,09 mm as many as 18 individuals. *Oestrea edulis* has 7 classes with the shortest size of 25.40 mm and the longest is 45.10 mm, the highest frequency is obtained in sizes 31.04-33.85 mm as many as 14 individuals.

In Gano waters, the length of oysters is 7 to 8 size classes, *Crasosstrea irredelei* has 8 classes with the shortest size of 30.50 mm and the longest is 72.11 mm, the highest frequency is obtained in sizes 40.92-46.12 mm as many as 76 individuals. *Saccrostrea cucullata* has 8 classes with the shortest size 25 mm and the longest 60.50 mm, the highest frequency is obtained in sizes 29.45-33.89 mm as many as 40 individuals. *Crassostrea gigas* has 7 classes with the shortest size of 25.30 mm and the longest of 60.20 mm, the highest frequency obtained in sizes 45.30-50.29 mm as many as 10 individuals. *Oestrea edulis* has 7 classes with the shortest size of 25.40 mm and the longest is 45.00 mm, the highest frequency is obtained in the size of 34.10-36.90 mm in 10 individuals. *Crassostrea virginica* has 7 classes with the shortest size of 29.20 mm and the longest of 53.50 mm, the highest frequency obtained in sizes 43.20-46.69 mm as many as 10 individuals.

3.4 Growth Pattern

The growth pattern of oysters in each station was analyzed by the relationship of length and weight. The relationship curve of the length and weight of the oysters tends to be sloping (Figure 1; 2; 3), and the length increase was faster than the increase in the weight of the oyster. Based on the t-test on the length and weight of oysters allometric results were obtained negatively at each research station, which means that the long growth of oysters was faster than the weight growth. It can be said that the growth of oysters in the general waters of the city of Banda Aceh tends to be thin. The coefficient value of b oysters in the waters of Banda Aceh City ranges from 0.9493-2.1065, this value is compared with the value of b from several other research results on shellfish (Table 2).

The asymptotic length shows how big the shell size can be achieved by an individual shell (old size). The growth coefficient (K) was an important factor to determine the rate of growth of shellfish reaching asymptotic size. According to Sparre and Venema (1998), the value (K) differs from one type to another, even the difference can occur in the same type with the same location. The L∞ and K values that have been obtained were then analyzed to get a value of t0 (age at the time of length equals zero).

Age t0 was also called the initial condition parameter which determines the point in the size of time when (fish / shellfish) has zero length. If viewed in terms of biology, this means that growth begins when larvae have a certain length (Sparre and Venema 1998).

The length of the oyster shell was related to the increase in the weight of the oyster. The most prominent part of the oyster to be monitored was the growth of the shell, so that the growth in the oyster was an increase in the length of the shell and then the weight of the body. The relationship of the length and weight of oysters in the waters of the city of Banda Aceh is closely correlated.

Overall the growth pattern of oysters in the waters of Banda Aceh City tends to be thin because the length and weight relationship curves that are formed tend to be sloping, thus indicating the long growth of oysters faster than weight gain. Some studies on other oysters also have b values that are similar to *C. gigas* in Indramayu Indonesia Lower Customs and oysters in Kuala Gigieng Aceh Besar (Octavina, 2014) [14].

The life span (t maks) of oysters in the waters of Banda Aceh City ranges from 1-5 years, while the maximum shell length was 43.29-66.73 mm. Oyter needs 5 years to get the maximum length. Octaviani (2014) [14] obtained the maximum

age of oysters in Kuala Gigieng Aceh Besar ranging from 0.11 to 3.42 years with a maximum oyster length of 37.91-72.81. Meanwhile, Coakley (2004) [6], states that oysters in the Chesapeake Bay reach a maximum size of 83.46 mm (mm, k = 0.55 L∞ = 90.85) within a period of 0-5 years. The Buroker (1983) [4] study found that oysters in the Gulf of Mexico were able to reach lengths of up to 3 inches in the span of 18-24 months.

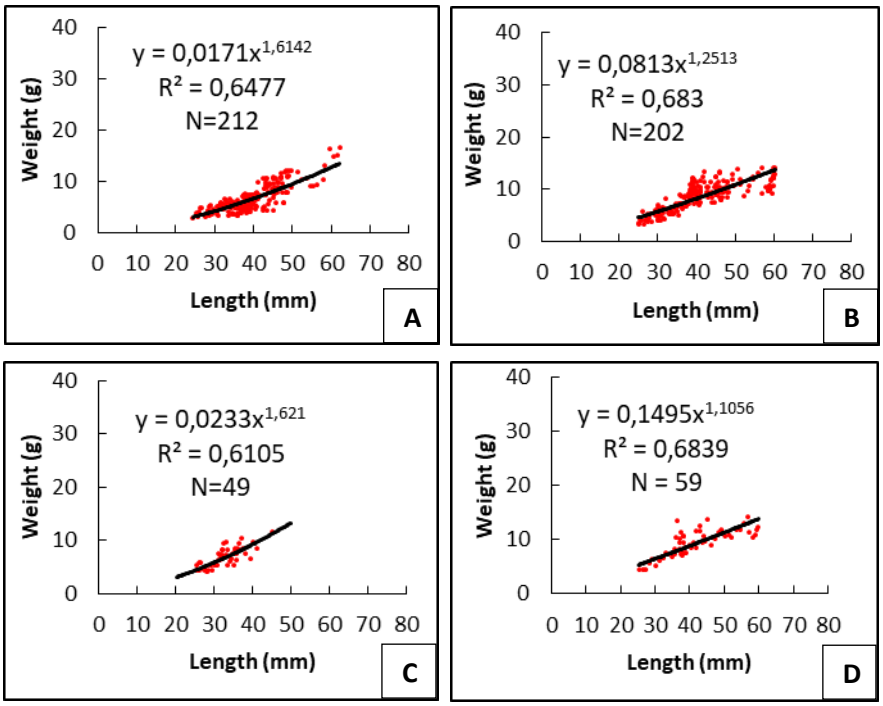

Fig 1: Relationship of Length (mm) and Weight (gram) of Aquatic oysters in Alue Naga A) *C. irredelei*; B) *S. cucullata*; C) *O. edulis*; D) *C. gigas*

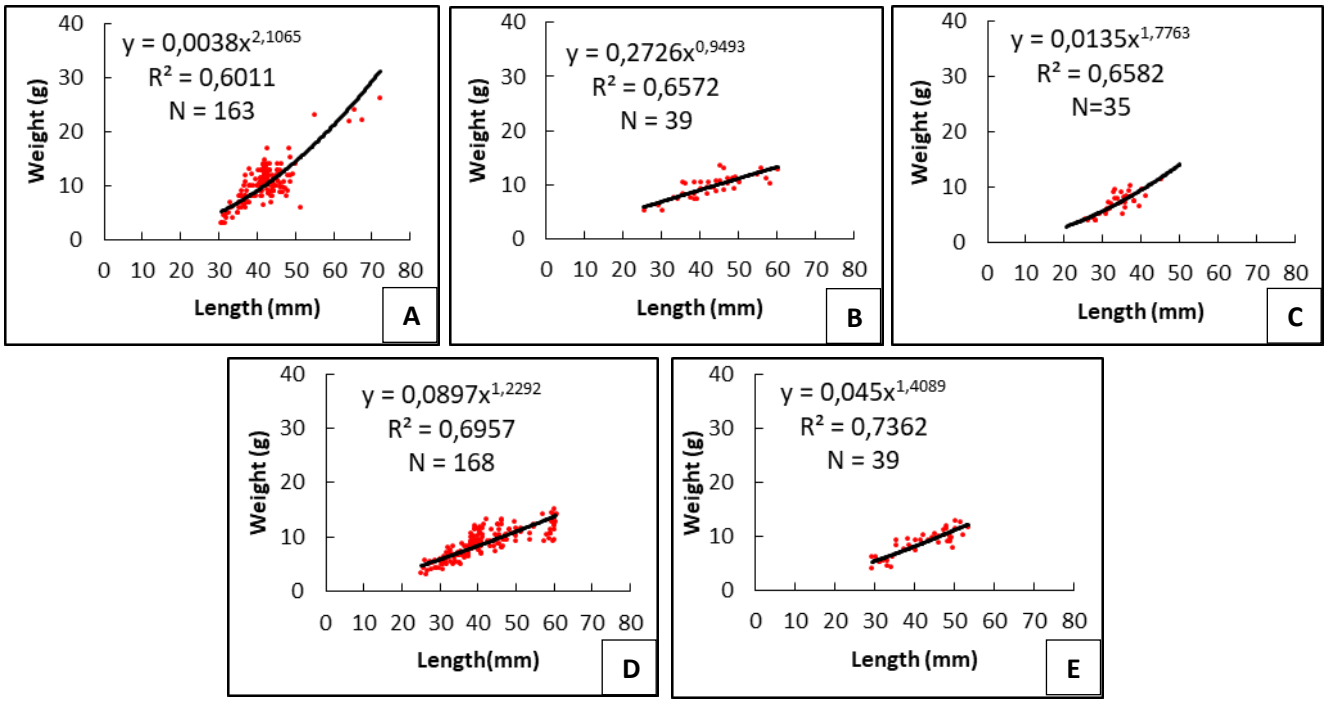

Fig 2: Relationship of Length (mm) and Weight (g) of Gano Aquatic oysters A) *C. irredelei*; B) *C. gigas*; C) *O. edulis*; D) *S. cucullata;* E) *C. virginica*

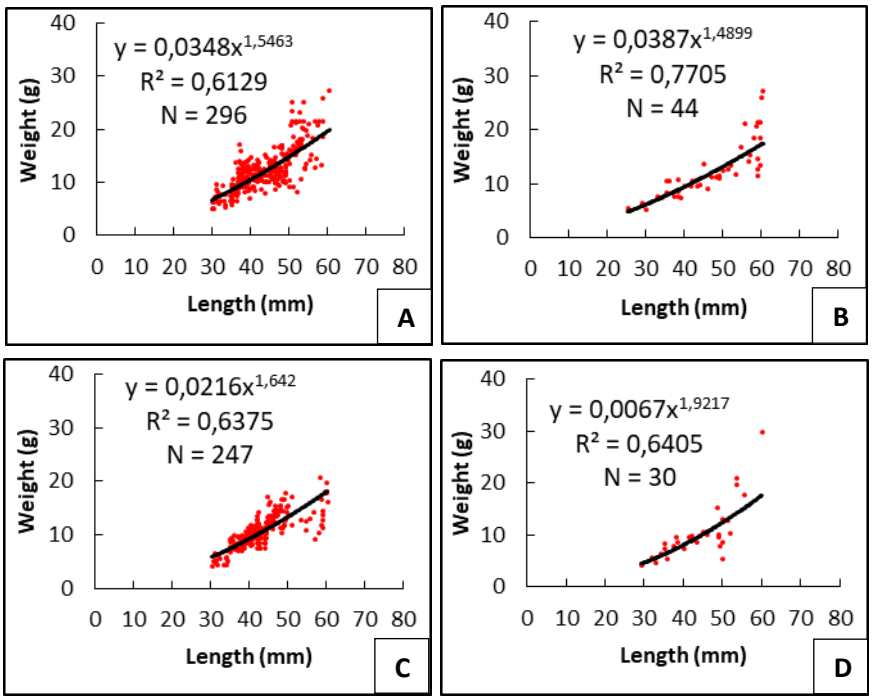

Fig 3: Relationship of Length (mm) and Weight (gram) of oysters of Gampong Pande Waters. A) *C. irredelei*; B) *C. gigas*; C) *S. cucullata;* D) *C. virginica*

3.5 Oyster Habitat Conditions

Oysters live in waters that are affected by salinity with the force of calm currents and into the still affordable light (Batista, 2007). The environmental conditions of the waters in the three research stations are coastal waters affected by the tides of seawater, the source of seawater waters north of Banda Aceh and fresh water originating from the Krueng Aceh River.

Alue Naga Station (Station 1) has a flow of sea water flowing through a river that has a large river flow and two small rivers. Large rivers cross the Lamnyong area of Banda Aceh City and lead to the waters of the Great Aceh District. At the time of data collection in this study purposive sampling of oyster populations in the small river flow of Alue Naga waters was carried out.

The environmental conditions of the waters where sampling is taken are the conditions of the waters that have mangrove vegetation on the banks of the river and there are limited activities of brackish water fishing using fishing rods and nets by local residents. The population of oysters can be clearly observed along the stream.

The waters of Gano (Station 2) consist of two small rivers that are sourced primarily from the sea waters of Syiah Kuala, Banda Aceh City. The small river flow resembling the big moat around it has mangrove vegetation. The small stream supports the supply of water for milkfish ponds and brackish water fish in the village of Gano. The population of oysters can be seen clearly along the stream and ponds which are fed by a small river in Gano. Oysters stick to mangrove roots and other hard substrates.

Station 3 is the waters of Gampong Pande. It is located nearby Ulee Lheue Sea, Banda Aceh City The condition of Gampong Pande waters to be strongly influenced by the sea water conditions of Ulee Lheue. The Ulee Lheue sea has branches and flow into the brackish waters in Banda Aceh City and Aceh Besar District. The environmental conditions of brackish water in Gampong Pande consist of mangrove vegetation and other brackish water species. The population of oysters can be seen clearly in the waters of Gampong Pande. Oysters stick to the mangrove roots and on other hard substrates.

Comparing the three research stations mentioned above, it can be said that the largest brackish waters are at Station 3 (Gampong Pande Waters) where the sea water flow directly forms a broad expanse of water column and is not a relatively small channel such as Station 1 and 2. , at Station 1 (Alue Naga Waters) has a river flow that is bigger and closer to sea water than Station 2 (Gano Waters) which has a relatively small river flow.

Plankton species at station 1 are seven species, at station 2 (Gano waters) there are thirteen plankton species, while at station 3 there are 7 plankton species. The most species are at station 2 (Gano waters), which are thirteen plankton species.

4. Conclusion

1. Oyster population structure includes: (a). Oyster density in all three research stations has different densities. The highest density is in the waters of Gampong Pande, then second in the waters of Alue Naga and the last in the waters of Gano. (b). The oyster dispersion pattern found was clustered. (c). The long-size distribution of oysters in the waters of Alue Naga has 7 to 9 size classes while the size distribution in the waters of Gampong Pande has 6 to 10 size classes and in the waters of Gano has 7 to 8 size classes.
2. Oyster Growth Pattern based on t-test on oyster length and weight obtained negative allometric results at each research station, which means that the long growth of oysters is faster than the weight growth, it can be said that the growth of oysters in Banda Aceh's general waters tends to be thin.
3. The environmental conditions of Banda Aceh City waters have a good carrying capacity for growing oysters, where the results of measurements of water-chemical physics parameters such as temperature, current, salinity, pH, sediment, brightness and DO patterns at each research station are in normal conditions to grow oyster flower.

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