Original Research Article

The effect of environment on puerulus settlement of the spiny lobster, *Panulirus homarus* in Awang Bay, Lombok Island

ABSTRACT

The increasing effort to catch lobster seeds will have a negative impact on the availability of lobster seeds in nature, and cause a break in the lobster life cycle chain in nature. Therefore, this study aims to observe the settlement of puerulus lobster larvae in the waters in relation to fluctuations in aquatic environmental conditions. This research was conducted from August to October 2020 in the waters of Teluk Awang, Lombok Island. The main data collected in this study is puerulus settlement, while the supporting data are physical, chemical and biological parameters of the waters. Observations of the aquatic environment are carried out in-situ, and using remote sensing and geographic information systems (GIS). The collected data were analyzed by multiple regression analysis. The results showed that the distribution of sea surface temperature and chlorophyll-a based on satellite imagery during August to October showed that warm temperatures and chlorophyll-a were concentrated in the coastal area and decreased towards the offshore. The nine environmental parameters studied contained two parameters that significantly influenced individually on puerulus lobster settlement, namely the abundance of plankton and temperature. Meanwhile, brightness, current velocity, dissolved oxygen, salinity, pH, phosphate and nitrate had no significant effect. The significant relationship between plankton abundance and temperature and puerulus lobster settlement was due to plankton being the main food for larvae, and the sea water temperature was still relatively stable so that lobster seeds still survived and could support puerulus lobster settlement.

Keywords: puerulus, settlement, spiny lobster, environment

1. INTRODUCTION

Spiny lobster (Crustacea: Decapoda: Palinuridae) is a typical species of coral reef and rocky waters in tropical and subtropical marine areas [1]. Lobster has 5 life phases, namely adults with sperm or egg production, filosoma (larval stage), puerulus (post-larval stage, final stage of filosoma) and young lobsters [2]. Reproduction begins with the mixing of spermatozoid with an egg (ovum), then the fertilized egg is placed under the belly of the female lobster, attached to the hairs found on the umbilies of the swimming legs [3]. During incubation, the eggs attached to the underside of the parent lobsters undergo division and development and hatch into larvae. The larvae undergo several skin changes, namely from the nauplisoma, filosoma, puerulus stages to the young lobster stage. Puerulus larvae are a transitional stage from the planktonic phase to the benthic phase [4], can swim freely and move to shallow areas and are protected by seaweed and coral reefs where there is food and can avoid predators [5].

The settlement of puerulus in shallow waters to find food and shelter is used by fishermen in Lombok to use various traps to catch the lobster seeds [6]. The high demand and the increasingly expensive price of lobster seeds have caused the exploitation of this resource to continue to increase. The price of seeds, which initially ranged from IDR 1,500- 2,500 / head for seed sizes of around 2-3 cm, continued to increase to IDR 17,000 - 20,000 / head [7]. The export of Indonesian lobster seeds from 2011-2014 has increased constantly and sharply. Vietnam is the largest importer of lobster seed commodity from Indonesia [7]. These seeds will be cultivated in Vietnam, then re-exported after maturity with a value that is many times higher [8]. Thus lobster seeds sourced from Indonesian waters provide economic benefits for people in these seed importing countries [9].

The waters of Lombok Island are one of the lobster seed producing locations in Indonesia, especially the waters of Gerupuk Bay, Bumbang Bay and Awang Bay [6], [10]. Based on the study of lobster seed abundance, seed distribution points were identified and the peak season for seed abundance is around June - July in the waters of Gerupuk Bay [9] and around January - February in the waters of Awang Bay [10]. Apart from the southern waters of Lombok Island, the southern waters of Sumbawa Island to the southern waters of Java Island are areas for catching lobster seeds [11]. The increasing effort of catching lobster seeds in the long term will have a negative impact on the availability of lobster seeds in the wild, and cause a break in the chain of lobster life cycles in nature. At a certain point, these lobster species will experience scarcity, even extinction, as happened in the western region of Mindanao Island, Philippines [12]. Likewise with conditions that occur in the waters of Lombok Island and southern Sumbawa Island. Therefore, it is necessary to study the bio-ecology of lobsters related to stock estimates, spawning areas, recruitment, and habitat as well as environmental factors that affect the settlement of lobster seed stocks in nature.

The existence of lobster seeds (puerulus) in a waters is influenced by environmental conditions such as sea surface temperature, salinity, currents and climate [13]. The presence of the lobster, *Palinurus elephas* in the western Mediterranean Sea began when sea surface temperatures began to rise in mid-May, peaked in June-July, and ended in August [1]. In the waters of Lombok Island, especially Gerupuk Bay, there is a very striking increase in the abundance of lobster seeds in June and July [9], this is closely related to oceanographic conditions and phenomena that occur around the study site. Data and information regarding recruitment patterns and their relationship with oceanographic phenonema are important to know as a basis for predicting fishing times and strategic management of lobster seeds in the wild [14].

Oceanographic phenomena observation can be done in-situ, namely direct measurement in the field or by using remote sensing applications and geographic information systems (GIS). The application of semote sensing and GIS in oceanographic observations in relation to fishing ground has been widely practiced in Indonesia [15], with the application of these two methods it was found that the relationship between temperature, depth, salinity and pH has an effect on lobster fishing ground in waters Nabire, Papua Province [16]. Research on the influence of the aquatic environment or oceanography on the presence (settlement) of lobster larvae in Awang Bay waters has never been carried out. Awang Bay was chosen as the location of this study, because based on the census of lobster seed catches in 2013, Awang Bay was the most productive fishing ground in Lombok [17].

This study aims to observe the settlement of lobster puerulus larvae in Awang Bay waters in relation to fluctuations in aquatic environmental conditions spatially and temporally. The results of this study are expected to provide information about the potential of lobster seeds that are useful for supporting the management and availability of seeds for lobster enlargement cultivation.]

2. MATERIAL AND METHODS

[2.1. Study Area

This research was conducted from August to October 2020 in the waters of Teluk Awang, Lombok Island, Indonesia. A total of 3 stations spread out simple random [18], were collected at the research location. Each observation and sampling station has its coordinates determined using a GPS device. Station 1 is located at the coordinate point 8°55.31S lat, 116°24.30E long, station 2 is at the coordinate point 8°53.44S lat, 116°24.37E long and station 3 at the coordinate point 8°52.36S lat, 116°24.18E long. ~~Meanwhile, Tthe~~The satellite data area extends from the coordinate point between 8°60 - 8°48S lat and 116°13 - 116°35E long (Figure 1).

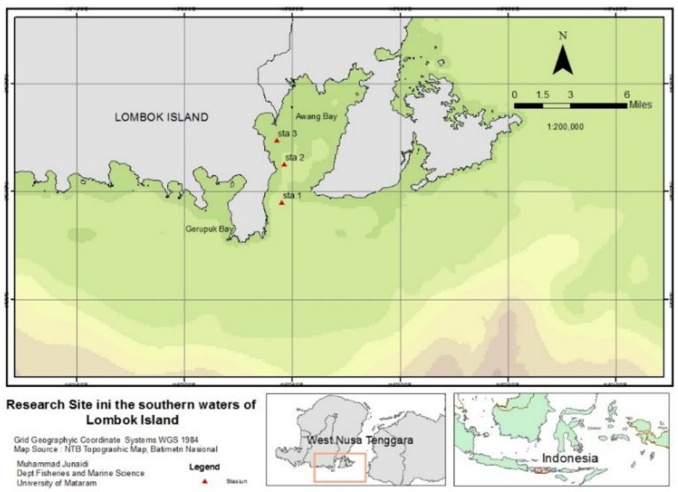

Figure 1. Research site

2.2. Data Collection

The materials used in this study were spiny lobster puerulus larvae, 4% formalin and 70% alcohol. While the tools used are lobster seed collectors, fishing boats, cameras, life jackets, stationery, global positioning system (GPS) to determine the position of observation stations, thermometers to measure temperature, hand ~~refracto-meters~~refractometers to measure salinity, DO meters to measure oxygen dissolved, secci disk for measuring brightness, current-meter for measuring current velocity, pH-meter for measuring pH, sample bottles, net plankton, microscopy, and satellite data.
The main data collected in this study were puerulus settlements or the abundance of lobster seeds, while the supporting data were physical, chemical and biological parameters of the waters (phytoplankton). Observation oflarvae or lobster seeds ~~are~~were carried out by installing a collector's tool which the local community calls the name "pocong"[10]. Pocong is made of used cement paper bags and waring. A sheet of cement bag paper measuring 20 x 20 cm is folded like a fan, and the middle is tied to the waring. The paper bags are 10 - 20 m long and 1.5 m wide. At the bottom of the waring is weighted, and the upper part is attached with a hanging rope. The collector made of paper and waring is hung on a raft assembled

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from bamboo and equipped with a float (drumpon) and an anchor (Figure 2). One 6 x 3 raft unit is used to pocket 6 collectors. When the collector operates at night, the raft of power plants and electric lamps is 6 units each with a power of 50 watts. The use of light in catching lobster larvae aims to attract larvae to gather around the raft area, because lobsters are phototaxis.

The number of larvae or lobster seeds found every month at each observation station was counted to determine the distribution and fluctuation of their abundance each month. The collected seed data is the sum of all collectors for each station. Measurement of water physical, chemical and biological parameters including temperature, salinity, pH, brightness, dissolved oxygen, current velocity, nitrate (NO3-N), phosphate (PO4-P) and phytoplactone. Parameters of temperature, salinity, pH, DO, brightness and current were measured directly in the field using a refractometer, pH-meter, DO-meter, secci disk, and current-meter. Parameters of nitrate (NO_3-N), phosphate (PO_4-P) and phytoplankton were carried out by taking water samples, then analyzed in the laboratory. Satellite image data on sea surface temperature (SST) and chlorophyll-a concentrations were downloaded from NASA's Ocean Color Web (https://oceancolor.gsfc.nasa.gov/) and current velocity was downloaded from the ERDDAP website (https: //coastwatch.pfeg. noaa.gov/erddap/index.html).

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Figure 2. A raft on which to hang a lobster puerulus collector

2.3. Satellite Image Data Processing

Sea surface temperature (SST) and chlorophyll-a data were obtained from satellite images of Aqua-MODIS (Moderate Resolution Imaging Spectroradiometer) Level 3 composite monthly for the period August 2019 to October 2019 with a spatial resolution of 4x4 km which was downloaded from the site http://oceancolor.gsfc.nasa.gov/ in the Hierachial Data Format (HDF) format. The extracted SPL and chlorophyll-a images can be displayed on the SeaWIFS Data Analysis System (SeaDAS 7.5.3) software. The image processing stage that is carried out begins with cutting the image (cropping) according to the research location. The SPL and chlorophyll-a images that have been cut according to the research location are then carried out by the export mask pixels process to obtain the SST and chlorophyll-a values. The value of each pixel based on the latitude and longitude position of the process is obtained in the Comma Separated Value (csv) format which is ready for further processing in ArcGIS 10.3 software.

Figure 3. Puerulus spiny lobster, Panulirus homarus

2.4. Data Analysis

To determine the relationship between water environment parameters and settlement of spiny lobster puerulus, multiple regression analysis was used. Regression analysis is a data analysis technique in statistics that is often used to study the relationship between several variables and predict a variable. The relationship or influence of two or more independent variables on the dependent variable is called a multiple linear regression model [19]. Multiple linear regression analysis was performed with the help of SPSS 16.0 software. The dependent variable used in this study was the settlement of puerulus, while the independent variables were temperature, brightness, current velocity, dissolved oxygen, salinity, pH, phosphate, nitrate and plankton abundance. The regression equation model is as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + €$$

where :
Y = lobster puerulus settlement; a = constant; X_1 = water temperature (^oC); X_2 = brightness (m); X_3 = current velocity (m/s); X_4 = dissolved oxygen (ppm); X_5 = salinity (ppt); X_6 = pH; X_7 = phosphate level (ppm); X_8 = nitrate level (ppm); X_9 = abundance of plankton (cells / l); b_1-b_9 = independent variable regression coefficient; and € = estimated interference error.

The F test is for testing the first hypothesis, which is to find out whether all independent variables simultaneously have a significant effect on the dependent variable. Testing is done by comparing the value of F_{count} with F_{table} at a degree of error of 5% in meaning ($\alpha = 0.05$). If the value of $F_{count} \geq$ from the value of F_{table}, it means that the independent variables simultaneously have a significant effect on the dependent variable or the first hypothesis so that it can be accepted.

The t-test is for testing the second hypothesis, which is to find out whether the effect of each independent variable (partial) on the dependent variable is significant or not. The test is carried out by comparing the tcount value of each independent variable with the ttable value with an error degree of 5% in the sense ($\alpha = 0.05$). If the value of $t_{count} \geq t_{table}$, then the independent variable has a significant effect on the dependent variable. The normality test is carried out to find out whether a variable is normal or not, normal in the sense that it has normal data distribution. There are two ways to see data normality, namely visually and by statistical tests. Visually using graphs and histograms with the assumptions used based on the normal probability graph that is formed, if the point spreads around the normal line, then the data can be said to have been normally distributed, and vice versa. Data normality test with statistical tests used the Lilliefors Test (Kolmogorov-Smimov Test), where if the significance value is greater than 0.05 (Asymp.Sig> 0.05), this indicates that the dependent variable and the independent variable are normally distributed.

The multicollinearity test aims to see whether there is multicollinearity or not by looking at the tolerance value and variance inflation factor (VIF). The smaller the tolerance value and the greater the VIF value, the closer to the multicollinearity problem. In most studies, it is stated that if the tolerance value is more than 0.1 and VIF is less than 10 then multicollinearity does not occur.]

3. RESULTS AND DISCUSSION

[3.1. Environmental Conditions

The aquatic environmental parameters observed based on Aqua Modis satellite imagery include sea surface temperature (SST), chlorophyll-a concentration and current velocity. The distribution of SST, chlorophyll-a and current velocity in the Southern Waters of Lombok Island can be seen in Figure 4. SST in the Southern Waters of Lombok Island based on the spatial distribution of Aqua Modis satellite imagery in August – October ranges from 25°C-to32 °C. Spatially, the distribution of warm temperatures is generally found in coastal waters, especially in bays, such as bays. The distribution of cold temperatures is in the offshore waters south of Lombok Island. Sea surface temperature (SST) is highly dependent on the amount of heat received from the sun, so the areas that receive the most heat from the sun are the tropics or around the equator.

The concentration of chlorophyll-a in the Southern Waters of Lombok Island based on the spatial distribution of Aqua Modis satellite imagery in August ranges from 0.3251 -to 2.3532 mg/m^3, in September it ranges from 0.2279 -to 2.1934 mg/m^3 and in October it ranges from 0.1370 -to 1.7392 mg/m^3. Chlorophyll-a is concentrated in coastal waters and the concentration is decreasing towards the offshore direction. The greatest concentration of chlorophyll-a is found in coastal waters, especially in bays such as Ekas Bay, Gerupuk Bay and Bumbang Bay. The current velocity in the Southern Waters of Lombok Island based on the spatial distribution of Aqua Modis satellite imagery in August ranges from 0.0 -to 0.1063 m/s, in September it ranges from 0.0230 -to 0.1074 m/s and in October it ranges from 0.0696 -to 0.2470 m/s.

Environmental parameters observed in situ include dissolved oxygen, brightness, temperature, salinity, pH, current velocity, phosphate levels, nitrite levels and plankton abundance. The value of aquatic environmental parameters in Awang Bay does not have a significant difference between observation stations and between observation times (Figure 5). The results of field measurements illustrate that the waters of Teluk Awang have a temperature range of 27.6 -to 31.2 ^{o}C, a brightness of 4 -to 20 m or a percentage of a brightness level of 60 -to 90%, a salinity of 32 -to 34 ppt, a pH of 7.8 -to 8.5, dissolved oxygen. 5.3 –to 7.6 ppm, current velocity 0.05 –to 0.25 m/s, phosphate levels ranged from 0.03 –to 0.53 ppm, nitrate 0.002 – 0.01 ppm, and abundance of plankton ranged from 72 x 106 – 240 x 106 cell/l.

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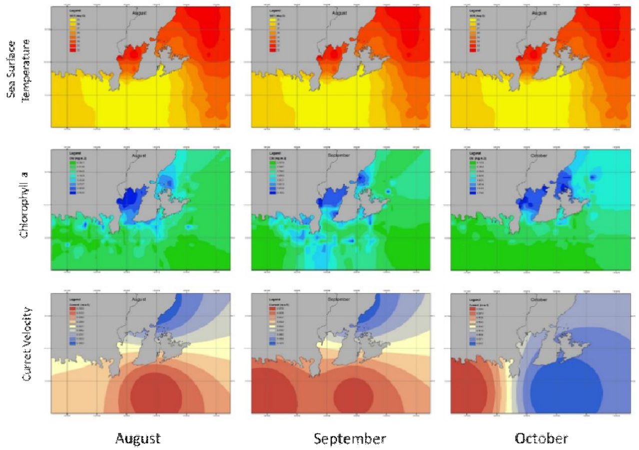

Figure 4. Spatial distribution of sea surface temperature, chlorophyll-a and currents in August - October

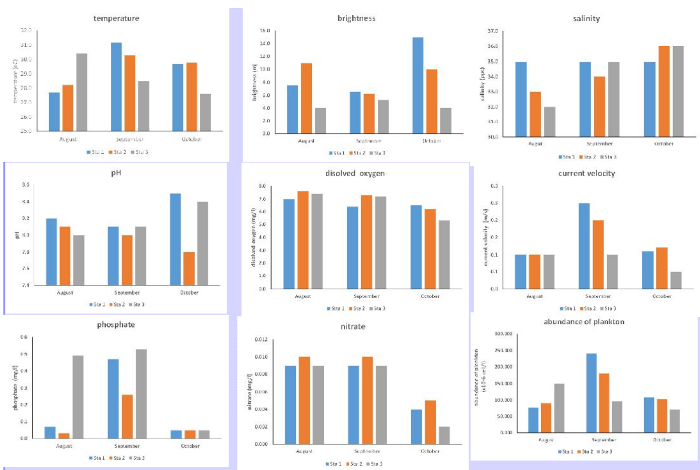

Figure 5.Temperature, brightness, salinity, pH, oxygen solubility, current, phosphate, nitrate and plankton abundance conditions in August - October

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3.2. Puelurus Settlement and its relation to Environmental Parameters

The distribution of lobster peurulus settlement at three observation stations in the waters of Awang Bay is shown in Figure 6.The number of lobster puerulus obtained from each installed collector shows that there is no difference in the distribution of puelurus between stations and the month of observation and the number is relatively small, ranging from 8-15 per trip. The relationship between aquatic environment parameters and settlement of lobster puerulus was analyzed using multiple regression with the Stepwise method, where settlement of lobster puerulus as the dependent variable and environmental parameters as the independent variable. The requirements are met to get the best regression model with normality test and multicollinearity test.

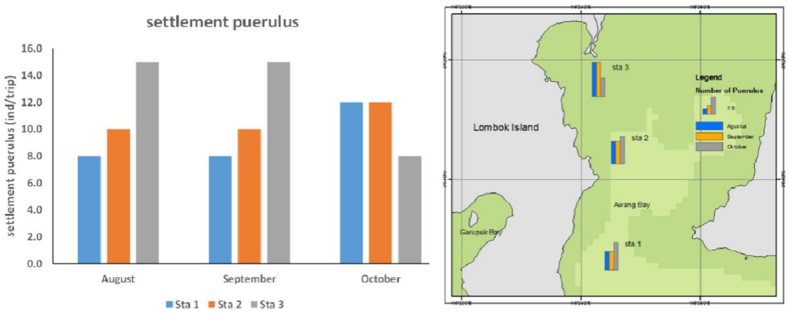

Figure 6. Settlement of lobster peurulus in August – October

The results of the data normality test using the One-sample Kolmogorov-Smirnov Test obtained a significance value greater than 0.05 (Asymp.Sig >0.05), this indicates that the dependent variable and the independent variable are normally distributed. Furthermore, the multicollinearity test results show that the independent variables of plankton abundance and temperature do not occur multicollinearity with a tolerance value> 0.1 and a variance inflation factor (VIF) value <10, while other independent variables such as brightness, current velocity, dissolved oxygen, salinity, pH, phosphate and nitrate occur multicollinearity (Table 1).

Table 1. Multicollinearity test results

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Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	abund_plankt	temp
1	1	1.921	1.000	.04	.04	
	2	.079	4.930	.96	.96	
2	1	2.903	1.000	.00	.00	.00
	2	.096	5.491	.00	.24	.00
	3	.000	116.488	1.00	.76	1.00

a. Dependent Variable: puerulus_lobster

The results of the analysis of variance (F test) to determine the effect of the independent variables of plankton abundance and temperature simultaneously on the settlement of lobster peurulus, in the first model the significance value (Sig < 0.050) and F_{count} is greater than F_{table} (129.320 > 5.591), after re-analysis by using the second model, the same value is obtained, namely the significance (Sig <0.050) and F_{count} is greater than F_{table} (244.262> 5.143). This shows that in the first and second models the independent variables of plankton abundance and temperature simultaneously significantly affect the settlement of puerulus lobster (Table 2).

The results of the regression coefficient (t-test) to determine the effect of the independent variable plankton abundance and temperature partially on the settlement of lobster puerulus, in the second model the significance value of the plankton abundance variable is obtained (Sig <0.050) and t_{coun}t is greater than t_{table} (6,400> 2,306) and temperature variables (Sig <0.050) and t_{count} greater than t_{table} (4.404> 2.306). This shows that the independent variables of plankton abundance and temperature partially significantly affect the settlement of lobster puerulus (Table 3).

Table 2. Results of analysis of variance (F test)

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	115.314	1	115.314	129.329	.000[a]
	Residual	6.241	7	.892		
	Total	121.556	8			
2	Regression	120.081	2	60.040	244.262	.000[b]
	Residual	1.475	6	.246		
	Total	121.556	8			

a. Predictors: (Constant), abund_plankt

b. Predictors: (Constant), abund_plankt, temp

c. Dependent Variable: puerulus_lobster

Table 3.Results of regression coefficient analysis (t test)

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.761	.808		4.656	.002
	abund_plankt	.068	.006	.974	11.372	.000
2	(Constant)	-29.675	7.605		-3.902	.008
	abund_plankt	.042	.007	.607	6.400	.001
	temp	1.252	.284	.417	4.404	.005

a. Dependent Variable: puerulus_lobster

The results of the regression analysis using the stepwise method obtained the best model for the relationship between plankton abundance and temperature with settlement of the lobster puerulus with the following equation:

$$Y = -29.675 + 0.042\ X_1 + 1.252\ X_2$$

Based on the regression model, it can be stated that an increase in plankton abundance of 106 ind/l is thought to have an effect on the settlement of puerulus lobsters by 0.042 and an increase in temperature of 1 °C which is thought to have an effect on the increase in settlement of lobster puerulus by 1.252. Figure 7 shows a graph of the relationship between field settlement and predicted puerulus lobster settlement.

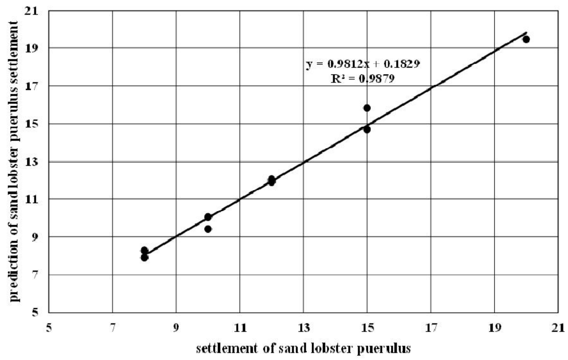

Figure 7. Relationship between field settlement and predicted puerulus lobster settlement

The results of statistical analysis show that of the nine environmental parameters studied, there are two parameters that have significant individual effect on the settlement of lobster puerulus, namely plankton abundance, and temperature. The results of linear regression analysis to determine the relationship of plankton abundance and partial temperature to the settlement of lobster puerulus can be seen in Figures 8 and 9.

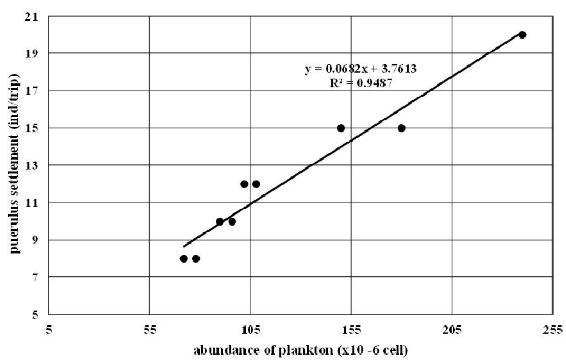

Figure 8. Results of linear regression analysis of plankton abundance with settlement of spiny lobster puerulus

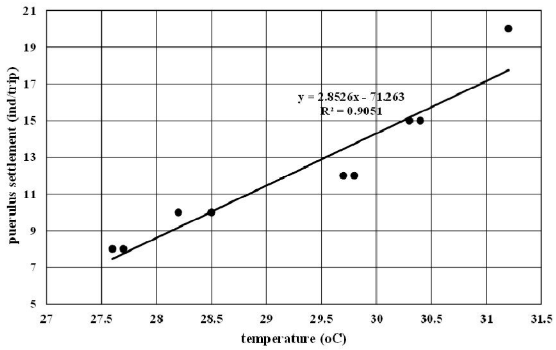

Figure 9.Results of temperature linear regression analysis with settlement of spiny lobster puerulus

In Figure 8, it can be seen that the settlement of puerulus lobster is generally in the sea water temperature range of 72 x 106 –and 240 x 106 ind/l. The coefficient of determination (R^2) between temperature and settlement of spiny lobster puerulus is 0.9487, meaning that the effect given by temperature on lobster puerulus settlement is 94.87% and the rest is influenced by other environmental parameters. Settlement of lobster puerulus generally is in the sea temperature range of 27.5 -and 31.2 ^{o}C. The coefficient of determination (R^2) between temperature and settlement of lobster puerulus is 0.9051, meaning that the effect of temperature on settlement of lobster puerulus is 90.51% and the rest is influenced by other environmental parameters (Figure 9).

3.3. Discussion

The dynamics of oceanographic environmental factors that tend to change with space and time can cause changes in the adaptation and behavior of fish or target biota, where each type of fish or biota has different adaptability to oceanographic conditions for their survival. Therefore, the distribution of chlorophyll a, temperature and changes as well as the current pattern that occurs will affect the fish in their activities, especially in foraging, laying eggs, conducting cultivation and migration. Water quality conditions play a major role in the existence, growth, reproduction and migration of lobster seeds in waters. Growth and development variability of lobsters is generally associated with environmental heterogeneity [4], [9].

The seasonal temperature changes in waters, apart from being caused by the heat of the sun shining on the sea surface, are also influenced by surface currents, cloud conditions, horizontal and vertical exchange of water masses as well as the presence of upwelling [20]. In addition to the influence of monsoon winds, SST in Indonesian waters is influenced by global climate phenomena such as El Nino and Indian Ocean Dipole (IOD), especially in waters associated with the Indian Ocean [21]–[23], and in general the west monsoon is cooler than the east monsoon. The low SST value in the Southern Waters of Lombok Island is due to the direct connection with the Indian Ocean which is the most intensive upwelling area [24]. The upwelling phenomenon that occurs in Lombok waters is due to differences in the pattern of movement of wind direction and speed from changes in the seasonal wind cycle which are divided into different patterns of movement of wind direction and speed from changes in the seasonal wind cycle which is divided into four seasonal cycles

The puerulus lobster (*Panulirus* spp) larvae are commonly found in waters with temperatures ranging from 26 - 30 C or prefer cold water in subtropical areas [4], while in the tropics the larvae can live in a temperature range of 28-32 ^{o}C [25], [26]. The temperature in the aquatic ecosystem fluctuates both daily and yearly, especially following the pattern of air temperature in the surrounding environment, sunlight intensity, geographical location, shade and the internal conditions of the waters themselves such as turbidity, depth, current velocity and accumulation of organic matter on the bottom of the waters. Temperature has a very important role for life in water. The solubility of various types of gases in water as well as all biological activities in the waters are strongly influenced by temperature. This temperature range usually applies in Indonesia as a tropical country so it is very profitable to carry out lobster cultivation activities

The concentration of chlorophyll-a in water depends on the availability of nutrients and the intensity of sunlight [27]. If enough nutrients and sunlight are available, the chlorophyll-a concentration will be high and vice versa. Chlorophyll-a in the Southern Waters of Lombok Island in a period of 5 years from 2009-2013. Chlorophyll-a is concentrated in coastal waters and its concentration is decreasing towards the offshore direction. The high concentration of chlorophyll-a in coastal waters occurs because of the accumulation of nutrients carried by river flows to sea waters in coastal areas [23]. Chlorophyll-a in bay and coastal waters is a product of high water productivity processes that occur due to the stirring process of the bottom of the waters by the movement of seawater masses towards the bay and coastal areas as happened on the coast of West Lombok [28]. The west season is the season where the chlorophyll-a concentration is quite high. This is thought to have occurred because of the high rainfall that fell on the island of Lombok, causing a lot of nutrients to enter sea waters through rivers. On the other hand, in the eastern monsoon and transition 2, there is a decrease in chlorophyll concentrations in the southern waters of Lombok Island.

Ocean currents are the movement of water masses vertically and horizontally so that they are in balance, or very broad water movements that occur throughout the world's oceans [29]. Current is also the flowing motion of a mass of water caused by wind or differences in density or wave movement. Current movement through Indonesia. from the Pacific to the Indies is part of the global circulation system (global conveyor belt) [30]. The mass of water flowing from the Pacific Ocean through several straits in the Indonesian Archipelago to the Indian Ocean, known as the Indonesian Cross Flow (ARLINDO), also affects the oceanographic conditions of the Eastern Indian Ocean including the Southern waters of West Java [30], [31]. One of the currents that is part of the regional circulation system of the Indian Ocean water masses in the southeast and plays a significant role in the supply of water masses entering the southern waters of Lombok is the Java Coastal Current (APJ) or the South Java Current [32].

The current speed is classified as weak. For the purposes of lobster cultivation, sea water flow velocity of 0.2 - 0.4 m/s is the optimal speed that can produce good water circulation. This water circulation is related to the supply of oxygen into the system and the discharge of ammonia to the outside of the culture system. Seawater flow velocity less than 0.2 m/s results in less than optimal water circulation, while flow velocity exceeding 0.4 m/s is too strong for cultured fish and damages the construction of the culture system. Water circulation that is not optimal can cause a low supply of oxygen, so that it has an impact on the low appetite and growth of cultured fish. Water circulation that is not optimal also has an impact on the high population growth of moss (periphyton) and other adhering biota (biofouling) on construction materials and net bags, and is detrimental. Net bags that are rapidly growing by biofouling must be cleaned frequently so as not to block ocean currents and interfere with water circulation in the codend.

Good brightness for aquaculture should be at least 3 m. Brightness indicates the ability to penetrate light into the water. The level of light penetration is greatly influenced by suspended and dissolved particles in water, thereby reducing the rate of photosynthesis. One of the brightness measurements can be done with a sechi disk with units of meters or percentages. The measured brightness level is very relative to the water depth. The lobster puerulus larvae (*Panulirus* spp) are found in waters with salinity ranging from 25 - 40 ppt [4]. Especially for lobster cultivation, the required salinity value is in accordance with the type of fish to be cultivated. This is because certain lobsters require a certain salinity as well. Lobsters have tolerance to changes in salinity, some types of fish have salinity values requiring different values.

Waters with a neutral to slightly alkaline pH are waters with ideal conditions for the development of marine aquaculture with various commodities. Tolerance for crayfish or fish to pH depends on many factors including temperature, dissolved oxygen concentration, variations in various anions and cations, type and life cycle of biota. Alkaline waters (7 – 9) are productive waters and play a role in encouraging the process of changing organic matter in water into minerals that can be assimilated by photoplankton. The pH of water fluctuates following dissolved CO2 levels and has an inverse relationship pattern, the higher the water CO2 content, the pH will decrease and vice versa.

Dissolved oxygen is the most critical parameter in lobster culture compared to seaweed and pearl oysters. Oxygen comes from the process of air diffusion and photosynthesis, and is influenced by temperature, salinity and air pressure. An increase in temperature, salinity and pressure causes a decrease in oxygen, and vice versa. If for life, 1 ppm of oxygen is needed, but to be able to grow and develop at least 3 ppm. For the benefit of lobster cultivation, optimal dissolved oxygen ranges from 5 - 8 ppm [33]. Phosphate levels at all stations are still normal for the tropics, where the Ministry of Environment concerning Seawater Quality Standards, the threshold value of phosphate and nitrate levels for marine biota is 0.015 ppm and nitrate is 0.008 ppm [34]. Elements of N and P are often used as limiting factors in waters because these two elements are needed by phytoplankton in large quantities, but if the availability of these two elements in the relevant habitat is below the minimum requirement, as a result the growth of phytoplankton will be disrupted or the population will decrease. The number of total P and total N forms in the waters is a potential estimate for the fertility of a waters [35].

The abundance of plankton obtained is very supportive of the survival of puerulus lobster larvae. The main diet of puerulus larvae in Teluk Awang waters consists of phytoplankton class bacillariophyceae (*Grammatophora marina, Navicula cancellata*, and Synedra radians) and zooplankton class oligotricheae (*Tintinnopsis lobbyancoi*) [36]. The existence of plankton greatly affects life in the waters because it plays an important role as food for various marine organisms [37]. Changes in water function are often caused by changes in the structure and quantitative value of phytoplankton. These changes can be caused by factors originating from nature or from human activities such as sporadic increases in nutrient concentrations so that it can cause an increase in the quantitative value of phytoplankton beyond the normal limits that can be tolerated by other living organisms. The dynamics of phytoplankton in the waters of the Lombok Strait, North Lombok Regency are influenced by conditions of brightness, phosphate and nitrate levels [38].

A relatively high abundance of lobster larvae was found in the June-July period, then decreased in the August-September period [9]. Trends in the abundance of lobster larvae such as this are due to the tendency in these waters around May to be the season for young lobsters (fingerling) measuring about 6-8 cm; which allows the availability of juvenile larvae measuring 2-3 cm (the size of larvae that are often attached to collectors) around this time is relatively low. While found that the abundance of *P. homarus* lobster larvae tends to be dominant at the mouth of the bay with an abundance ranging from 10-12 ind./unit [10].

The results of statistical analysis showed that of the nine environmental parameters studied, there were two parameters that significantly influenced individually on the settlement of puerulus lobster, namely the abundance of plankton and temperature. The significant relationship between plankton abundance and settlement of obster puerulus is thought to be due to plankton, especially phytoplankton, which is the main food of puerulus larvae, so that the abundance of phytoplankton is directly proportional to the abundance of puerulus larvae (Figure 8). This is supported by the statement that the distribution of puerulus larvae is influenced by habitats with specific characteristics according to their needs related to the availability of food, shelter, and reproduction [39]. The main diet of puerulus larvae in Awang Bay waters consists of phytoplankton class bacillariophyceae (*Grammatophora marina, Navicula cancellata*, and *Synedra radians*) and zooplankton class oligotricheae (*Tintinnopsis lobbyancoi*) [36].

The significant relationship between temperature and settlement of lobster puerulus is thought to be due to the temperature of the sea waters in Awang Bay which is still relatively stable so that the lobster seeds still survive and can support the growth of lobster puerulus. The results of research in South Konawe Waters show that puerulus larvae live and develop well in the temperature range between 28 -and 32 ^{o}C (Owu *et al.*, 2020; Wandira *et al*., 2020). The development of larvae and post larvae of lobsters is very sensitive to changes in water temperature [4].

Temperature is an important parameter in determining heat or heat energy, while water temperature affects many life cycles in the sea. Fish spawning, feeding, and nursing arealso affected by the temperature in the waters [40]. Water temperature can also affect natural phenomena in the sea and affect a global climate [41]. The seasonal pattern that occurs in the southern waters of Lombok is influenced by the movement pattern and monsoon wind speed. The pattern of monsoon wind movement will affect the distribution of SST in the waters north and south of Lombok. The pattern of wind movement in Lombok waters is influenced by four seasons, namely the west season, transition season I, east season, and transition season II [24]. The west season in Lombok waters occurs from December to February, the transitional season I occurs in March-May, the eastern season occurs in June-August, and the transitional season II occurs in September-November. If the distribution of SST is related to the movement of wind direction and speed, it will strengthen the statement that the high or low SST values are influenced by winds and changes in seasons.]

4. CONCLUSION

[The distribution of sea surface temperature and chlorophyll-a in the waters of Awang Bay and its surroundings based on satellite imagery during August to October shows that warm temperatures and chlorophyll-a are concentrated in coastal areas and are decreasing towards offshore. Based on field measurements, all parameters of the aquatic environment have appropriate threshold values for marine biota.The results of statistical analysis show that of the nine environmental parameters studied, there are two parameters that have significant individual effect on the settlement of lobster puerulus, namely plankton abundance and temperature. Meanwhile, brightness, current velocity, dissolved oxygen, salinity, pH, phosphate and nitrate have no significant effect due to multicollinearity.

The significant relationship between plankton abundance and temperature and settlement of lobster puerulus is due to plankton being the main food for larvae, and the temperature of the sea waters in Awang Bay is still relatively stable so that lobster seeds still survive and can support the growth of puerulus lobster.The spatial and temporal distribution of the fishing ground for lobster seeds in the waters of Awang Bay and its surroundings is unknown from this study, due to time constraints. Therefore, further research is needed to represent the eastern, western and transitional seasons.]

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