

THE EFFECT OF ENVIRONMENTAL CONDITION ON THE SPAWNING PERIOD OF BLOOD COCKLE *Anadara granosa* (Bivalvia: Arcidae) IN LHOKSEUMAWE, THE NORTHERN STRAITS OF MALACCA

PENGARUH LINGKUNGAN TERHADAP PERIODE PEMIJAHAN KERANG DARAH *Anadara granosa* (Bivalvia: Arcidae) DI LHOKSEUMAWE, BAGIAN UTARA SELAT MALAKA

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Abstract

Tujuan dari penelitian ini adalah untuk menganalisis perubahan dalam perkembangan gonad kerang *Anadara granosa* di Lhokseumawe, bagian utara Selat Malaka dalam hubungannya dengan fluktuasi kualitas air harian. Untuk menentukan periode pemijahan populasi kerang, dilakukan analisis indeks kondisi (condition index/CI). Sampel kerang dikumpulkan dari Juli 2009 sampai Mei 2010 dan parameter kualitas air turut diukur secara berkala. Indeks kondisi tertinggi dari populasi kerang diamati pada Oktober 2009 (13.97 ± 3.49), sedangkan indeks kondisi terendah ditemukan pada Januari 2010 (6.76 ± 1.13). Periode pemijahan untuk *A. granosa* diketahui terjadi terus-menerus sepanjang tahun, dengan puncak pemijahan terjadi pada bulan Oktober 2009 sehingga Januari 2010. Suhu air dan salinitas harian di lokasi penelitian berkisar antara 24-34 °C dan 27-33 ppt. Periode pemijahan populasi *A. granosa* diketahui bertepatan dengan terjadinya fluktuasi secara drastis pada suhu air dan salinitas harian. Analisis kualitatif menunjukkan bahwa suhu dan salinitas adalah modulator utama peristiwa reproduksi. Ketika suhu dan salinitas berfluktuasi, aktifitas pemijahan secara sporadis terdeteksi pada spesies ini. Penelitian ini juga menunjukkan bahwa periode pemijahan yang diikuti oleh proses rekrutmen dalam populasi kerang *A. granosa* Lhokseumawe sangat tergantung pada kondisi lingkungan kawasan tersebut..

Katakunci: *Anadara granosa*, parameter kualitas air, modulator, periode pemijahan, indeks kondisi, bagian utara Selat Malaka.

INTRODUCTION

The northern Straits of Malacca is an important nursery area for many intertidal organisms, and a feeding area for migrating species. *Anadara granosa* is one of the 7500 of bivalve species in the family Arcidae, often called “blood arks” or “blood cockles”. Their common name refers to the hemoglobin and hemocyanin pigments in their blood and tissue cells, giving their blood dark red colors. The species is indigenous to the intertidal mudflats bordering the coastal regions of many South East Asian countries particularly Indonesia, Malaysia and Thailand. In these countries, the cockles are mainly distributed in mangrove forest, mud vegetation or mixed areas. Intertidal species *A. granosa* was predicted as a keystone species at mangrove in several areas in Northern Straits of Malacca. This species also has been one of the most important fisheries commodities in South East Asia for many years (Broom, 1985).

A number of studies have been carried out on the ecological alteration of genus *Anadara* from different habitats in previous studies (Kastoro, 1978; Broom, 1985; Suwanjarat and Parnrong, 1990; Mzighani, 2005; Aviati, 2007), but no data was available on the effect of physical, chemical and

biological parameters, which had affected the population of *A. granosa* in Northern Straits of Malacca. Regardless of the geographical area and bivalve species, population growth and reproduction in intertidal species are grossly regulated by similar environmental factors particularly temperature, salinity and food availability (Bayne 1985, MacDonald & Thompson 1985, Baqueiro-Cardenas & Aldana-Aranda 2000, Freitas et al., 2010). Environmental conditions are considered exogenous factors related to gametogenesis in bivalve in their natural habitat.

This study evaluated the changes in the environment conditions affecting the intertidal population of cockle *A. granosa* on the spawning period which correlated to recruitment process and determine temporal changes in the gross condition of animals. This information can help propose managing protocols of this species for ecological of intertidal habitat.

MATERIALS AND METHOD

Collection of Samples

A total of 30 samples of adult *A. granosa* (size range: 38–71 mm) were collected monthly from

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July 2009 until May 2010 from the natural grounds in Lhokseumawe (Figure 1) at the East coast of Sumatera Indonesia ($05^{\circ} 9' 38.1''\text{N}$, $95^{\circ} 08' 32.3''\text{E}$). The sampling area was characterized by muddy area, relatively no wave action and mangrove area was found sheltered and exhibit high in salinity. After collecting, the specimens were stored in isotherm containers and immediately transported to the laboratory. The samples were fully removed from bio fouling and other adherences.

Measurement of Environmental Parameters and Collection of Water Samples

The environmental parameters were recorded *in situ* and *ex situ*. Water temperature, salinity, pH, turbidity, and dissolved oxygen were recorded *in situ* while minimum and maximum water temperature and salinity were recorded daily. Water temperatures were collected at sampling areas daily at the bottom of sea beds during the sampling period.

Temperature was measured with a handheld maximum minimum thermometer, and salinity was measured with a hand refractometer. The salinity of the seawater was collected daily at the bottom of sea bed depth. Hydrogen Ion Concentration (pH) was measured using portable pH meter periodically during the sampling period.

The turbidity consisted of organic and inorganic matters held in suspension by turbulence in seawater. The turbidity was measured using a turbidity meter Model HACH Turbidimeter 2100 AN, while the Dissolved Oxygen was measured using Dissolved Oxygen Meter model YSI 52. Chemical parameters such as nitrate, nitrite, ammonia, and orthophosphate were measured using spectrophotometry. The biological parameter such as phytoplankton density was monitored to determine food ability at the cockle habitat.

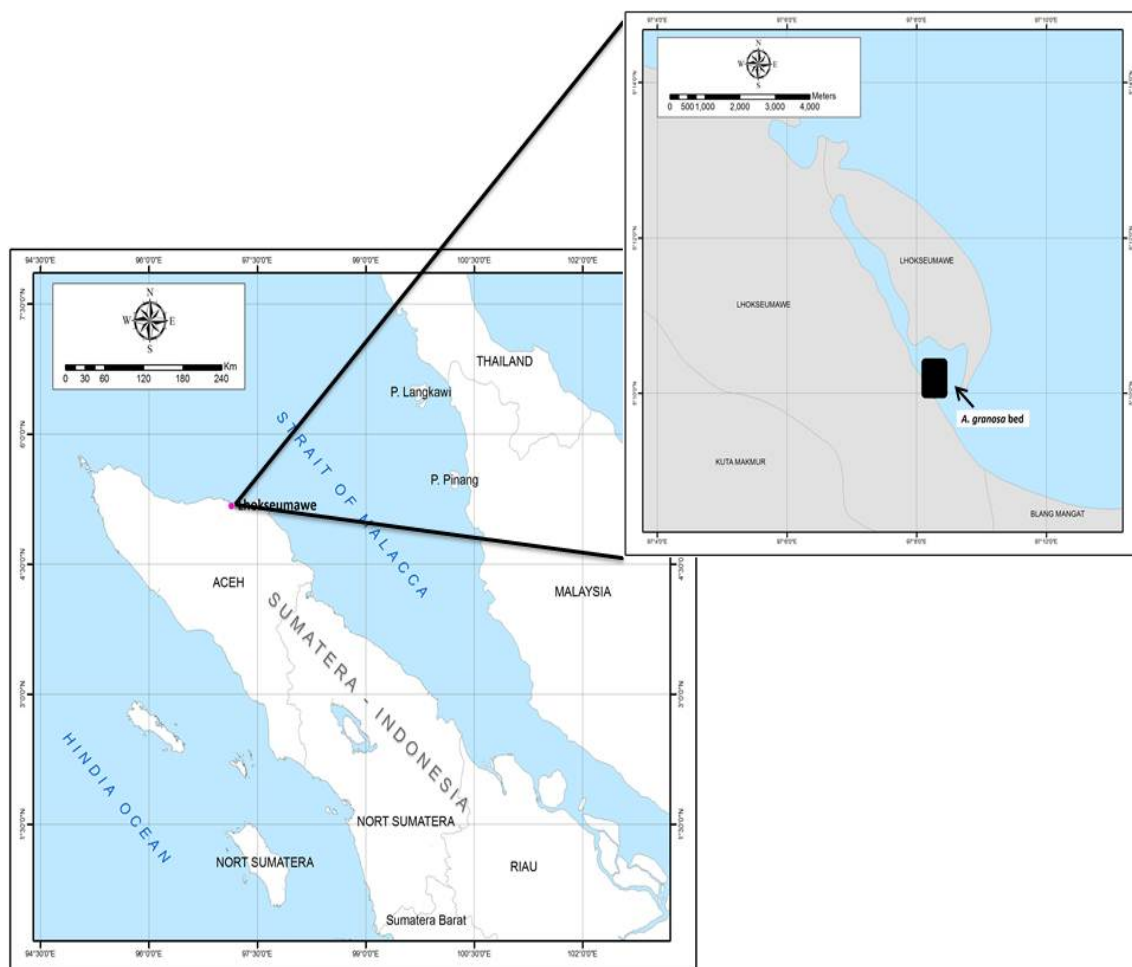


Figure 1. Sampling area of *Anadara granosa* from Lhokseumawe, the Northern Straits of Malacca.

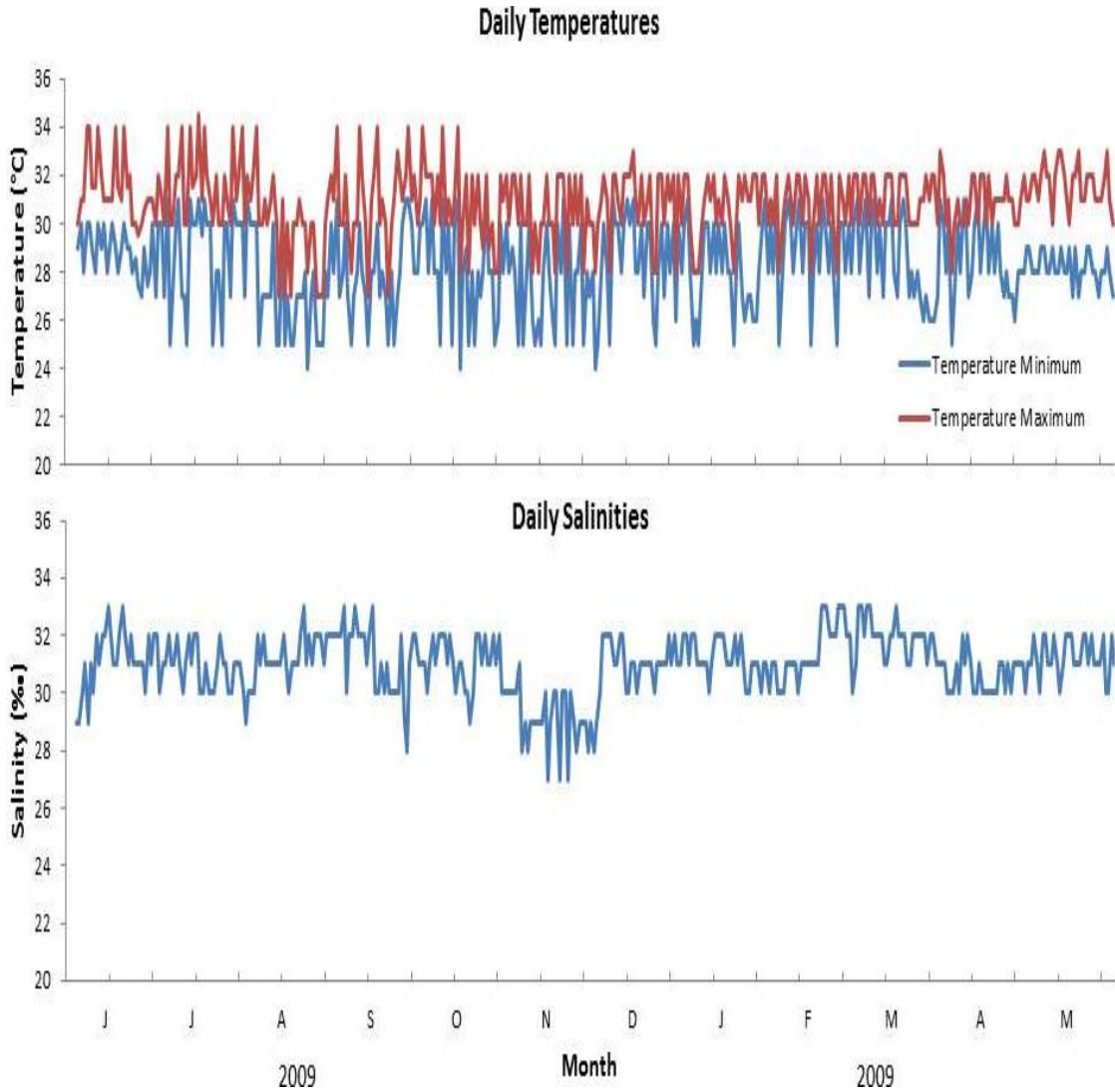


Figure 2. Variation in maximum-minimum temperature and salinity measurement at Lhokseumawe, from June 2009 to May 2010.

Condition Index (CI)

The condition index can determine the ecophysiological factors which affect the physiologic changes of the carbohydrate, glycogen and protein fractions under environment influences. In another term, CI is a reflection of the reproductive biology of bivalves. When the gonad mass increases during maturation, the CI will also increase, condition index will decrease progressively after spawning had occurred (Angell, 1986). Water displacement method was used to determine the condition index. A total of 30 specimens were analyzed monthly. Each specimen was measured on the: dry flesh weight, wet weight of shell in grams (g) and internal cavity volume (ml). Flesh was dried at 105^oC for 72 hours to a constant weight. These data were used to

calculate the condition index using the formula described by Scott & Lawrence (1982):

$$\text{Condition Index} = \frac{\text{Dry Flesh Weight (gram)} \times 100}{\text{Shell Internal Cavity Volume (cm}^3\text{)}}$$

RESULTS

Water Quality Parameters

During the study period, the variation in the daily temperature recorded did not show any significance differences. The highest temperature recorded was 34 °C and the lowest was 24 °C. There was a drastic fluctuation in temperature in middle of

June 2009 until early October 2009, thereafter remaining stable through March 2010 (Figure 2).

Salinity is important in determining the distribution of bivalves and able to influence the physiological rates of bivalve including reproductive process (Dame, 1996). Salinity fluctuation between

27-33ppt, with highest fluctuated observed in October 2009 until end November 2009. The lowest salinities were recorded during the month of October to December 2009 during the highest intensity of rain.

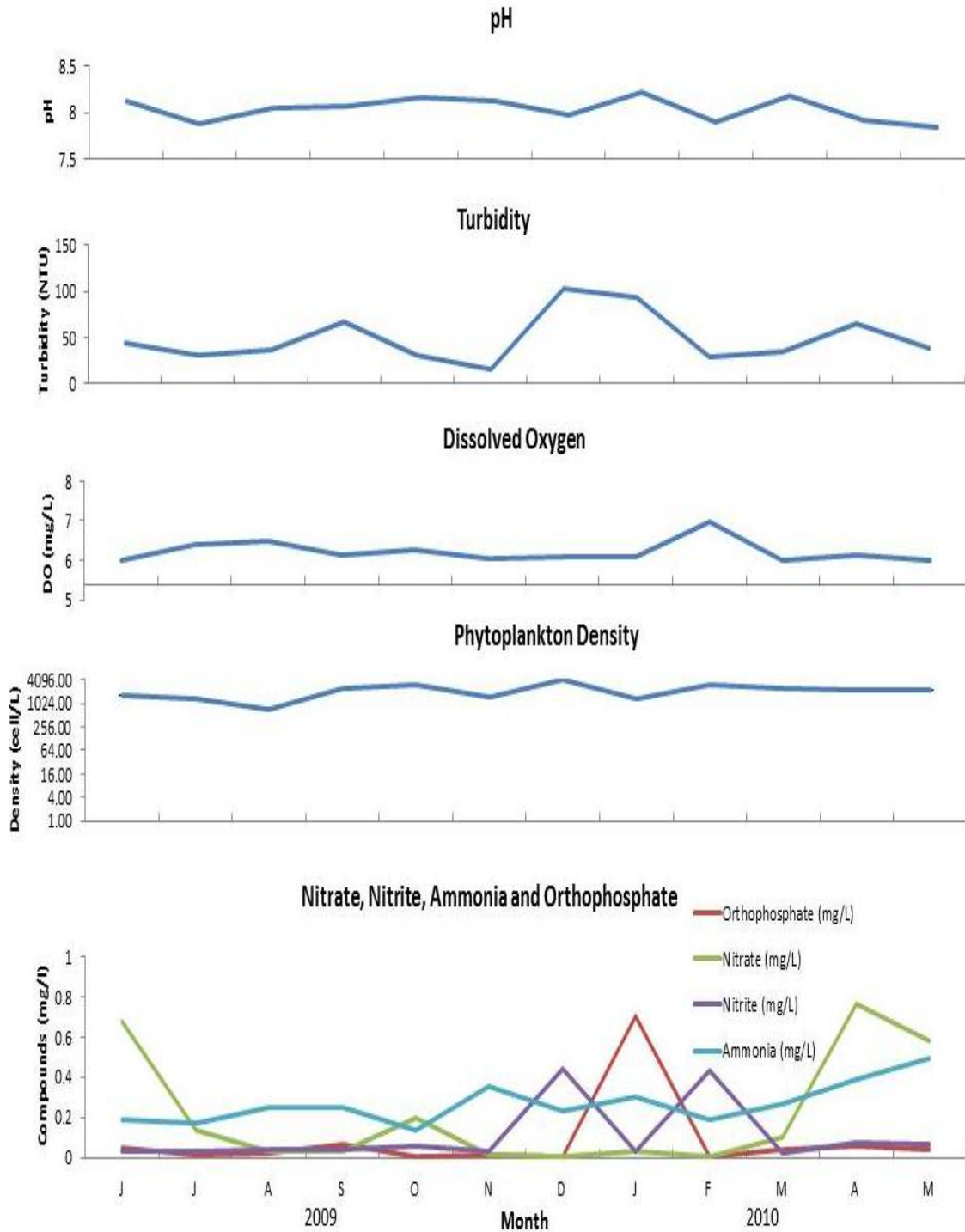


Figure 3. Variations in environmental parameters at Lhokseumawe, including pH, turbidity, dissolved oxygen, phytoplankton density and, nitrate, nitrite, ammonia and orthophosphate, from June 2009 to May 2010

The variation of pH, turbidity, dissolved oxygen, phytoplankton density and other chemical compounds at Lhokseumawe from June 2009 to May 2010 were shown in Figure 3.

The mean value of pH recorded during the study period was 8.04 ± 0.13 with the lowest value recorded in May 2010 (pH=7.84), and the highest in January 2010 (pH=8.21). The mean turbidity recorded during the study period was 49.07 ± 27.22 NTU, with a range between 15.18 NTU and 103 NTU. The lowest turbidity was recorded in November 2009, while the lowest was in December 2010. The mean value of dissolved oxygen recorded during the study period was 6.22 ± 0.28 mg/L. The lowest dissolved oxygen was recorded in May 2010 with value of 5.98 mg/L, while the highest value of dissolved oxygen recorded in February 2010 with value of 6.97 mg/L. Phytoplankton density showed a high variability throughout the year. The mean values of phytoplankton density recorded during the study period was 2181.67 cells/L. Phytoplankton density with values more than 3000 cells/L occurred in October 2009 and December 2009, with a peak in December (4001.67 ± 20.43 cells/L). Minimum values occurred in August 2009 (711.67 ± 5.77 cells/L).

sampling area was 0.21 ± 0.28 mg/L. The highest peak of nitrate was recorded in April 2010 with the value of 0.715 mg/L, while the lowest peak was in December 2009 with value of 0.002 mg/L. The range between the lowest and the highest values for nitrate was 0.713 mg/L. The mean value of nitrite during the study period was 0.11 ± 0.16 mg/L. The highest peak of nitrite was recorded in December 2010 with value of 0.442 mg/L, while the lowest peak was in June 2009 with value of 0.028 mg/L. The nitrite range between the lowest and the highest values was 0.414 mg/L.

The mean value of ammonia from June 2009 to May 2010 was 0.27 ± 0.10 mg/L. The highest peak of ammonia was in May 2010 with value of 0.49 mg/L, while the lowest value was in October 2009 with value of 0.14 mg/L. The range value between the highest and the lowest values was 0.35 mg/L. The mean value of orthophosphate during the sampling period was 0.090 ± 0.195 mg/L. The highest value was recorded in January 2010 (0.700 mg/L), while the lowest value was recorded in February 2010 (0.001 mg/L). The range between the highest and the lowest values of orthophosphate was 0.699 mg/L.

The chemical compounds i.e. nitrate, nitrite, ammonia and orthophosphate were below the tolerance level for intertidal benthic species. The mean value of nitrate during the study in the

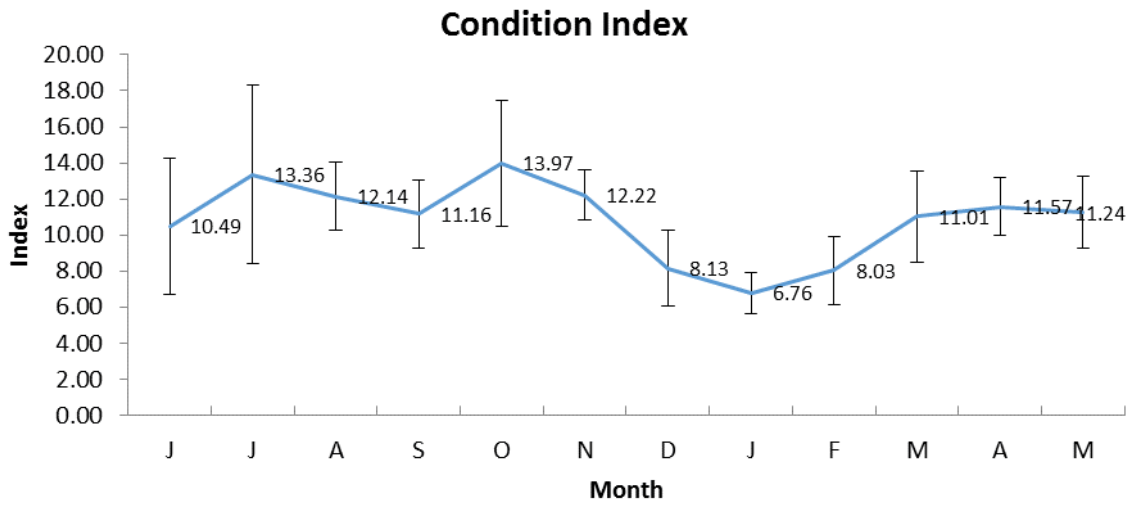


Figure 4. Condition Index of *Anadara granosa* from Lhokseumawe from June 2009 to May 2010).

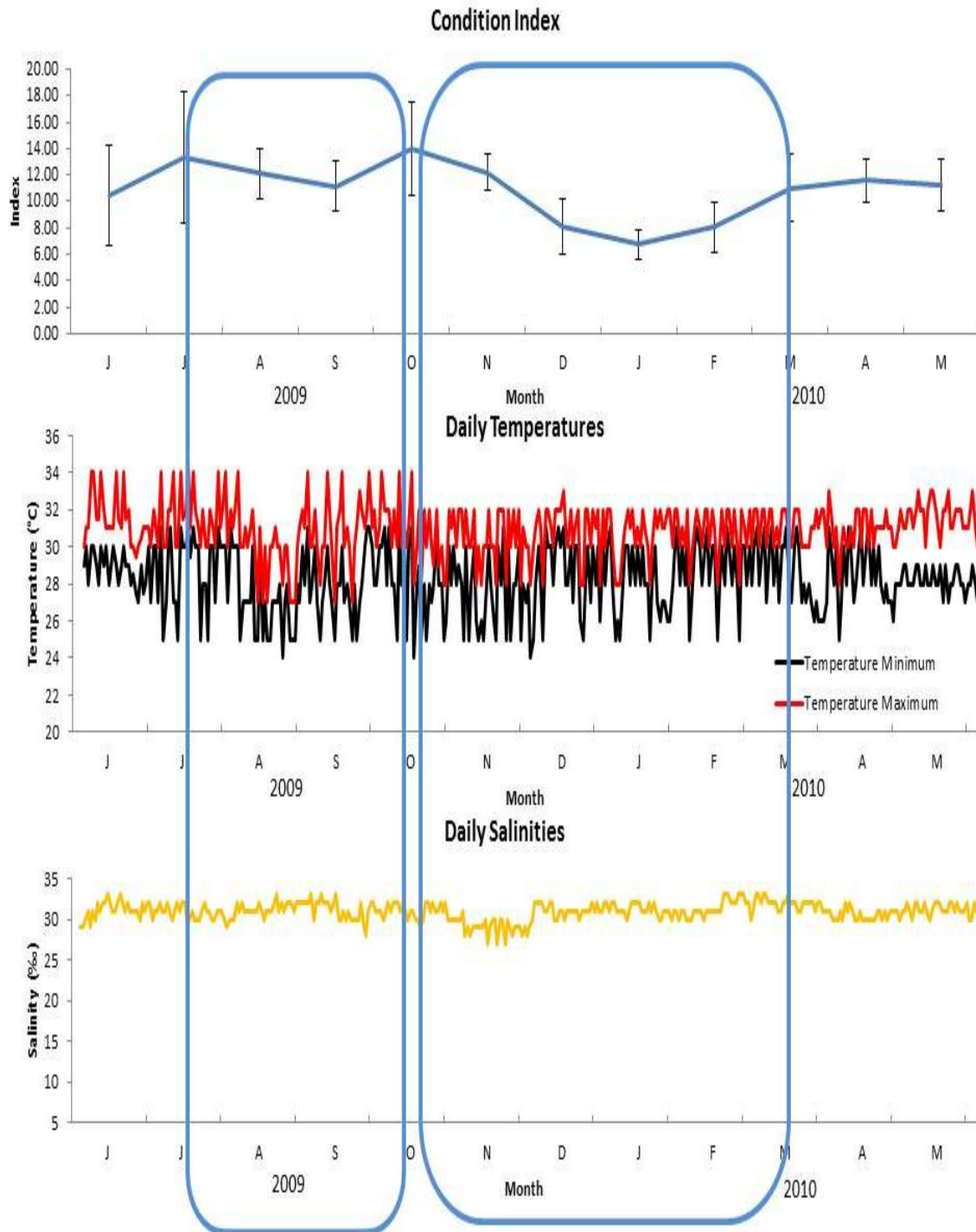


Figure 5. Correlation between spawning period of *Anadara granosa* with changes of temperatures and salinities from June 2009-May 2010 in Lhokseumawe, Indonesia.

Condition Index

Condition Index has correlation with maturity period. The high values of CI showed that the cockles had reached the ripe stages while the low values of CI shows the cockles were on spawning process (Figure 4). The highest condition index of

the cockle population from Lhokseuwawe was observed in April 2010 (11.57 ± 1.58) whereas, the lowest showed in January 2010 (6.76 ± 1.13). Spawning period of *A. granosa* was continuous throughout the year, the peaks spawning period was occurred in October 2009 until January 2010.

DISCUSSION

In this study, condition index (CI) was used to evaluate the tissue quality in the intertidal species *A. granosa* in Lhokseumawe, Indonesia. The condition index was known to be influenced by many environmental factors, such as temperature (Chipman, 1947, Freitas et al., 2010), salinity (Engle, 1957; Haven, 1947), seasonal variations (Rebelo et al., 2005; Sahin et al., 2006), chemical characteristics of the water and sediment (Engel, 1957), crowding and availability of food (Korringa, 1952; Galtsoft, 1964).

In this study, temperature and salinity were the main environmental regulating factors of habitual performance of spawning period in *A. granosa* Lhokseumawe, Indonesia. In addition, gonad development proceeded more actively during the periods of drastic fluctuating of temperatures and salinities, from October 2009 through January 2010 (24–34°C). These suggested an inverse relation between water temperature, salinities and gametogenesis. The release of gametes by the natural population of *A. granosa* at Lhokseumawe coincided with the drastic daily fluctuations in temperature and salinity as indicated by the rectangle boxes in Figure 5.

Reproductive cycles of the cockle population in Lhokseumawe were highly influenced by the fluctuation of abiotic factors such as temperature and salinity, where in July 2009 until October 2009, maximum and minimum temperatures were actively fluctuating. Similar condition was recorded in salinity, where fluctuation had occurred in September 2009 until December 2009. Both these fluctuations were suggested as factors which have positive correlation in the reproductive cycle of bivalve *A. granosa* in Lhokseumawe.

Based on this study, The Condition Index of the cockle population in Lhokseumawe was a combination result of the fluctuations on two main environment factors, namely temperature and salinity. Combined effect of the fluctuations in temperature and salinity had become the stimulus for the spawning activities of the cockle population. Form the observations of Condition Index of *A. granosa* (12 months), it was found that high fluctuation in daily temperature followed by the onset of high fluctuation in salinity resulted two reproductive cycles. The first reproductive process was recorded in July 2009 to September 2009 and the second cycle was in October 2009 to March

2010, with a higher interval compared to first cycle. Fluctuation in temperature and salinity act as the main trigger and an active response for cockle to perform reproductive cycle. High fluctuation of daily temperature and salinity had induced the development of gonad. Once the gonads matured, highest fluctuation in temperature and salinity would trigger the spawning process in *A. granosa* at Lhokseumawe, Indonesia.

CONCLUSION

Changes on water temperature and salinity exhibited the maximum reproductive activity of intertidal bivalve species *A. granosa*. The CI of *A. granosa* has shown a direct relationship with the amount of body reserves and has correlation with the environmental condition in their habitat. The main parameters found to be directly affecting the reproductive process were temperature and salinity. Temperature and salinity were the main modulators of reproductive events. When temperature and salinity fluctuated, sporadic spawning was detected in this species, possibly inducing a survival strategy whereby the spawning period is extended to increase reproductive success.

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