NATURAL GROWTH AND PRODUCTION OF COCKLE (*ANADARA ANTIQUATA*, L.), TANJUNG PASIR COAST, WEST JAVA

By Fredinan Yulianda
Faculty of Fisheries, Bogor Agricultural University, Indonesia

ABSTRACT

Two major collections of cockles were carried out in consecutive months using the systematic plot sampling method. Length, width and weight were measured and the data analyzed with regard to habitat cluster, dispersion pattern, age cluster, correlation of morphometric parameters, growth parameters, total mortality, recruitment pattern, population stock and biomass, production and elimination. Two neighbouring areas (separated by a jetty) were compared. Environmental parameters displayed marked between-area differences in terms of salinity, turbidity, and substrate composition. In addition, one area was influenced by human exploitation, while the other area was more influenced by environmental conditions.

INTRODUCTION

The construction of a jetty in coastal waters can change the hydrodynamic processes, affecting the biotope and yield of benthic organism. This has been observed on the coast of Tanjung Pasir, where cockle collection is conducted traditionally (picking by hand upon encounter). For local people, the bivalves *Anadara antiquata*, *Anadara granosa*, and *Meretrix meretrix* constitute a source of food and income. However, the high intensity of bivalve collecting may easily cause overfishing. The purpose of this study is to estimate potential production which constitutes a useful tool in drawing up guidelines to prevent overfishing of *Anadara antiquata*. The demographic structure of a population is a product of population interaction with the environment, so demography can highlight the dynamics of temporal and spatial distribution.

MATERIALS AND METHODS

The first sampling occurred in June, and the next one in July 1994. Two areas (A and B), located east and west of a jetty, were selected at the coast of Tanjung Pasir, Tangerang, West Java, Indonesia. Cockles were collected using the plot sampling method. The plot division was done systematically. Each area had 32 plots consisting of 4 plots parallel to the beach and 8 plots perpendicular to these in the offshore direction. The cockles found in each plot were kept separate, counted, and measured. Temperature, salinity, pH and turbidity were measured each sampling time.

Data Analysis

a) Habitat cluster :

Canberra Similarity Index (Clifford and Stephenson 1975).

$$Ic = 1 - 1/n\sum_{i=1}^{n}\frac{|Ai - Bi|}{Ai + Bi}$$

Where: Ic = Canberra Index
Ai = value of parameter i at plot 1
Bi = value of parameter i at plot 2

b) Dispersion Pattern:

Morisita Index (Brower and Zar 1977)

$$Id = \frac{n(\sum x^2) - n}{N(n-1)}$$

Where: n = number of plots
x = number of individuals per plot
N = total number of individuals

c) Size Cluster:

Using computer Software NORMSEP (NORMAL SEParation)

d) Growth (Morphometric) :

$$W = aL^b$$

Where: W = weight of individuals
L = length of shell
a & b = constants

e) Mortality:

$$Z = -\ln\left(\frac{N_{t+1}}{N_t}\right)$$

Where: Z = mortality
N_t = number of individuals at time t
N_{t+1} = number of individuals at time t + 1

f) Recruitment:
Using distribution method of Shell Length Frequency (Pauly 1982) with the aid of Computer Software ELEFAN II.

g) Stock Estimation:

$$B = p\sum f_i n_i \overline{W_i}$$

$$p = A / a$$

Where: A = stock area
a = total area of plot
f_i = number of plots in the location i
n_i = density of individuals per plot in the location i
$\overline{W_i}$ = mean weight of individuals in the location i

h) Production Estimation (Parson *et al.* 1977):

$$p = 1/2(N_t + N_{t+1})(\overline{W}_{t+1} - \overline{W}_t)$$

Where: N_t = number of individuals at time t
N_{t+1} = number of individuals at time t+1
$\overline{W}_t$ = mean weight of individuals at time t
$\overline{W}_{t+1}$ = mean weight of individuals at time t+1

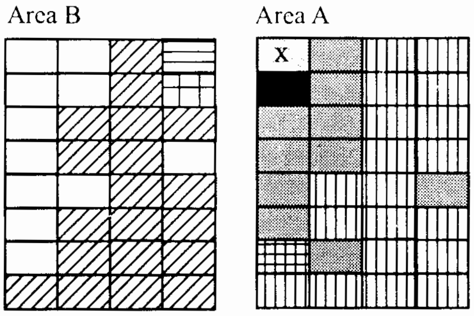
Loss of Biomass (E):

$$E = 1/2(\overline{W}_t + \overline{W}_{t+1})(N_t - N_{t+1})$$

Where: N_t = number of individuals at time t
N_{t+1} = number of individuals at time t+1
$\overline{W}_t$ = mean weight of individuals at time t
$\overline{W}_{t+1}$ = mean weight of individuals at time t+1

RESULTS

Habitat cluster
Based on water quality, there are 9 groups of habitats, 5 groups in area A and 4 groups in area B (Fig. 1). Turbidity is the main factor in this grouping.
Based on substratum type, there are 5 groups of habitats (Fig. 2). Three types of substratum were classified in area A, *viz*., sandy clay (14 plots), clayey sand (14 plots) and sand (4 plots). Five types of substratum were classified in area (B), *viz*., silty clay (2 plots), sandy silt-clay (6 plots), sandy clay (17 plots), clayey sand (6 plots) and sand (1 plot). In general, particle diameters of the substratum were smaller in area B than in area A.



	Turbidity (NTU)	Salinity (‰)	pH
	66.8	27.6	7.4
	58.9	25.2	7.2
	35.5	28.5	7.3
	48.5	29.5	7.3
x	17.0	32.5	7.0
	13.8	31.5	6.9
	8.5	32.8	7.8
	5.5	29.8	7.0
	4.5	29.0	6.9

Figure 1. *Anadara antiquata*: Habitat cluster based on water quality.

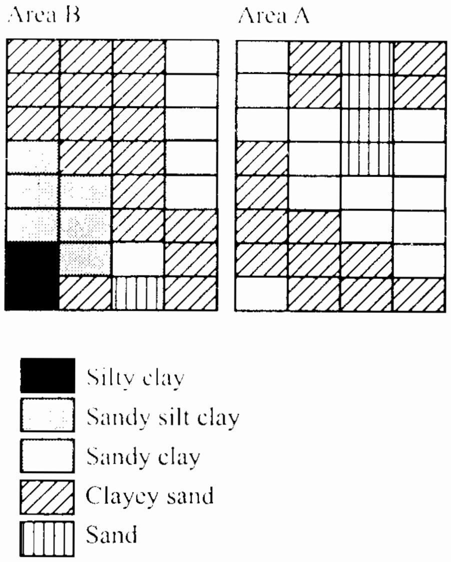


Figure 2. *Anadara antiquata*: Habitat cluster based on substrate composition.

Dispersion pattern

Dispersion pattern each area is clumped (Fig. 3). Temporal difference only occurs in area A.

Shell length distribution

The length-frequency distribution is influenced by sample size. Hence, cockles in area A are closer to a normal distribution compared to area B (Fig. 4). Cockle shells are longer in area B compared to area A but the mean size was small in the both areas. The mean length of cockles sold in the market is about 30 mm, and the species may grow to a size of about 55 mm in the present study area.

Age Cluster Estimation

Using computer software NORMSEP, there are 4 age clusters (Tables 1 & 2).

Table 1. *Anadara antiquata*: Estimation of age cluster in June

Cluster	Mean Length (mm)	Deviation	Percentage (%)
I	9.03	2.57	29.75
II	11.12	1.76	58.52
III	18.92	2.31	6.18
IV	25.96	1.88	5.55

Table 2. *Anadara antiquata*: Estimation of age cluster in July.

Cluster	Mean Length (mm)	Deviation	Percentage (%)
I	10.14	4.39	33.44
II	13.38	1.60	56.95
III	20.31	3.09	6.54
IV	27.65	2.03	3.07

Growth

Relative growth was estimated from the length, width, and weight of individuals. Estimation of Von Bertalanffy growth parameters was achieved using the computer software programme ELEFAN II.

The relationships between log shell length (l) and log weight (w) were calculated for areas A & B as follows (n = 50):

Area	relationship
A	$\log w = -2.9797 + 2.802 \log l$; $r = 0.9912$
B	$\log w = -3.2224 + 2.968 \log l$; $r = 0.9890$

The relationships between log shell width (t) and log weight (w) were calculated for areas A & B as follows (n = 50):

Area	relationship
A	$\log w = -2.2305 + 2.400 \log t$; $r = 0.9923$
B	$\log w = -2.3191 + 2.456 \log t$; $r = 0.9926$

Mortality

Death rates (z) were calculated for June and July 1994. The value of (z) was 0.312 for area A and 0.010 for area B, and 0.243 for the whole area. The value of z can only be predicted for the total death rate, including natural death and death due to exploitation.

Recruitment

The organism recruitment pattern over one year was calculated with ELEFAN II. Values of recruitment are relative values. I have not been able to estimate absolute values. Recruitment in area A has a gentle slope pattern while it is steep in area B.

Stock Assessment

The number of individuals and biomass was estimated in the study area as shown in Tables 3 and 4.

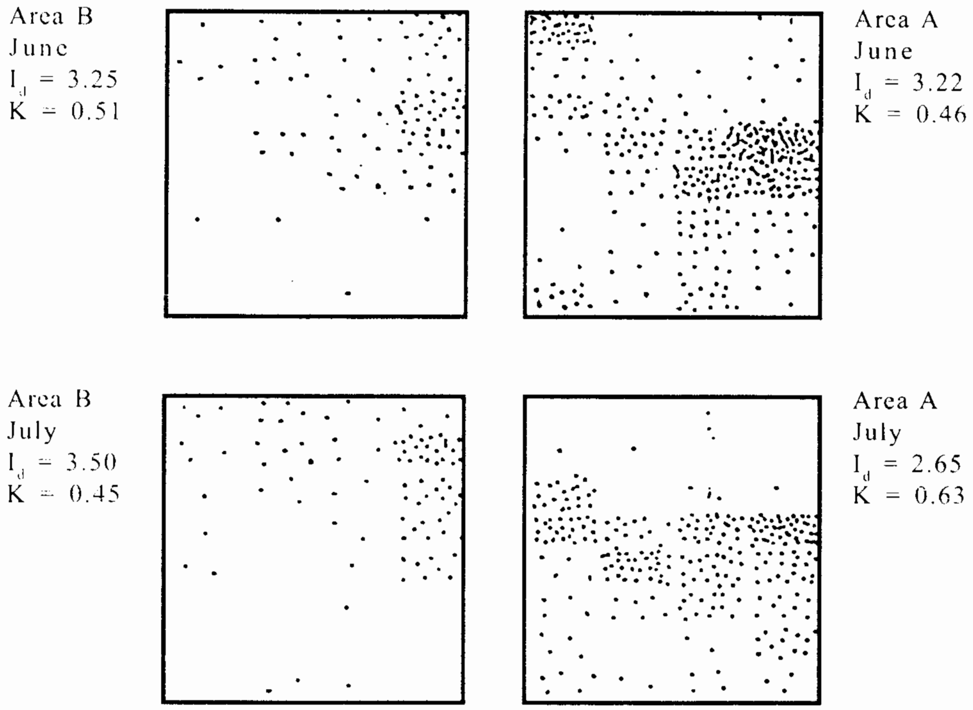


Figure 3. Dispersion patterns of cockle, *Anadara antiquata*

Production and Elimination

Production and elimination (biomass change) were obtained from the number of individuals and the mean weight as shown in Table 5.

Table 3. *Anadara antiquata*: Number of individuals and biomass in June.

Area	No. of individuals	Biomass (g)
A	233,119	581,629
B	10,019	183,366
Total	243,138	764,995

Table 4. *Anadara antiquata*: Number of individuals and biomass in July.

Area	No. of individuals	Biomass (g)
A	166,063	561,592
B	59,338	198,853
Total	225,401	760,444

Table 5. *Anadara antiquata*: Production and Elimination. The values are expressed as g per month from each area (A and B), and the whole area.

Area	Production (g)	Elimination (g)	Elimination (%)
A	175,640	197,145	52.9
B	17,307	2,183	11.2
Total	192,947	199,327	50.8

DISCUSSION

The cockle, *Anadara antiquata* is generally more abundant in sandy clay than in other types of substrata. Area A, with the highest percentage of sandy clay, is therefore predicted to be a better biotope than area B. The estimated environmental parameters fluctuated less in area A compared to area B. The existence of another jetty west of area B, and runoff from the big river Cisadane, have considerable impact on the environment in area B. But, salinity, sediment *etc.*, are still within the range tolerated by cockles in both study areas.

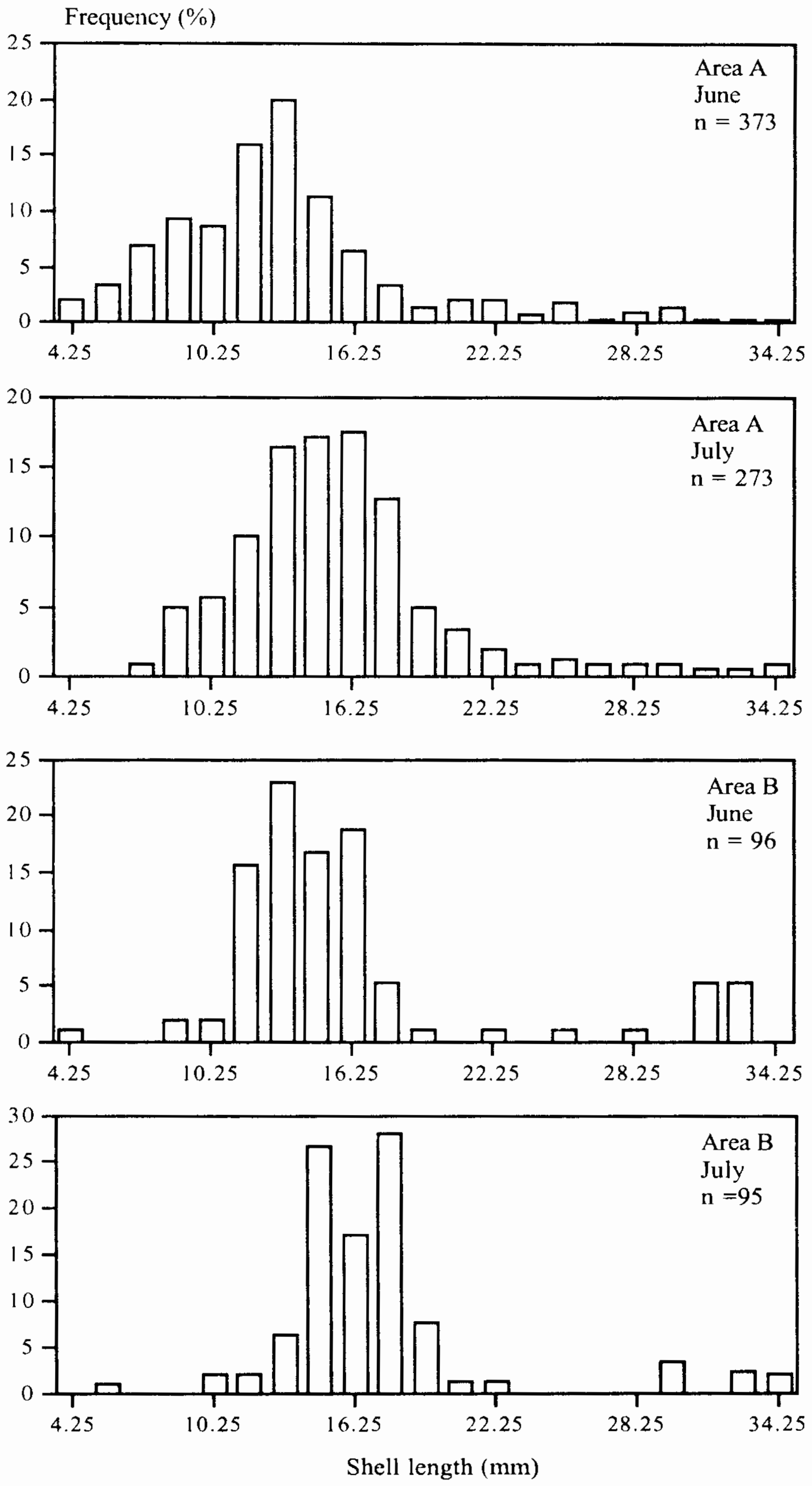


Figure 4. *Anadara antiquata*: Frequency distribution of shell lengths in areas A and B.

The dominant dispersion pattern of cockle is clumped which is in accordance with Parson *et al.* (1977). Cockle dispersion, in general, is much more influenced by substratum type and spatial distribution of environmental parameters than by intraspecific factors (Krebs 1972). Temporal dispersion was not observed in the present study.

In spite of a higher growth coefficient (k) in area A, the cockles were smaller than in area B. A high growth rate is related to food availability and/or low environmental stress, while a small mean size is related to the pattern of recruitment and/or selective removal of larger individuals. I suggest that both environment and exploitation must be considered. Area A is characterized by more stable environmental factors and the substratum is more suitable for cockles. The marine conditions and low stress may explain the high k value. The smaller mean size in area A is, without doubt, related to exploitation. Villagers harvest cockles with a large mean shell size. The small cockles are left in the substratum, and these were the cockles I have collected. High elimination in area A is predicted due to exploitation by man. Area A is close to a village, and transparency of the water is quite high so cockle collection is easy compared to the more muddy area B.

The L-value indicates the chance to reach a larger size. The L-value is bigger in area B indicating reduced intraspecific competition for food and space, i.e., the chance to grow big is related to cockle density. The mortality rate in area B is far lower (0.010) compared to area A (0.243). Mortality due to exploitation by villagers is probably the factor which explains most of the total mortality in both areas.

The biomass was much higher in area A than in B. The low biomass in area B is caused by a low initial stock and a low growth rate. The low initial stock will affect reproduction, *i.e.*, a low number of breeding females. However, recruitment not only depends upon the local breeding population. Larvae are pelagic and may be brought to the study area by ocean currents. Recruitment strategy is reflected in the peak distribution of juveniles (Pauly 1982). The present study period was too short for a detailed analysis of the recruitment but data show a predictable recruitment in area A while more fluctuation can be expected in area B.

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