HORIZONTAL DISTRIBUTION OF GASTROPODS ALONG A THERMAL GRADIENT, CILEGON COASTAL WATERS, INDONESIA

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ABSTRACT

The horizontal distribution of gastropods was determined along a transect line from the shore in offshore direction. Samples with 6 replicates were taken from 4 stations using a grab sampler. The number of species and abundance of individuals from each station were compared. Furthermore, comparisons of diversity using Shannon-Wiener Index of Diversity and k-dominance curve were made. A total of 27 gastropod genera were found. The number of taxa, abundance, and Shannon-Wiener Index of Diversity were lower at the innermost station close to a thermal discharge outlet of an electric power plant. Dominance curves showed that certain genera of gastropods such as *Cerithium*, *Planaxis*, and *Clypeomorus* dominated at this station.

INTRODUCTION

Setyobudiandi *et al.* (1996) studied the ecology of macrobenthic fauna in Cilegon coastal waters, western Java. The study indicated that the distribution of Gastropoda was strongly influenced by activities of the electric power plant of Krakatau Steel Factory. Furthermore, the study showed that temperature might be the main factor determining the distribution pattern of benthic fauna around the outlet of the power plant at Glebeg Bay, Cilegon waters. Since gastropods dominated in the bay, we have focused on populations of these molluscs. The aim is to describe the spatial distribution of species and individuals of gastropods in relation to environmental factors, especially the effects of thermal discharge on gastropods.

MATERIAL AND METHODS

The material was sampled in January and February 1996 from an area adjacent to the outlet from Krakatau Steel Factory electric power plant into the Bay of Glebeg, Cilegon waters. The power plant has 400 MW capacity. It has been in operation since 1979. The bay is a shallow coastal system in front of the Sunda Strait (05°54'06" - 06°02'06" S, and 105°55'04" - 105°59'08" E) on the north west coast of Java (Fig. 1).

Sampling procedure

Four stations were established, two stations within the area most heavily affected by thermal discharge (Sts. I & II) and two stations outside this area (Sts. III & IV), almost unaffected by thermal pollution. Quantitative samples with 6 replicates were collected at each station using a grab bottom sampler (0.04 m^2). The sediment was sieved through 0.5 mm mesh screen (Holme & McIntyre 1984). Animals were picked by hand, sorted, fixed in 4 % formalin, and stored in 80 % ethanol until identification.

Data analysis

The species and individual abundance of gastropods from each station were compared. In conjunction with Shannon-Wiener Index of Diversity approximation based on natural logarithm (after Krebs 1989), a dominance-diversity curve (see Clarke 1990; Warwick & Clarke 1991), and Pielou's measure of evenness (J') were made. Analysis of similarity in individual abundance to identify grouping of assemblages was conducted by the average linkage clustering method (Krebs 1989). The analytical procedure consisted of 2 steps. First, using the complement of the Bray-Curtis Dissimilarity Index (1.0

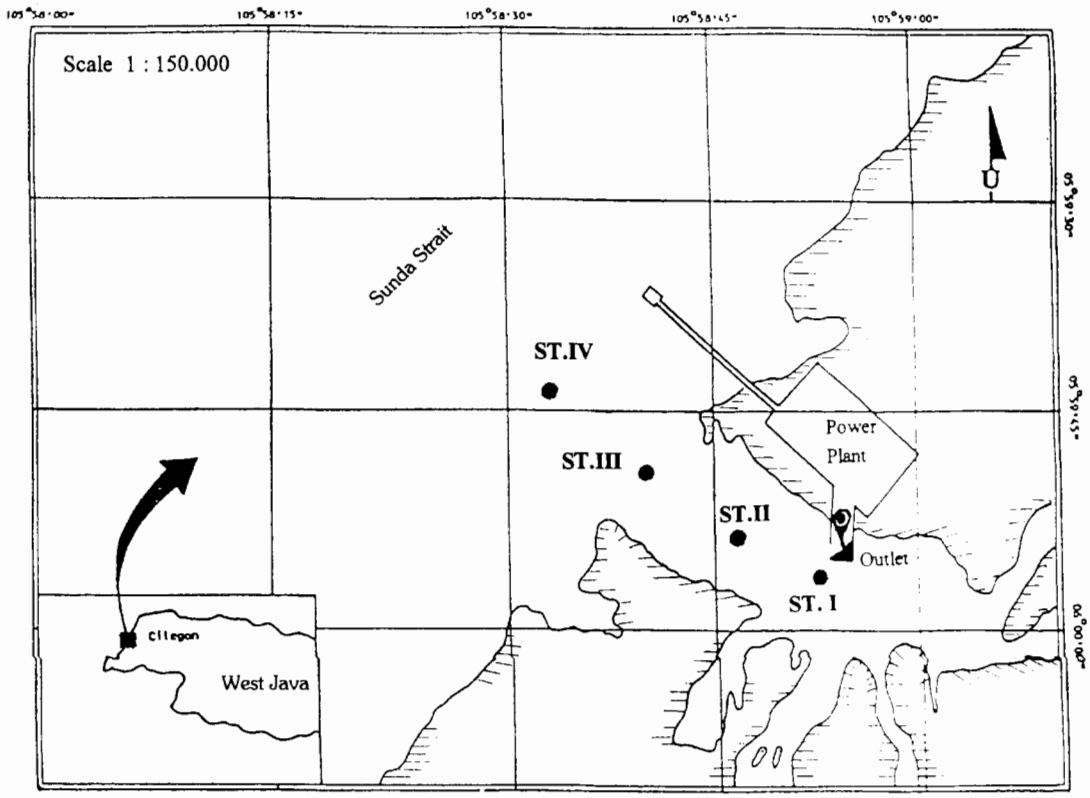

Figure 1. Map of study location and sampling sites at Glebeg Bay of Cilegon, western Java.

- B) to determine the level of similarity among species; and second, measurement of a group-average single linkage algorithm to construct a dendrogram (Krebs 1989).

RESULTS

A total of 27 genera of gastropods were collected together with other benthic fauna. Snails dominated the total macrobenthic fauna (Setyobudiandi *et al.* 1996) Station I had a low number of species and a low density of individuals (Table 1). Gastropods ranged from 1.6 to 10.4 individuals m^{-2} but increased from Station I toward Station IV. The Shannon-Wiener's diversity index (H') and the Pielou's evenness value were applied to evaluate the structure of the gastropod community. For interpreting community structure, a single index of diversity, such as H', can be ambiguous and insensitive to changes in proportions of rare species. Therefore, we also constructed dominance-diversity curves (Fig. 2). Compared to the diversity at Station I, the diversity of gastropods

Table 1. Numbers of gastropod genera with Shannon-Wiener indices and Pielou's evenness values.

	St. I		St. II		St. III		St. IV	
Item	A	B	A	B	A	B	A	B
No. of species	5	5	20	23	25	26	22	24
Diversity index (H')	1.31	1.33	2.62	0.83	2.81	2.96	2.51	2.78
Pielov's Evenness (J')	0.81	0.83	0.88	0.90	0.87	0.91	0.81	0.88

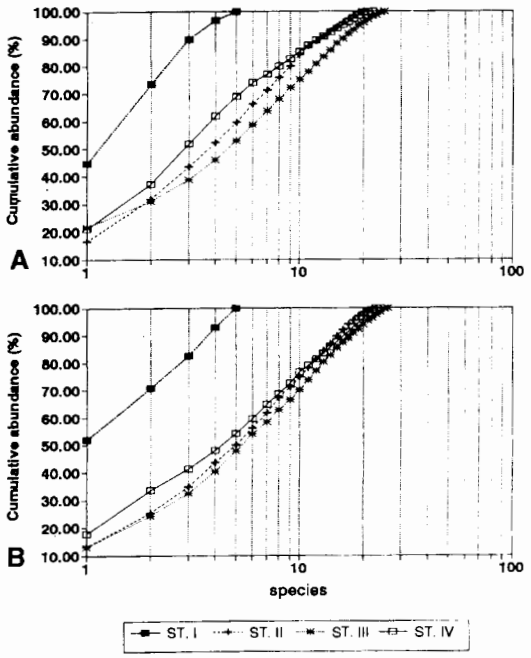

Figure 2. Dominance-diversity curves (A: sampling period I; B; sampling period II).

is always higher at Stations II-IV during both sampling periods. Fig. 2 indicates that the dominance-diversity curve at Station I is located far above curves of the other three stations. Fig. 2 also indicates that there are at least three genera dominating the gastropod community at Station I. The dendrogram in Fig. 3 represents the classification hierarchically, using cluster analysis on the samples taken at all stations. Clusters linked at higher values are more similar than those linked at lower values. The dendrogram forms three groups (A, B, C) having 70 % degree of similarity.

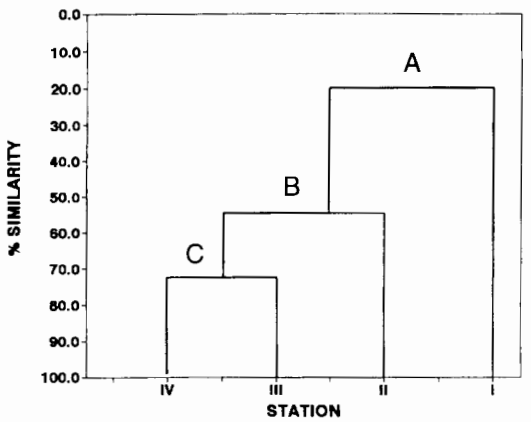

Figure 3. Dendrogram showing linkage cluster of sampling station.

Group A contains Station I which is situated adjacent to the outlet of the power plant. A total of 5 genera of gastropods were recorded in this group. The individual abundance was 1,133 ind. m^{-2} (SE = 149) in January; and 928 ind. m^{-2} (SE = 84) in February. The lowest densities and number of species were found in this group. The H' values were consistently lower than 1.5 bits ind^{-1}, both in January and February; and 80 to 90 % of the dominance was shared by 3 genera.

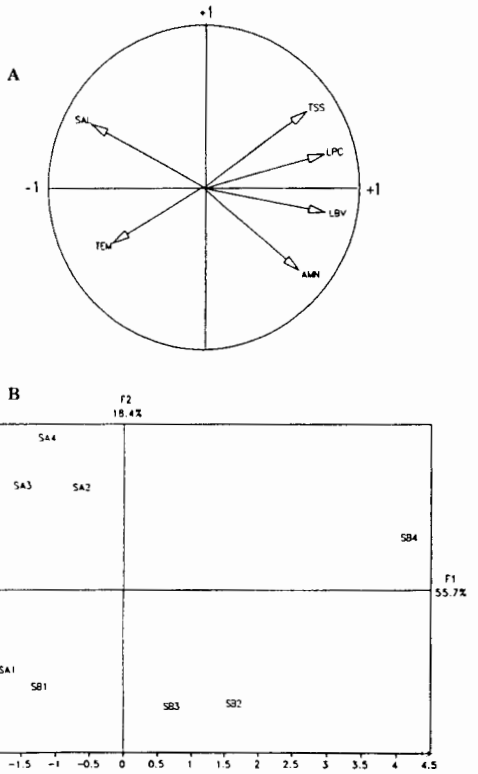

Figure 4. Graphs resulting of Principal Component Analysis (A: Correlation between physical-chemical character to sampling sites; (B: Distribution of sampling sites and sampling periods based on physic-chemical character; after Setyobudiandi *et al.* 1996).

Table 2. Physical-chemical variables of water and sediment in Glebeg Bay of Cilegon waters.

Parameter	St. I	St. II	St. III	St. IV
Water Physics				
Temp. (surface) (°C)	33.0-36.0	32.0-33.6	31.5-32.4	30.1-31.5
Temp. (bottom) (°C)	33.8-35.3	33.0-33.7	29.9-30.8	29.3-29.7
Turbidity (ntu)	16-22	14-23	17-20	7.0-16
Total suspended solids (mg/l)	88.0-92.0	110-124	90-96	12-138
Salinity (‰)	26.0-32.0	29.0-30.0	28.0-30.0	28.0-30.0
Current (cm/dt)	14.4-15.2	11.1-13.5	9.14-12.0	9.7-15.9
Water Chemistry				
pH (unit)	8.0-8.4	8.0-8.5	8.4-8.6	8.5-8.6
COD (mg/l)	156.0-195.7	128.0-147.5	68.0-171.6	68.0-147.5
BOD (mg/l)	13.0-14.3	13.0-13.5	9.13-13.5	9.14-13.75
NO_3 (mg/l)	<0.001-0.008	<0.001-0.129	0.062-0.112	0.156-0.218
NH_3 (mg/l)	0.223-0.957	0.339-1.015	0.152-1.056	0.332-1.259
PO_4 (mg/l)	<0.001-0.008	0.009-0.012	<0.001-0.044	0.015-0.019
Silicate (mg/l)	0.0108	1.224	0.538	0.195
H_2S (mg/l)	0.437	0.45	0.325	0.428
DO (mg/l)	4.8-5.2	4.4-5.0	3.1-5.2	4.8-5.8
Sediment				
Cu (mg/l)	<0.001-4.105	<0.001	<0.001	<0.001
Zn (mg/l)	1.017	0.169	2.304	2.203
Sand (%)	83.43	34.5	76.43	95.03
Silt (%)	7.88	5.69	7.68	0.18
Mud (%)	8.69	59.81	15.89	4.79
C-Org. (%)	2.61	1.64	1.16	0.99

Group B contains Station II in the inner part of the bay. On the average, 22 gastropod genera were recorded; the diversity was higher than at Station I. The individual abundance was 1,963 ind. m^{-2} (SE = 125) in January, and 2,188 ind. m^{-2} (SE = 221) in February. Group C connects stations III & IV in the outer part of the bay. On the average 25 gastropod genera were found in this group. The highest individual abundance was recorded, on an average 5,244 ind. m^{-2} (SE = 356), in January; and 5,373 ind. m^{-2} (SE = 214) in February.

DISCUSSION

Setyobudiandi *et al.* (1996) showed that Station I (SA1 and SB1) located near the outlet of the power plant is characterised by high temperature (Fig. 4, Tab. 2). Moving seaward to Stations II, III, and IV there are temperature and salinity gradients, with the lowest values (approaching the natural values) at Station IV (SB4). The same gradient pattern, but having an opposite direction, can also be seen in the suspended solids (TSS), the abundance of bivalve larvae (LBV), and polychaete larvae (LPC). The values decreased toward Station I. Discharge of hot waste water has resulted in a temperature gradient affecting the spatial distribution of gastropods and other fauna. Thermal discharge may have negative effect on the

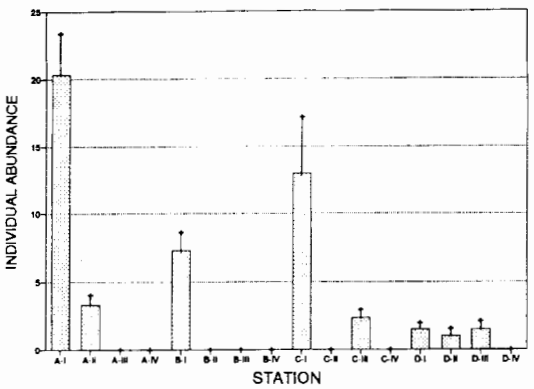

Figure 5. Histogram showing individual abundance of gastropod genera (indv. 0.04 m^2) and its upper limits (95% confidence interval). A-I: *Cerithium* at St. I. B-I: *Planaxis* at St. I. C-I: *Clypeomorus* at St. I. D-I: *Cerithidea* at St. I.

benthic fauna due to increased temperature, altered salinity, strong currents, physical modifications of substrate, or introduction of lower quality water (Hocutt *et al.* 1980). The low diversity index of gastropods is in accordance with Dittmann (1990) who stated that unfavourable physical-chemical conditions of the environment will result in differences in individual abundances as well as number of species. We found a low Index of Diversity, but relatively high individual densities. Certain gastropod genera seem to be able to adapt themselves to increased temperature. High densities per unit area were recorded in the gastropod genera *Cerithidea* (Potamididae), *Cerithium* (Cerithidae), *Clypeomorus* (Cerithidae), and *Planaxis* (Planaxidae). The high densities were significantly different from the other stations (Fig. 5). The stability at Station I is indicated by Pielou's evenness value which is relatively high.

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