GASTROPOD COLONISATION OF INTERTIDAL SOFT AND HARD BOTTOM SUBSTRATA INFLUENCED BY WARM WATER DISCHARGE IN CILEGON BAY, INDONESIA

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ABSTRACT
PVC tubes filled with bottom sediment functioned as soft substratum. Cement blocks constituted hard substratum. The substrata were set up at two sites in November 1996 and sampled in the following months December and January. Four species colonised both substrata, *viz Clypeomorus petrosum*, *Clypeomorus brevis*, *Cerithium coralium*, and *Rhinoclavis sordidula*. There was no significant difference in individual density between the two kinds of substrata.

INTRODUCTION
A number of monitoring studies have been carried out on marine benthic fauna of Cilegon waters from 1991-94, basically from an ecological point of view, but only published in local journals. A comprehensive study was conducted by Setyobudiandi *et al.* (1996) regarding the ecology of macrobenthic fauna in Cilegon Coastal waters. The result of that study indicated that temperature and substratum were the ultimate factors influencing the composition of macrozoobenthic communities in Cilegon Bay. Some marine gastropod species became dominant in the thermally polluted environment generated by a power plant. However, it was unknown if the water temperature *per se* or properties of the sediment both were important for the build up of gastropod populations. Therefore, the present study aims at isolating the influence of sediment regarding the abundance of gastropods; and for this purpose an experiment with artificial substratum was set up adjacent to the power plant of Krakatau Steel Factory. The power plant has 400 MW capacity has been operated since 1979.

MATERIALS AND METHODS
This study was carried out inside and outside the discharge area of a power plant at the Bay of Glebeg in Cilegon water. The bay is a shallow coastal system on the north-west coast of Java (Fig. 1). It is located in front of the Sunda Strait between 05° 54' 06" - 06° 02' 06" South and 105° 55' 04" - 105° 59' 08" East. The study period was from November 1996 until January 1997.

Temperature, salinity, water current velocity, total suspended solids, turbidity, and dissolved oxygen (DO) were measured *in situ*, except total suspended solids which was estimated in the laboratory of the Faculty

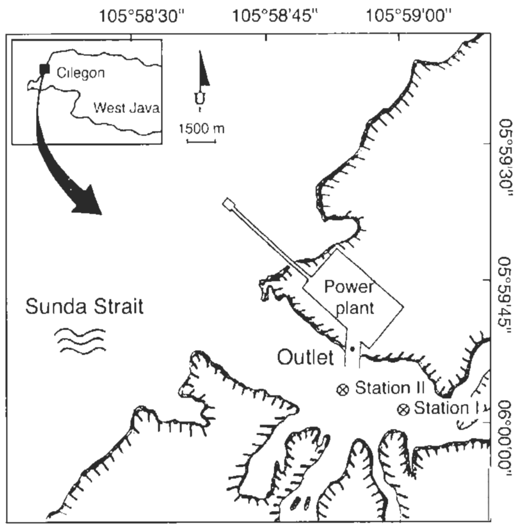

Figure 1. Study site showing sampling stations at Glebeg Bay.

Table 1. Water characteristics of sampling sites at Glebeg Bay of Cilegon Waters. Range of 3 measurements.

No.	Parameter	Station I	Station II
1	Temperature (°C)	31.0 - 32.6	33.0 - 36.5
2	TSS (ppm)	88.0 - 124.0	90.0 - 96.6
3	Turbidity (NTU)	16.0 - 23.0	14.0 - 22.0
4	Salinity (‰)	26.0 - 32.0	29.0 - 33.0
5	Dissolved oxygen (ppm)	3.0 - 5.3	3.3 - 5.1
6	Water current (cm/s)	11.4 - 12.5	14.7 - 16.9

of Fisheries Bogor Agricultural University (IPB). Identification of molluscs was carried out at the Zoological Museum, LIPI, Bogor, and checked by Dr Kilburn during the 8th TMMP Workshop in Thailand.

Two stations were established: Station I was assumed unaffected by thermal discharge. Station II was assumed heavily affected by thermal discharge.

A total of 8 PVC tubes arranged in 2 racks with 4 tubes in each, were placed on the bottom at the 2 stations. The tubes contained sieved sediment (80.0 % sand, 7.5 % silt, 12.5 % clay). A sample of 4 tubes (2 stations with 2 replications) were collected in December and January respectively; the samples were sieved (0.5 mm mesh screen) (Holme & McIntyre 1984), 4 % formalin added, and gastropods identified and counted in the laboratory.

Four settling plates (cement) were similarly placed on the bottom at each of the two stations. On each sampling occasion, 2 plates were collected, the attached animals preserved, and identified in the laboratory.

The gastropod data consist of species composition and density of individuals on the artificial substrata. A two-way non-parametric rank analysis (Bernard *et al.* 1993) was applied in comparisons of the individual density of snails exposed to substratum, station, and observation.

RESULTS

The shell lengths of *Clypeomorus petrosum* ranged from 15.6-18.2 mm, *Clypeomorus brevis* 19.4-22.1 mm, *Cerithium coralium* 22.2-28.0 mm, and *Rhinoclavis sordidula* 11.5-12.3 mm. The size distributions indicate that the snails colonised the substrata as migrating adults.

Setyobudiandi *et al.* (1996) found high water temperatures in the vicinity of Station II located near the outlet of the power plant. The present study showed that this condition still prevailed (Tab. 1).

Three gastropod species were recorded at Station I, but *Cerithium coralium* was only found at this station (Tab. 2). The density of individuals was 45 ind. 0.04 m^{-2} in the first sample (December), and 86 ind. 0.04 m^{-2} in the second sample (January).

At Station II, three gastropod species were also recorded, but *Clypeomorus brevis* was only found at this station (Tab. 2). The density of individuals was 85 ind. 0.04 m^{-2} in the first sample and 119 ind. 0.04 m^{-2} in the second sample. Tab. 2 shows the occurrence of the 4 gastropod species recorded in soft bottom and on hard substrata.

Table 2. Occurrence of four gastropod species in soft bottom and on hard substrata at two stations in December and January (average of individual density and its standard error, n=2).

Species	ST. I				ST. II			
	December		January		December		January	
	Hard substratum	Soft substratum	Hard substratum	Soft substratum	Hard substratum	Soft substratum	Hard substratum	Soft substratum
Clypeomorus petrosum	4 ± 1.0	8 ± 3.5	12 ± 0.5	10 ± 3.0	11 ± 3.5	14 ± 1.0	15 ± 1.0	13 ± 2.0
Clypeomorus brevis	0	0	0	0	6 ± 1.0	1 ± 1.0	6 ± 0.5	8 ± 3.5
Cerithium coralium	2 ± 1.0	11 ± 2.0	4 ± 0.5	11 ± 0.0	0	0	0	0
Rhinoclavis sordidula	2 ± 1.0	1 ± 1.0	3 ± 2.5	5 ± 2.5	5 ± 1.5	7 ± 2.5	13 ± 3.0	6 ± 1.5

Clypeomorus petrosum and *Rhinoclavis sordidula* occurred at both stations. There were no differences in terms of the number of species between observations and the type of substrata. Certain species fluctuate considerably in number of individuals, but most markedly in the thermally polluted Station II (Tab. 2).

Clypeomorus petrosum
A two-way nonparametric rank analysis was used to test the density of *C. petrosum* with station versus observation, station versus substratum, and observation versus substratum. The analysis showed that no significant differences were found in the number of individuals between samples with respect to substratum and observation. However, *C. petrosum* showed a significant difference between stations regarding the number of individuals which was higher at Station II ($P<0.05$). The average number of individuals of *C. petrosum* at Station II, irrespective of substrata and observation, was 13 individuals compared to 8 ind. 0.04 m^{-2} at Station I (Fig. 2).

Clypeomorus brevis
C. brevis was only found at Station II. No significant differences were found in number of individuals between samples with respect to substratum and observation. However, the species showed a significant difference between stations regarding the number of individuals ($P<0.05$). The average number of individuals of *C. brevis*, irrespective of substratum and observation, was 5 ind. 0.04 m^{-2} at Station II (Fig. 3).

Cerithium coralium
C. coralium was only found at Station I. There were no significant differences in the number of individuals between samples with respect to substratum and observation. But, *C. coralium* showed a significant difference between station and the number of individuals ($P<0.05$). The average number of individuals of *C. coralium*, irrespective of sub-

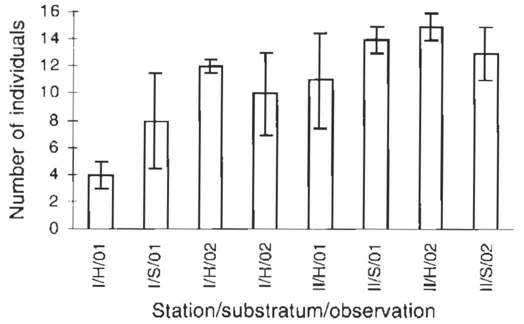

Figure 2. Density of *Clypeomorus petrosum* (ind. 0.04 m^{-2}) and the lower and upper limits (95 % Confidence interval). I = station; H = hard substratum; S = soft bottom; 01 = December; 02 = January.

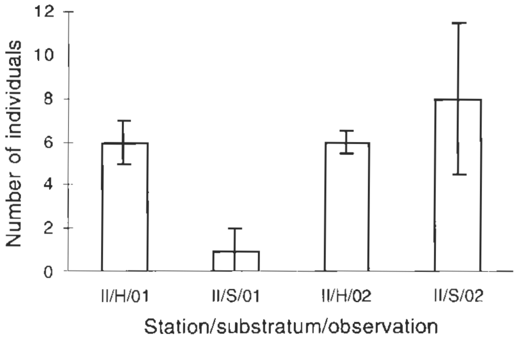

Figure 3. Density of *Clypeomorus brevis* (ind. 0.04 m^{-2}) and the lower and upper limits (95 % Confidence interval). I = station; H = hard substratum; S = soft bottom; 01 = December; 02 = January.

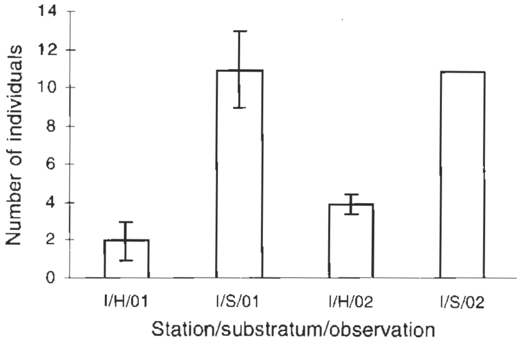

Figure 4. Density of *Cerithium coralium* (ind. 0.04 m^{-2}) and the lower and upper limits (95 % Confidence interval). I = station; H = hard substratum; S = soft bottom; 01 = December; 02 = January.

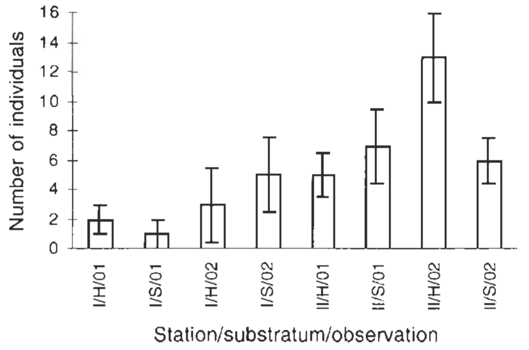

Figure 5. Density of *Rhinoclavis sordidula* (ind. 0.04 m^{-2}) and the lower and upper limits (95 % Confidence interval). I = station; H = hard substratum; S = soft bottom; 01 = December; 02 = January.

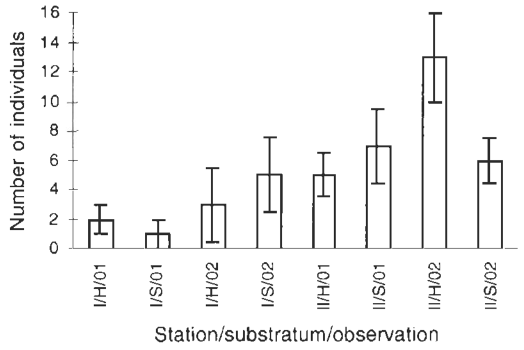

Fig. 6. *Cerithium* and *Clypeomorus*. Average density of individuals (ind. 0.04 m^{-2}) on hard substratum, soft substratum, and in grab samples at Cilegon. I = station; H = hard substratum; S = soft bottom; 01 = December; 02 = January.

stratum and observation, was 7 ind. 0.04 m^{-2} at Station II (Fig. 4).

Rhinoclavis sordidula
The number of individuals of *R. sordidula* showed no significant differences in the number of individuals between samples with respect to substratum and observation. However, *R. sordidula* showed a significant difference between stations regarding the number of individuals which was higher at Station II ($P<0.05$).

The average number of individuals was 7 ind. 0.04 m^{-2} compared to 3 ind. 0.04 m^{-2} at Station I (Fig. 5).

Clypeomorus had a higher density of individuals per unit area both on the artificial substrata and in grab samples; particularly at Station II characterized by high water temperatures (Fig. 6).

DISCUSSION

Setyobudiandi *et al.* (1996) found 4 gastropod genera (*Cerithium*, *Clypeomorus*, *Planaxis,* and *Cerithidea*) at the thermally polluted Station II. In this study, only *Cerithium* (*C. coralium*) and *Clypeomorus* (*C. petrosum, C. brevis*) were found. The number of individuals of *Clypeomorus* spp. showed a relatively high variation at Station II compared to Station I. It suggests that the discharge of warm water was able to influence the occurrence of these gastropods. *Clypeomorus petrosum* and *Rhinoclavis sordidula* were present at both stations, and the number of individuals was significantly different. It indicates that these species have a wider range of temperature tolerance compared to the other species. The effect of thermal pollution on gastropod colonisation was significant while the type of substratum had no effect. This finding supports Setyobudiandi *et al.* (1996) who suggested that *Clypeomorus* and *Cerithium* should be tested in experiments on temperature tolerance.

Thermal discharge into receiving bodies of water may affect benthic fauna by limiting utilisation of affected areas due to increased temperatures, strong currents, physical modifications of substrata, or introduction of lower quality water (Hocutt *et al.* 1980). The ecological stress caused by the high water temperature near the outlet of warm waste water at Station II, will affect the community as a whole, and in turn there will only be a few genera having the ability to adapt themselves to the surrounding condition. Setyobudiandi *et al.* (1996) found that initially, the abundance of mollusc and polychaete larvae were relatively high despite the high temperature of the water at

Station II. Larvae from neighbouring areas were probably transported by currents toward that station, but were unable to survive. This would be in accordance with Dittmann (1990) who stated that besides predation and competition, the unfavourable physical-chemical conditions of the water will result in differences in individual abundance as well as the number of species.

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