La mer 39 : 77-85, 2001
Société franco-japonaise d'océanographie, Tokyo

Seasonal variation of water characteristics in the northern coastal area of Java

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Abstract : Seasonal variation of water characteristics in the northern coastal area of Java was investigated to understand the causal factors of its variability and to evaluate the water quality status in the future within this region. Water temperature, salinity and density in the northern coastal area of Java Sea seasonally varied corresponding to the monsoon. Water temperature in January(wet season)was lower than that in September(dry season) as well as for salinity and density. Nutrient concentration was influenced by discharge of the local river and local coastal topography and was also affected by surface current corresponding to the monsoon. Phosphate was high in January at the central part and in September at the western part. Silicate was high in January at the eastern part and in September at the western part as well as for nitrate. Redfield ratio in the whole part of the northern coastal area of Java was lower than 16 and nitrate may act as the limiting factor for the primary production within this region. Chlorophyll-*a* was high in January at the central and western parts of Java due to large supply of nutrients by river discharge. While in the eastern part of Java, high conecentration of chlorophyll-*a* in September was due to the nutrients supply from the eastern region of Indonesia by surface current.

Key words : *seasonal variation, water characteristics, northern coastal area of Java*

1. Introduction

Shince more than 2 decades ago, the northern coastal area of Java has been developed as the most important area for the economical growth in the Java Island. The rapid development of the agriculture activities such as rice field, shrimp culture as well as the industrial and housing estate within this area are suspected to have caused some negative excess on the degradation of the environmental condition (ONGKOSONO *et al*, 1990; ONGKOSONO, 1992; PRASENO, 1995; NURDJANA, 1997). The appreciable pollution and waste deposition from those activities that are carried by river discharges, ultimately cause the water quality deterioration in the coastal sea within this region.

To conserve this area for sustainable utilization in the future and to select the area for suitable activities, an observation of water characteristic along the coastal area of Java is necessary to be established in order to understand the water quality status as a basic knowledge on the regional planning. To achieve such objective, since 1979-1981, the Ministry of the Environmmental Affair, Indonesia has collaborated with The Research Institute for Oceanography-LIPI to collect the numerous data of physical, chemical and biological oceanography as a basic information to develop various kind activities on the basis of water quality status. Since the seasonal change has trong affected on the performance of the agricultural production, e.g. for shrimp culture (SACHOEMAR and YANAGI, 1999), the information of water quality status corresponding to the seasonal variation becomes important to provide a proper management and planning of shrimp culture activity. Currently, however, there is almost no information on the water quality status corresponding to the seasonal variation along the northern coastal area of Java, except partially on the small area with limited data in

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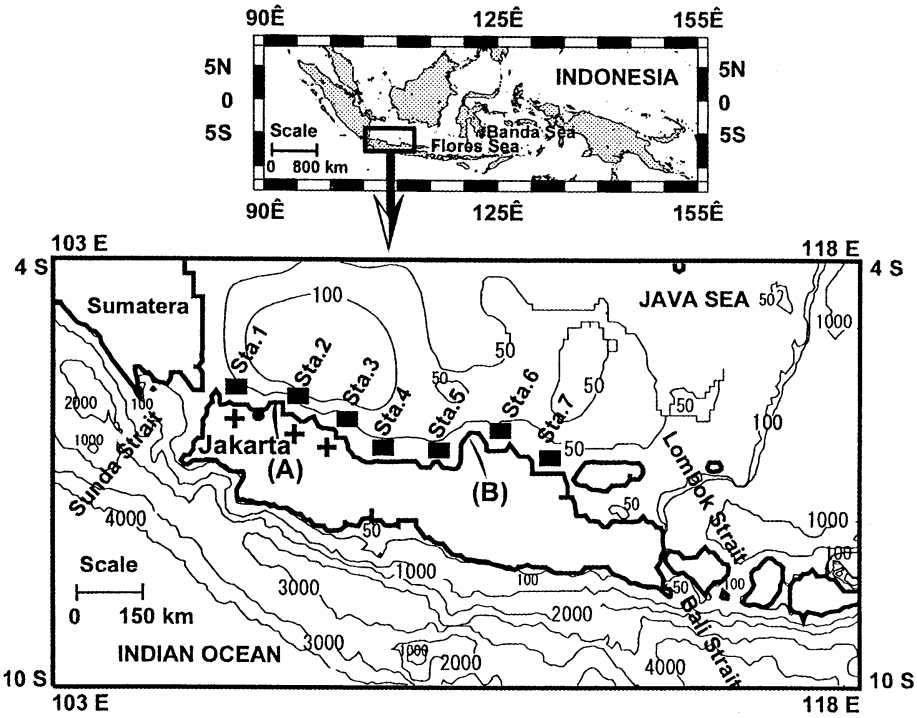

Fig. 1. Maps showing the study area. Bathymetry (meter) and sampling points are inserted. The symbols (A) denotes Citarum river, (B) Serang river and (+) industrial area in the northern coast of Java.

the certain season (ROHILAN, 1992; PRASENO and ADNAN, 1996; PUTRI *et al*, 1999). While a basic knowledge is required to recover the deteriorated water quality due to the excessive pollution during the intense utilization in a long period toward the initial status when the highest production of shrimp was achieved. Hence, the review of water characteristic of the northern coastal area of Java corresponding to the seasonal variation is to be necessary to complete the lack information of the water quality within this region. This information is hoped to be an important information to evaluate the water quality status in the present time for the future sustainable utilization and to understand the causal factors of water quality variability within this region.

2. Data collection and analysis

A series of hpysical, chemical and biological data in January (northwest monsoon) and September (shoutheast monsoon) 1979–1981 were obtained from The Research Institute for Oceanography-LIPI (Lembaga Oceanologi Nashional-LIPI, 1980 and 1981) to study a seasonal variation of water characteristics within this region. Horizontal and vertical data were collected from the study area of 7 regions of western Java (Sta. 1, Sta. 2 and Sta. 3), central Java (Sta. 4 and Sta. 5) and eastern Java (Sta. 6 and Sta. 7) in the northern coastal area of Java (Fig. 1).

Water temperature of the surface, 5m, 10m and 20m depth were measured by thermometer, salinity by Portable Inductive Salinometer model RS-7C. While phosphate, nitrate and silicate were analyzed by spectrophotometric method using Spectronic 20 and 21 of Bausch and Lamb, Germany, with wave length of 885 nm for phosphate, 543 nm for nitrate and 810 nm for silicate (STRICKLAND and PARSON, 1968). Dissolved oxygen was measured by Winkler method (U. S. Navy Hydrographic office, 1959) and chlorophyll-*a* by spectrophotometric

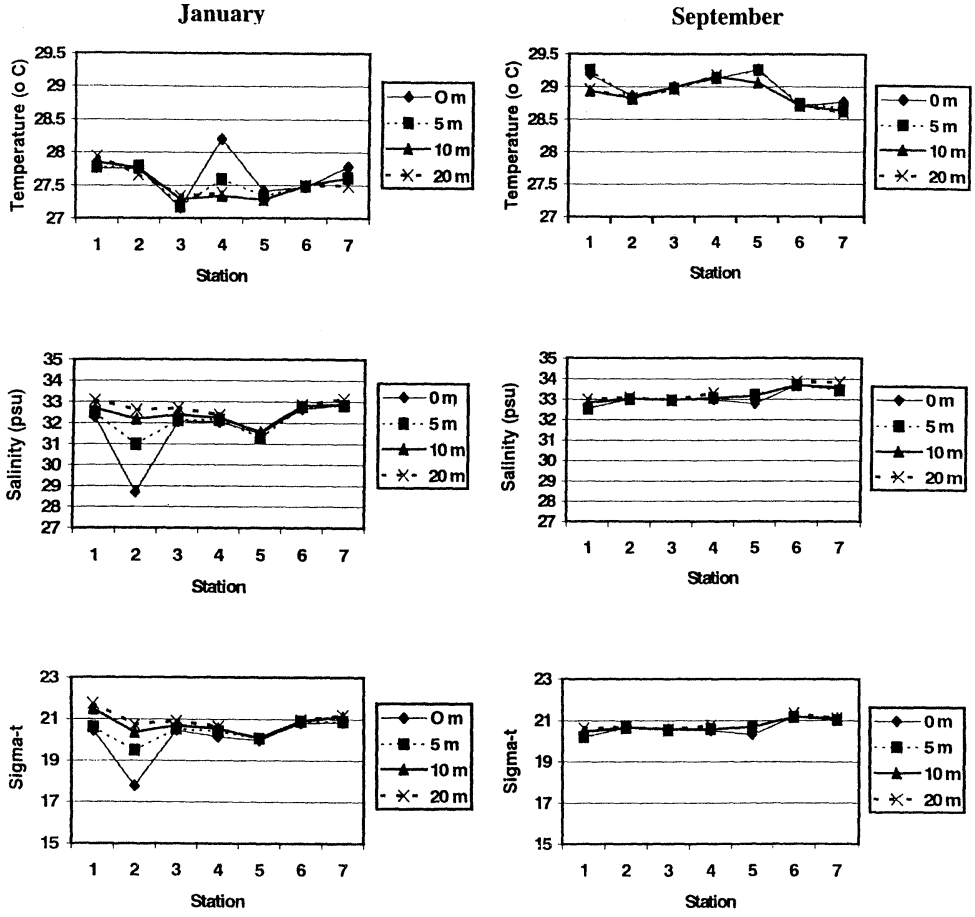

Fig. 2. Horizontal and vertical distributions of water temperature (℃), salinity (psu) and density (sigma-t) in the northern coastal area of Java in January and September 1981.

method using Spectronic 21 model UV-M with wave length of 750, 665, 645 and 630 nm (PARSON and STRICKLAND, 1963). To support this study, air temperature at the observation stations and a series of meteorological data of solar radiation, rainfall, humidity and evaporation at Jakarta derived from 1930–1961 were also collected from Meteorological Agency of Indonesia.

3. Results

Horizontal and vertical distributions of water temperature, salinity and density (sigma-t) in January (northwest monsoon) and September (southeast monsoon) 1981 are shown in Fig. 2. Water temperature in January was lower than that in September. Water temperature in January was within 27.2–28.2℃ with stratified distribution at Sta. 4 of the central part and mixing in the western and eastern parts of Java. In September, water temperature was within 28.6–29.3℃ with vertical mixing in the whole area. Salinity and density in January were relatively lower than those in September, especially for the surface layer of Sta. 2 in the western part of Java. Salinity and density in January were within 28.7–33.1 psu and 17.8–21.7, respectively, with stratified distribution at Sta. 2 of the western part and vertical mixing in the central and eastern parts of Java. In September salinity and density were within 32.6–33.9 psu and 20.2–21.3, respectively, with vertical mixing condition in the whole area.

Horizontal and vertical distributions of

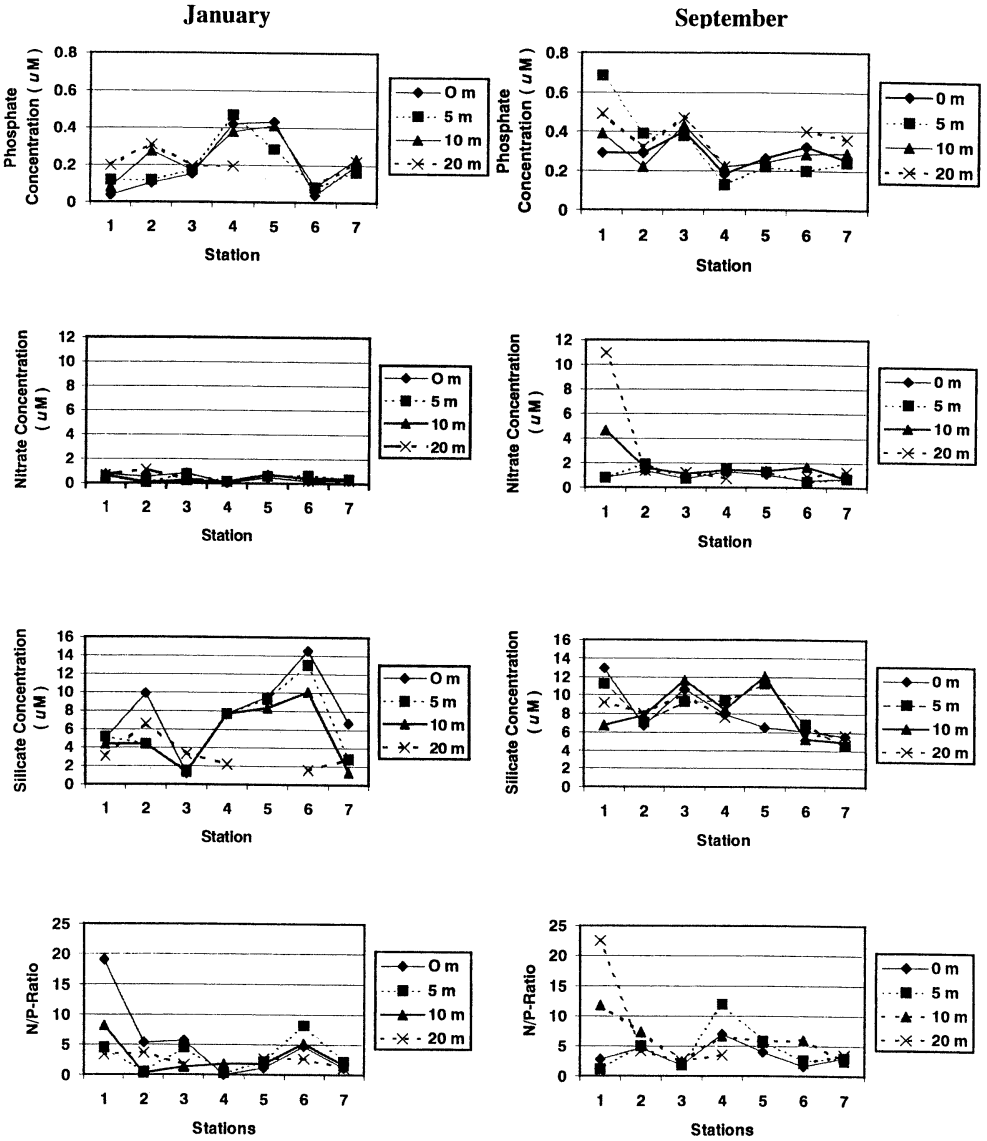

Fig. 3. Horizontal and vertical distributions of phosphate (μM), nitrate (μM), silicate (μM) and N/P-Ratio in the northern coastal area of Java in January and September 1981.

phosphate, nitrate and silicate in January and September 1981 are shown in Fig. 3. Phosphate concentration in January was relatively lower than that in September in the western part and at Sta. 6 of the eastern part. Phoshate concentration in January was within 0.04–0.47 μM and stratified at Stas. 1 and 2 of the western part and at Sta. 4 of the central part. In September, phosphate concentration was within 0.13–0.68 μM and stratified at Sta. 1 of the western part.

Nitrate concentration in January was lower than that in September, especially at Sta. 1 of the western part. Nitrate concentration in January was within 0.14–1.14 μM with vertical mixing condition in the whole area. In September, nitrate concentration was within 0.52–11.00 μM with stratified condition at Sta. 1 of the western part.

Silicate concentration in the western part in January was lower than that in September,

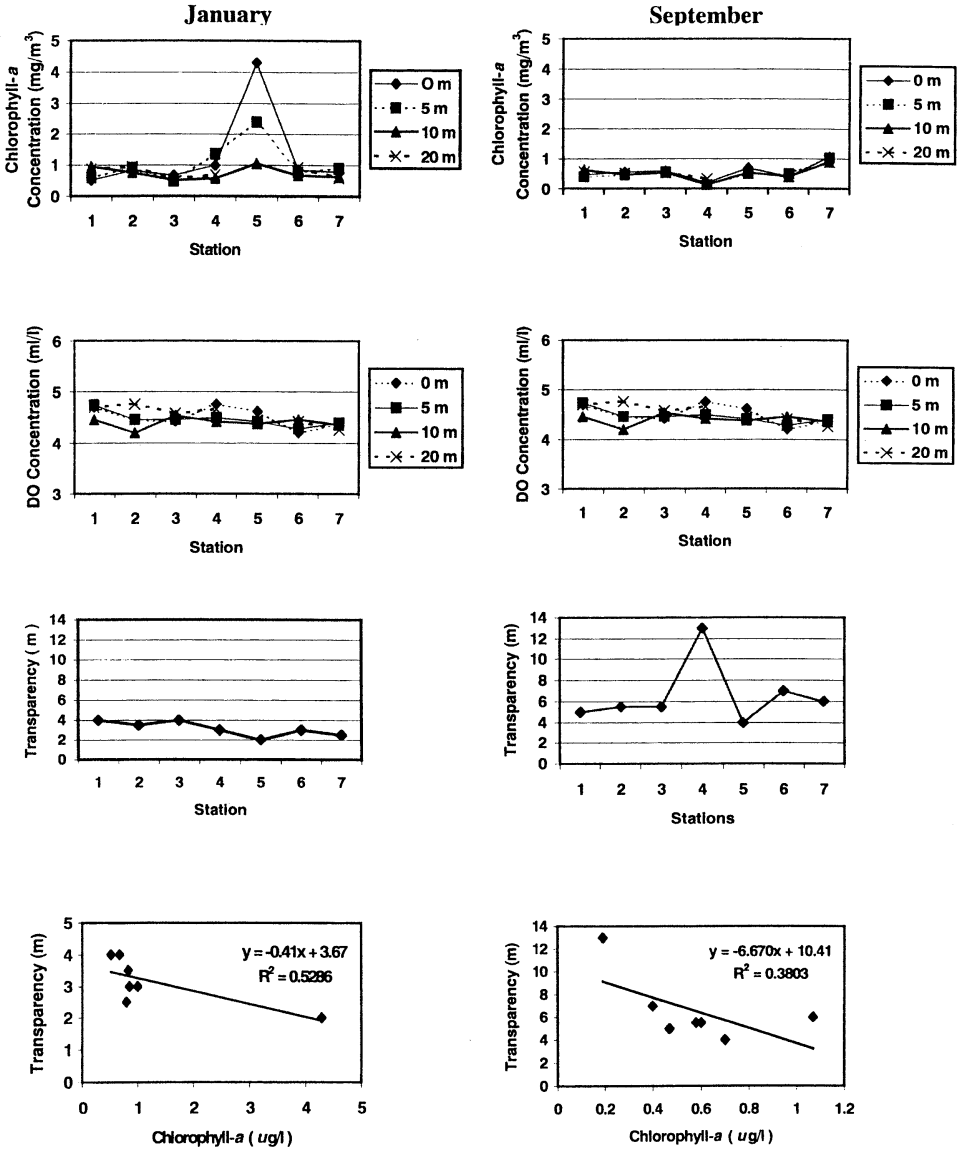

Fig. 4. Horizontal and vertical distributions of chlorophyll-*a* (μ g/l), DO (ml/l)and transparency (m)in the northern coastal area of Java and correlation between chlorophyll-*a* (μ g/l)and transparency (m)in January and September 1981.

except for the surface layer of Sta. 2. While at Sta. 6 of the eastern part, silicate was relatively higher in January than that in September. Silicate concentration was within 1.21–14.54 μ M in January and stratified at Sta. 2 of the western part and Sta. 6 of the eastern part. In September, silicate concentration was within 4.46–12.93 μ M and stratified at Stas. 1 and 3 of the western part and Sta. 5 of the central part.

Moreover, N/P ratio in January was lower than that in September, except for some layers at Stas. 3 and 6. N/P ratio in January was within 0.05–19.00 and in September within 1.75 –22.44.

Horizontal and vertical distributions of chlorophyll-*a*, dissolved oxygen (DO) and water

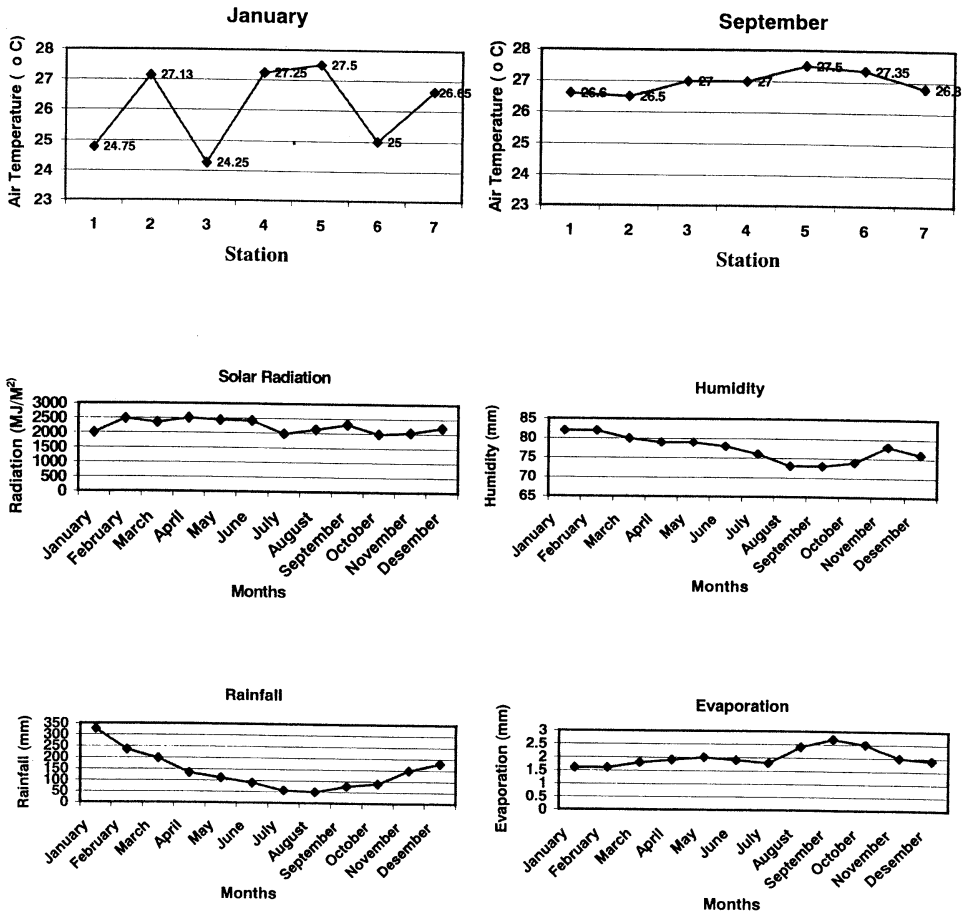

Fig. 5. Air temperature (℃) at the observation stations in January and September 1981, monthly mean solar radiation, rainfall, air humidity and evaporation at Jakarta are derived from the data during 1931–1960 (Meterological Agency, Indonesia).

transparency in January and September 1981 are shown in Fig. 4. Chlorophyll-*a* concentration in January was relatively higher than that in September, especially for Sta. 5 of the central part. Chlorophyll-*a* concentration in January was within 0.54–4.29 μg/l and stratified at Stas. 4 and 5 of the central part. In September, chlorophyll-*a* was within 0.13–1.07 μg/l with vertical mixing condition in the whole area.

DO concentration in the western part in January was slightly lower than that in September. DO concentration in January was within 3.80–4.82ml/l with stratified at Sta. 2 of the western part, Sta. 4 of the central part and Sta. 7 of the eastern part. In September DO concentration was within 4.19 – 4.77ml / l with slightly stratified at Sta. 2 of the western part, Sta. 4 of the central part. Water transparency in January was within 2.0–4.0m and it is lower than that in September within 4.0–13.0m.

4. Discussion

The variability of the water characteristics in the northern coastal area of Java is expected to be affected by meteorological condition, the current of the Java Sea corresponding to the monsoon and local topography of coastal area. Variability of water temperature, salinity and density in the northern coastal area of Java in January (northwest monsoon)and September (southeast monsoon) is caused by precipitation and solar radiation as shown in Fig. 5.

Higher precipitation and lower radiation in January caused water temperature, salinity and density lower than those is September. Higher water temperature in September in due to the stronger solar radiation because the sun crosses the equator southward from the northern hemisphere. This situation was obviously seen on the air temperature status, that is, air temperature in September was higher than that in January as shown in Fig. 5. Other work (ATMADIPOERA *et al.*, 1999) note that the temporal variation of air temperature had a similar pattern to that of the sea surface water temperature.

Lower salinity and density within this region were mainly due to the effect of high river discharge in the rainy season of January as shown in Fig. 5. Lower salinity and density at Stas. 2 and 5 in January were due to high discharge of the Citarum river, the biggest river in the northern coast of West Java, and the Serang river in the central Java, respectively (Fig. 1). Horizontal and vertical distributions of density were governed by those of salinity as shown in Fig. 2. This means that the northern coastal area of Java has a character of estuary.

Horizontal variability of nutrient concentration within this region seemed to be governed by surface current of the Java Sea and precipitation due to the monsoon. This situation was confirmed by TOMASCIK *et al* (1997) which denoted that the concentration of suspended particulate matter (SPM) in the Java Sea was affected by rainfall and surface current of the Java Sea and the condition depended on the distance from shore. For the adijacent area of the shore, the effect of SPM from the terrestrial area is dominant, while the offshore area more than 3km of the shore, the surface current has a significant effect on the horizontal distribution of SPM concentration. NINGSIH and SUPRIJO (1998) denotes that the particulate matter in the Java Sea moves estward in the northwest monsoon and westward in the southeast monsoon. Because the observation areas at this time were located more than 5km from the shore, the effect of the surface current on the horizontal distribution of nutrients within this region will be significant. Moreover, since the concentrations of municipal, agriculture and industrial wastes in the northern coastal area of Java are variously, this situation will also affect on the nutrient distribution. For instance, high concentration of phosphate at Stas. 4 and 5 of central Java in January 1981 was probably due to the addition and accumulation of phosphate by the eastward surface current of the Java Sea that brought a high concentration of nutrient from industrial region of West Java shown in Fig. 1. The accumulation of phosphte in the central part was also occurred due to the presence of the local eddy that was generated by semi-enclosed topography of the central Java as shown in Fig. 1. On the odher hand, higher river discharge of the Serang river in the central Java also contributed on the intensification of such condition. The almost similar pattern was also seen on the distribution of silicate where high concentration was found in the central part and at Sta. 6 of the eastern part in January. High concentration of silicate within this region may be resulted from high discharge of Serang river in the central Java which is added by the eastward surface current into Sta. 6 in the eastern Java. On the contrary, concentration of phosphate and silicate in September was relatively increased toward the western part. It is suspected mainly due to the addition of phosphate from land by the westward surface current, because the river discharge was relatively low during this season. Although the unclear pattern was seen on the variability of nitrate, high nitrate concentration at Sta. 1 of the western Java in September may be related to the addition of nitrate due to the westward current. High concentration of nitrate fund in the lower layer of Sta. 1 in September may be due to high decomposition and demineralization of the organic matter in the bottom layer. Such situation, however, is not supported by the condition of the DO conecentration at that station as shown in Fig. 4. In fact, the DO concentration in the lower layer of Sta. 1 was relatively high. So, more detailed investigation should be conducted to understand the nitrate distribution within this region. Meanwhile N/P ratio within this region shows that nitrate may act as the limiting factor of the primary production in the whole part of the northern coastal area of Java because N/P ratio

is lower than the Redfield ratio of 16.

Variability of chlorophyll-*a* concentration shown in Fig. 4 expresses that chlorophyll-*a* concentration in January was slightly higher than that in September. Higher concentration chlorophyll-*a* at Sta. 2 in the western part and Sta. 5 in the central part in January is probably due to large amount of nutrient supply in the rainy season from the terrestrial environment by increasing river discharge of Citarum river in the western part and Serang river in the central part, respectively. But at Sta. 7 in the eastern part of Java, higher concentration of chlorophyll-*a* in September is suspected to be due to the influence of nutrient and phytoplankton supply from the upwelling area of Banda and Flores Seas (upper panel of Fig. 1) by the westward surface current in the southeast monsoon (TOMASCIK *et al*, 1997). In the central and eastern parts of Java, lower transparency in January is significantly contributed from the phytoplankton bloom generated by increasing nutrient load from the river discharge as supported by the result of correlation analysis shown in Fig. 4.

Variability in dissolved oxygen (DO) was very small. The tendency of the increasing DO toward the eastward in the northwest monsoon and the westward in the southeast monsoon might be related with the primary production variability due to the surface current of Java Sea. Since the DO concentration is governed by not only physical but also bio-chemical processes, the clarification of the DO status within this region should be made in the future by obtaining further information of the main factor of DO variability.

5. Conclusion

The variability of the water temperature, salinity and density in the northern coastal area of Java corresponds to the monsoon which influences in precipitaion, wind and solar radiation. Water temperature in January was lower than that in September as well as for salinity and density.

Nutrients variability, influenced by the local river discharge and the local coastal topography, was also affected by the nutrients transport due to surface current corresponding to the monsoon. Phosphate in the central Java was high in January and that in the western part in September. Silicate was high in the eastern part in January and in the western part in September as well as for nitrate.

Redfield ratio in the whole part of the northern coast of Java is lower than 16, hence, nitrate may act as the limiting factor for the primary production within this region. Chlorophyll-*a* concentration was high in January in the central and western parts due to large supply of nutrients by river discharge. While in the eastern part, higher concentration of chlorophyll-*a* in September may be due to the nutrient supply from the upwelling area in the eastern region of Indonesia by surface current.

The integrated invesitigation of the ecosystem is necessary to be established within this region to understand systematically various factors that influence on the water characteristic for sustainable utilization in the future.

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Received July 10, 1999
Accepted December 5, 2000