D-3.2.2 Studies on changes in distribution of chlorophyll a and phytoplankton in Tsushima Current Area

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Abstract: In order to estimate the influence of nutrient-rich terrestrial waters from Asian Continent in the Tsushima Current waters, hydrographic observations were carried out in summer when surface low-salinity waters developed. As a result, there was a negative correlation between surface salinity and chlorophyll-a. The distributions of low-salinity and high chlorophyll-a waters were often observed around the Tsushima Western Straits in the Japan Sea. However, nutrient were exhausted in surface layers of low-salinity and high chlorophyll-a waters. These results implied that nutrients supplied from terrestrial waters were immediately consumed within the East China Seas and high chlorophyll-a water extended to the Tsushima Strait. Species diversity of phytoplankton in the high chlorophyl-a waters were lower than that in the southwestern Japan Sea.

Key Words: Hydrographic condition, Chlorophyll, Water color, Nutrient, Species composition

1. Introduction

Transparency in the Tsushima Current waters has been declining for recent thirty years (Nagata, personal communication). This fact suggests that standing crop and production of phytoplankton has been increasing and an influence of anthropogenic activity in the Asian Continent has been expanding to an ecosystem in the Japan Sea. A property of Tsushima Current surface water [1)], which is formed in the East China Seas and flows into the Japan Sea, shows a clear seasonal fluctuation [2)]. In summer low salinity waters spread around a estuary of the Chong Jiang River and extends to the Japan Sea [3)]. Present study focuses the Tsushima Current surface water in summer which is affected by the terrestrial waters from Asian Continent. We aim to understand hydrographic conditions in the Western Japan Sea and to estimate the influence of nutrient-rich terrestrial waters in the Tsushima Current surface waters.

2. Research Method

Monthly full resolution mapped images derived from SeaWiFS data were used from http://seawifs.gsfc.nasa.gov//SEAWIFS.html in order to analyze a characteristic features of surface chlorophyll-a distribution in the East China Seas and the Japan Sea. And also CTD, ADCP and serial water sampling observations were carried out by r/v Mizuho-maru in summer from 1996 to 1998 (Fig.1). Chlorophyll-a and nutrient concentrations of sampled water were measured by fluorescent luminosity meter and,

autoanalyzer respectively. In the 1996-year cruise phytoplankton species in the surface water were investigated.

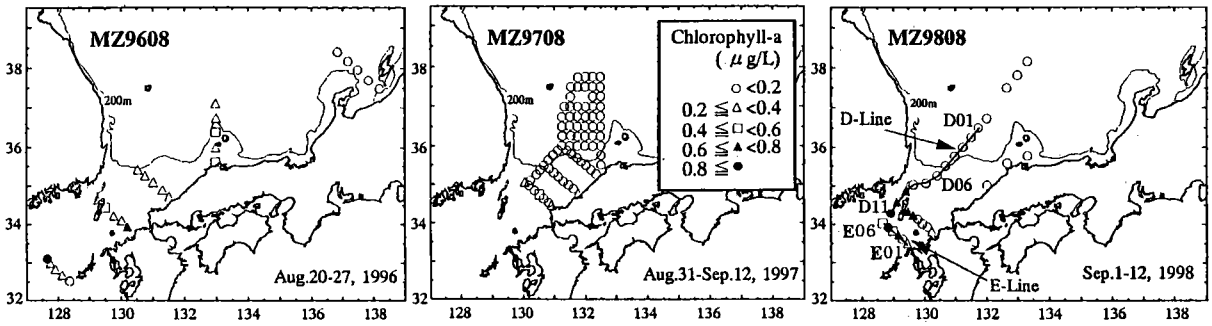

Fig.1 Stations of hydrographic observation and surface chlorophyll-a in summer during 1996 and 1998.

3.Results and Discussion

(1) Chlorophyll-a distribution from satellite data in the East China Seas and the Japan Sea

Fig.2 shows surface chlorophyll-a distribution from SeaWiFS during Jun and November, 1998. Chlorophyll-a concentrations are highest around the estuary of the Chong Jiang River in all season and the area of high concentration extends to the Japan Sea as season goes by. In Jun and July this area of high concentration was limited from the estuary to a central water of the East China Seas, however in August , September and October expanded to the Tsushima Straits in the Japan Sea. Around the Tsushima Strait high chlorophyll-a concentrations were recognized only in the Western Strait. In comparison with the fact that abnormally low salinity water spread in the surface layers of the Japan Sea caused by a large number of floods of the Chong Jiang River [4),5)] , it is considered that inflow of high chlorophyll-a water and low salinity water concurrently occurred. Although the algorithm and validation to retrieve chlorophyll-a concentrations from SeaWiFS data are not sufficient yet, wide and concurrent chlorophyll-a map is considered to be useful to monitor the standing crop of phytoplankton.

(2) Hydrographic structures and chlorophyll-a concentrations in summer

Fig.3 shows the distribution of surface chlorophyll-a concentrations in the southwestern part of the Japan Sea during August 27 and September 13, 1998 and cross sections of salinity, sigma-t and chlorophyll-a along observation line-E around the Tsushima Strait shown in Fig.1. Surface salinity was lower than 32psu in almost whole western Japan Sea, especially around the Tsushima Strait very low salinity (<30psu) was observed. Surface chlorophyll-a concentration was lower than 0.2 μ g/L in almost whole western Japan Sea, however around the Tsushima Strait high chlorophyll-a concentration (>0.6 μ g/L) was observed. Moreover around the Tsushima Strait chlorophyll-a concentrations were higher in the western Strait than in the eastern Strait. In 1996 the highest value of chlorophyll-a concentrations were also observed in the Tsushima Western Strait.

On the cross sections along the line-E high salinity and heavy water (>34.25psu, >24.5) was widely distributed in the deeper layers than 60m. In the upper layers than 10m, low salinity and light water (<30psu, <18.0) lay in the western strait. Chlorophyll-a concentration was high in the upper layer of the western strait corresponding to the low salinity and light water. However, in the eastern strait subsurface chlorophyll-a maximum

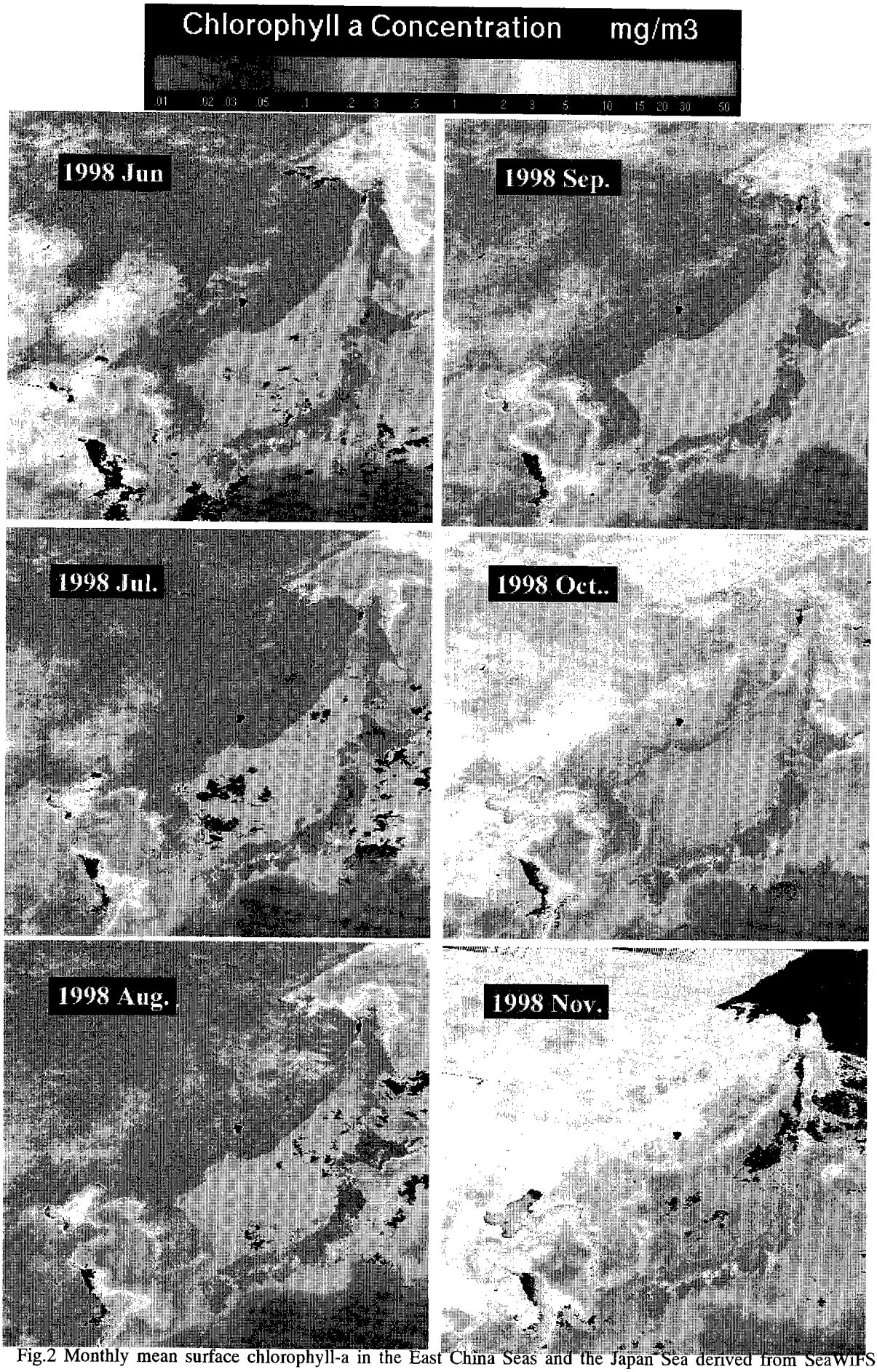

Fig.2 Monthly mean surface chlorophyll-a in the East China Seas and the Japan Sea derived from SeaWiFS.

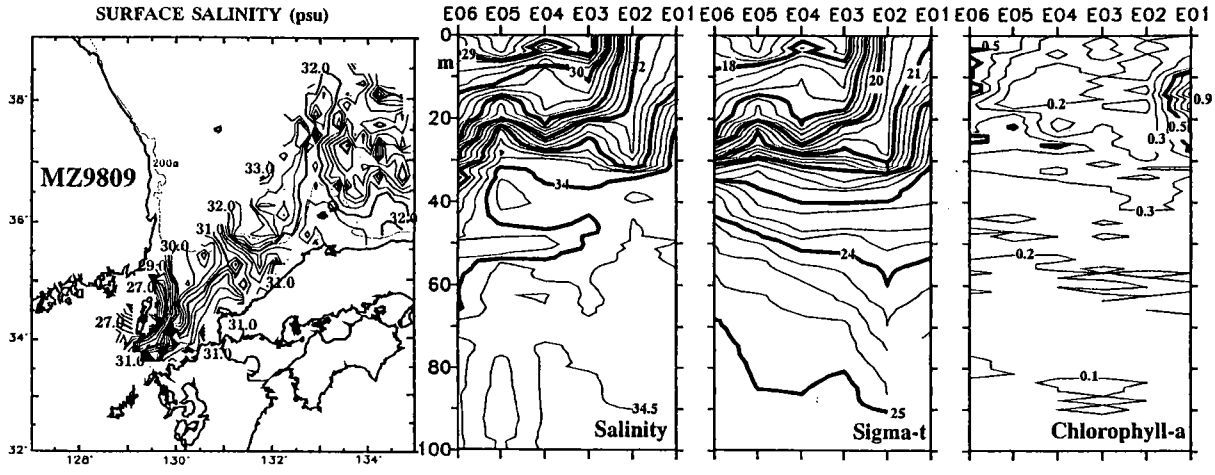

Fig.3 Distribution of surface chlorophyll-a concentrations during August 27 and September 13, 1998 and cross sections of salinity, sigma-t and chlorophyll-a along the observation line-E shown in Fig.1.

was recognized in the 10-30m layers and chlorophyll-a concentration was low in the upper layers than 10m. Thus, there were at least two water types of the Tsushima Current surface water around the Tsushima Strait in summer in relation to salinity and chlorophyll-a concentration.

Next, we tried to classify the water types of the Tsushima Current surface water in the southwestern part of the Japan Sea from salinity and chlorophyll-a concentration (Fig.4). High correlations were recognized between surface salinity and chlorophyll-a concentration in all three years. These correlations implies, the lower salinity shows, the higher chlorophyll-a concentration shows in the southwestern part of the Japan Sea. In the diagram of 1998 we can classify the two types of surface water. One is very low salinity and high chlorophyll-a water which is distributed around the Tsushima Strait. Another one is lower salinity than usual year but low chlorophyll-a water which is widely distributed in the southwestern part of the Japan Sea. Judging from this hydrographic observational results and the distribution of chlorophyll-a concentration from satellite as mentioned above, a low salinity and high chlorophyll-a surface water which is strongly affected by the terrestrial waters from Asian Continent is distributed as far as the Tsushima Strait.

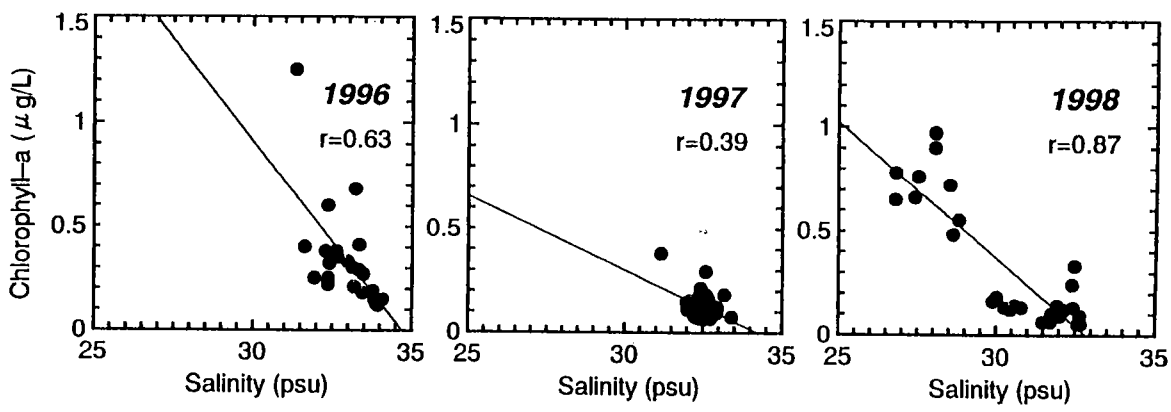

Fig.4 Salinity vs. chlorophyll-a concentration diagram.

(3) Species composition of phytoplankton in the Tsushima Current surface water

Number of species of phytoplankton appeared in the observation of 1996 were from 6 to 26 and number of cells were from 700 to 3088 cells/l. Species diversity was low in the East China Seas and increased around the Tsushima Strait, off Yamaguchi and off shimane in order. These facts implies species composition is simple in high chlorophyl-a waters which is strongly affected by the terrestrial waters from Asian Continent, and becomes complicated in the downstream waters along the Tsushima Current.

In high chlorophyl-a waters west to Kyushu Island only five diatoms were dominated, such as *Leptocylindrus mediterraneus*, *Guinardia flaccida*, *Rhizosolenia alata*, *Chaetoceros compressus* and *Nitzschia pungens*. They belong to the coastal/warm water species or cosmoporitan species. They are common species in the Japan Sea and are not peculiar species to be appeared in the terrestrial waters from Asian Continent. In the downstream waters along the Tsushima Current in the Japan Sea, *Rhizosolenia, Bacteriastrum, Chaetoceros and Thalassionema* appeared other than above five species. Park (1956) [6] reported that dozens of phytoplankton species appeared in the waters south to Korean Peninsula in August and Choe (1966) [7] reported that more than twelve species of phytoplankton species appeared in the low surface salinity waters around Cheju Island in August. These facts suggest that dominant species composition is simple in high chlorophyl-a waters which is strongly affected by the terrestrial waters from Asian Continent in spite of large interannual fluctuation the of number of appeared species.

(4) Production of phytoplankton in response to the inflow of nutrient-rich terrestrial waters

In this section we consider characteristic features of production of phytoplankton in response to the inflow of nutrient-rich terrestrial waters by using the distribution of nutrients in 1998. Fig.5 shows vertical profiles of salinity, chlorophyll-a and phosphate-p along the observation line-D shown in Fig.1. In the shallower layers than 20m of Stn.E06-Stn.D09 where low salinity water was distributed chlorophyll-a concentrations were high (0.5-1.2 μ g/L), however were low (<0.2 μ g/L) in the deeper layers than 50m. On the other hand in the shallower layers than 20m of Stn.E04- Stn.D01 where surface salinity was not so low chlorophyll-a concentrations were low (<0.2 μ g/L), and subsurface maximum was recognized at 30m-50m depth. At the middle Stations (Stn.D08-Stn.D05) subsurface maximum was recognized at 20m-30m depth. We can point out the features that the depth of chlorophyll-a maximum becomes deep in the downstream waters along the Tsushima Current from Tsushima Strait to the middle of southwestern part of the Japan Sea.

On the other hand in the vertical profiles of phosphate-p there were no significant differences among Stns. E06-D01 from the Tsushima Strait to the southwestern Japan Sea. Phosphate-p concentrations were approximately lower than 0.2 μ g/L and higher than 0.8 μ g/L in the shallower layers than 30m and deeper layers than 50m, respectively. Such a feature of nutrient profile is considered to be a feature in summer of the Japan Sea [8] . Nitrate-N concentrations in the surface layers were also very low level. Judging from the results of chlorophyll-a and nutrient profiles, primary productivity was not high at the Stns.E06-D09 in spite of high chlorophyll-a concentrations. It is considered that a primary productivity and chlorophyll-a concentration are high around the estuary of the Chong Jiang River by means of continuous nutrient supply [9] , but nutrients are rapidly utilized by phytoplankton in the East China Seas [10] . It is considered that nutrients supplied from

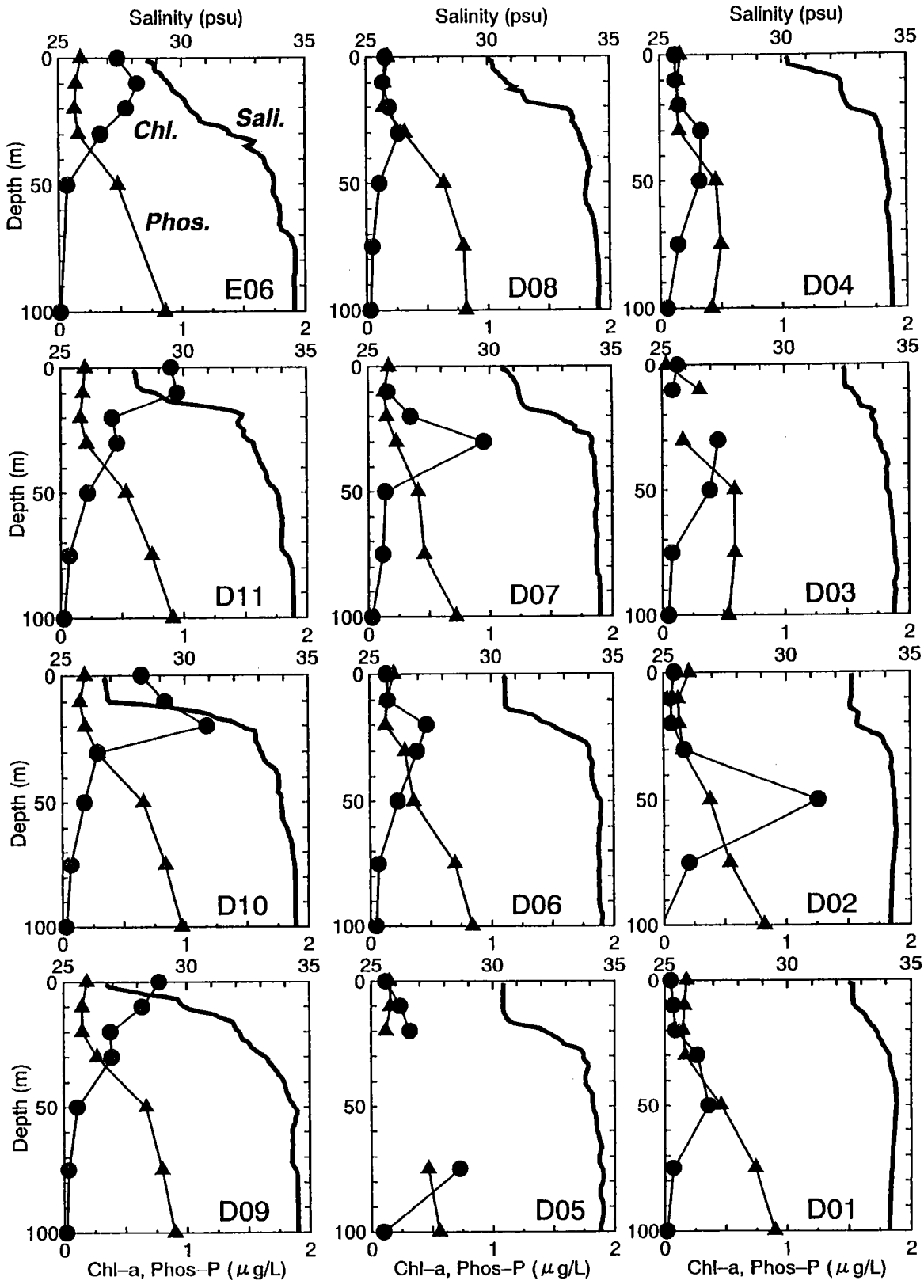

Fig.5 Vertical profiles of salinity, chlorophyll-a and phosphate-p along the observation line-D shown in Fig.1.

terrestrial waters were immediately consumed within the East China Seas, and consequently the high chlorophyll-a waters were transported from East China Seas or Korean coastal waters and extended to the Tsushima Strait.

Thus it is considered that influence of nutrient-rich terrestrial waters from Asian Continent is not so large to a primary productivity of the southwestern Japan Sea in summer. However, the inflow of high chlorophyll-a waters have a possibility of high production cased by sudden vertical mixing or seasonal mixing in autumn. In future it is necessary to establish the monitoring systems of chlorophyll-a and nutrient concentrations. Moreover as the volume transport of the Tsushima Current is larger in the western Tsushima Strait than in the eastern Strait [11], it is necessary to establish the monitoring systems in the Tsushima Western Strait through international cooperation.

4. References

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Figure captions

Fig.1 Station map of hydrographic observation and distributions of surface chlorophyll-a concentration in summer during 1996 and 1998.

Fig.2 Monthly mean surface chlorophyll-a distribution in the East China Seas and the Japan Sea derived fromSeaWiFS data (http://seawifs.gsfc.nasa.gov//SEAWIFS.html).

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