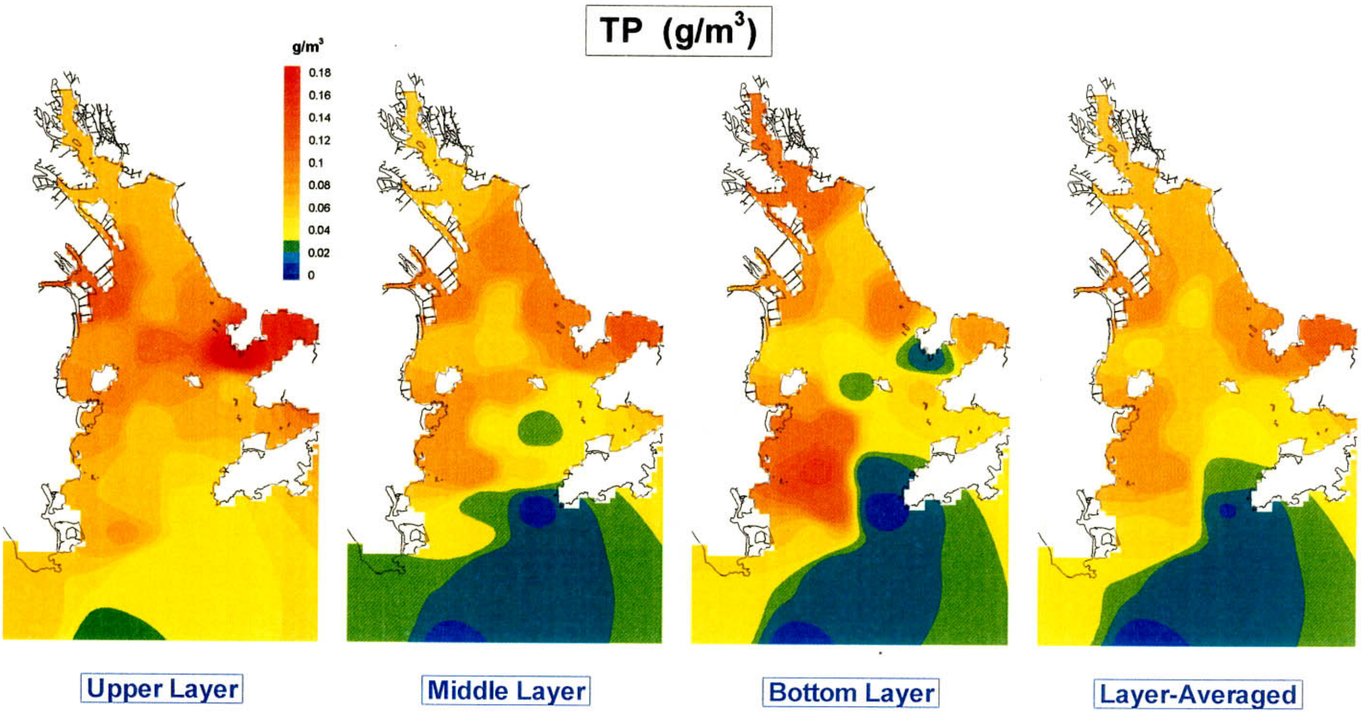


Figure 2.2.5 (1) Rainy Season Water Quality Survey Results (Graphic Rendition by Interpolation)

Spring Tide : July 31 - August 3, 2000

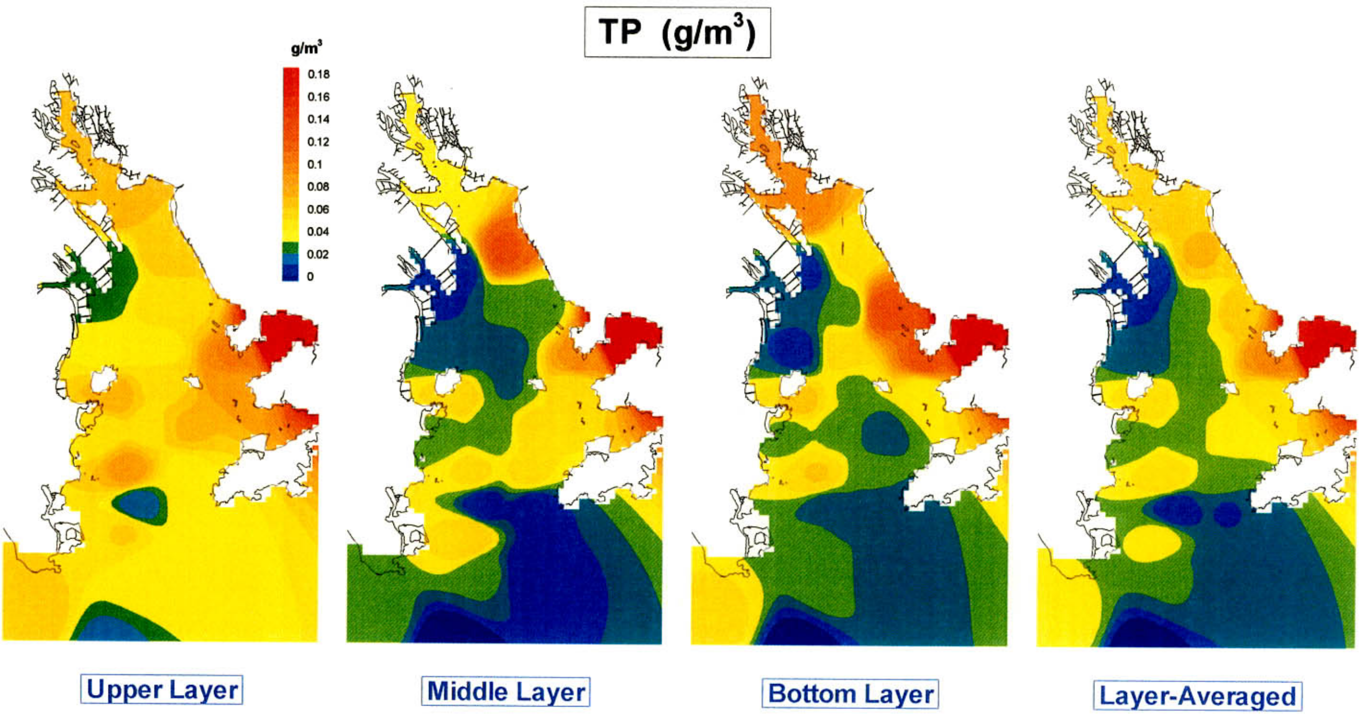


Figure 2.2.5 (2) Rainy Season Water Quality Survey Results (Graphic Rendition by Interpolation)

Neap Tide : August 6 - 9, 2000

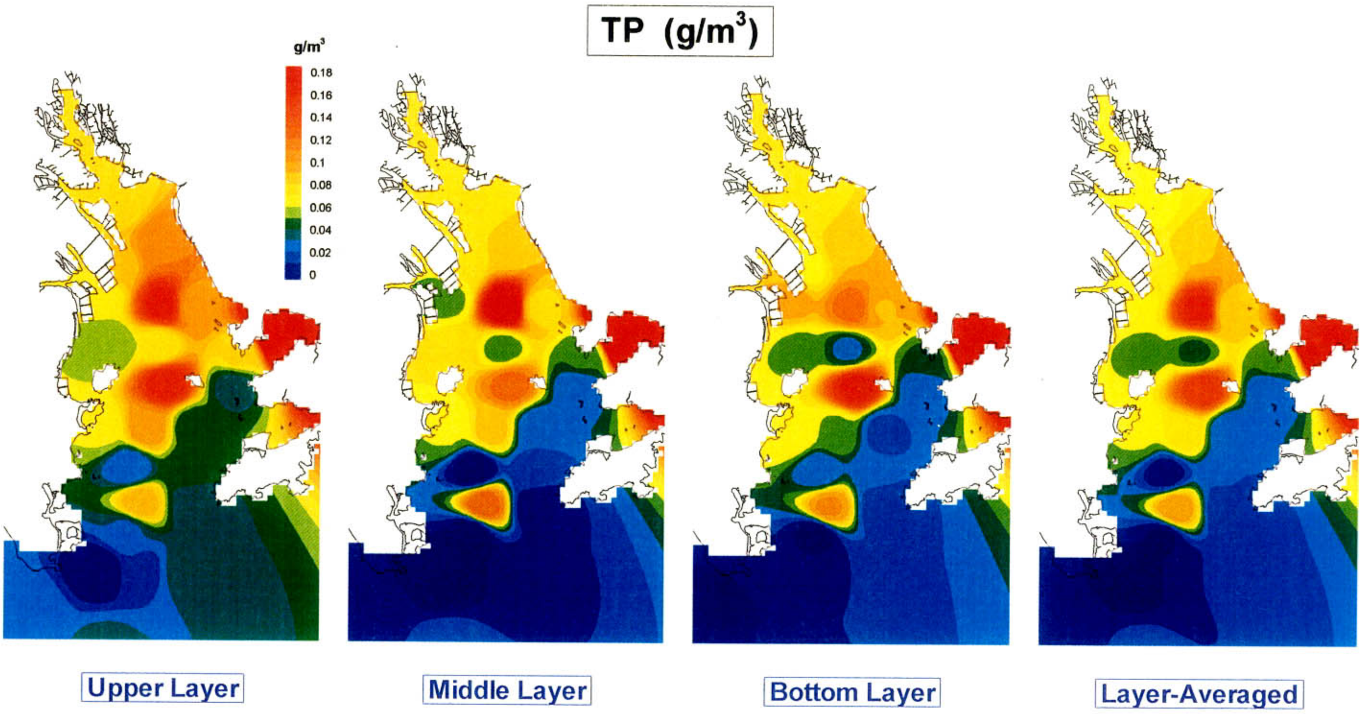


Figure 2.2.5 (3) Dry Season Water Quality Survey Results (Graphic Rendition by Interpolation)

Spring Tide : December 9 - 14, 2000

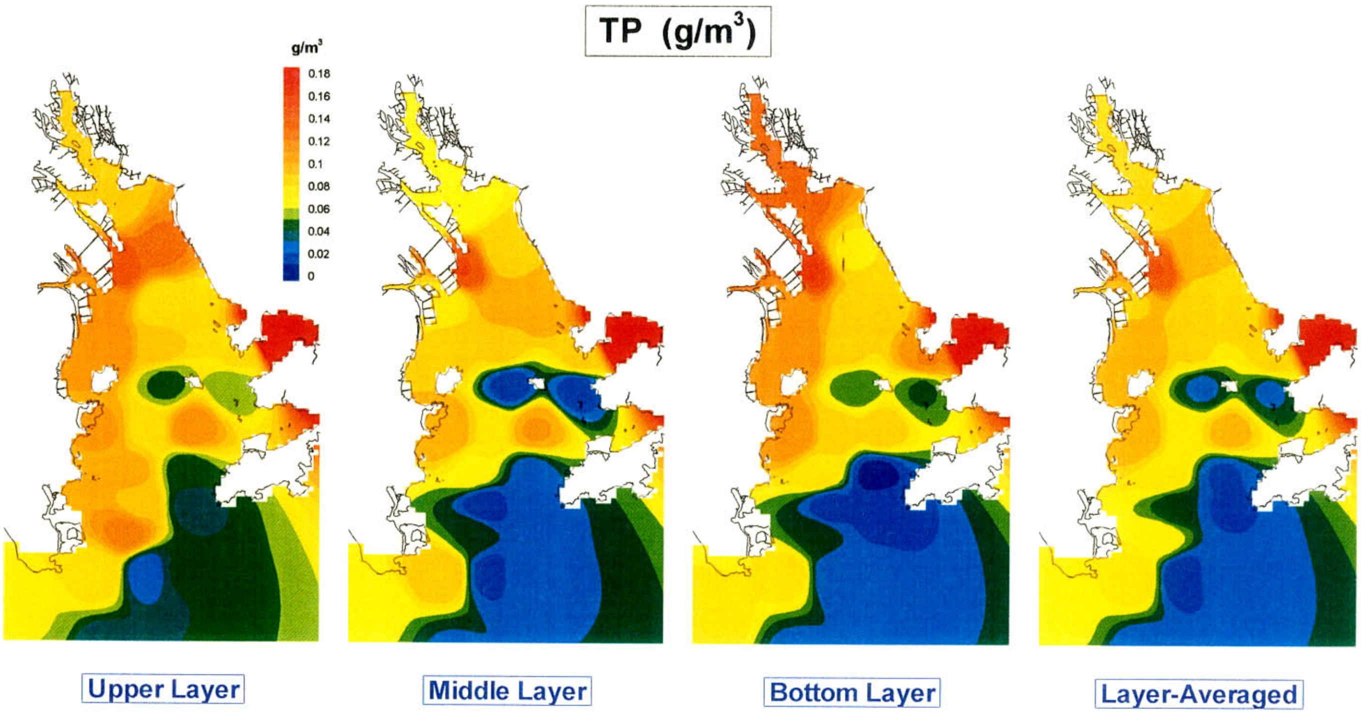


Figure 2.2.5 (4) Dry Season Water Quality Survey Results (Graphic Rendition by Interpolation)

Neap Tide : December 4 - 8, 2000

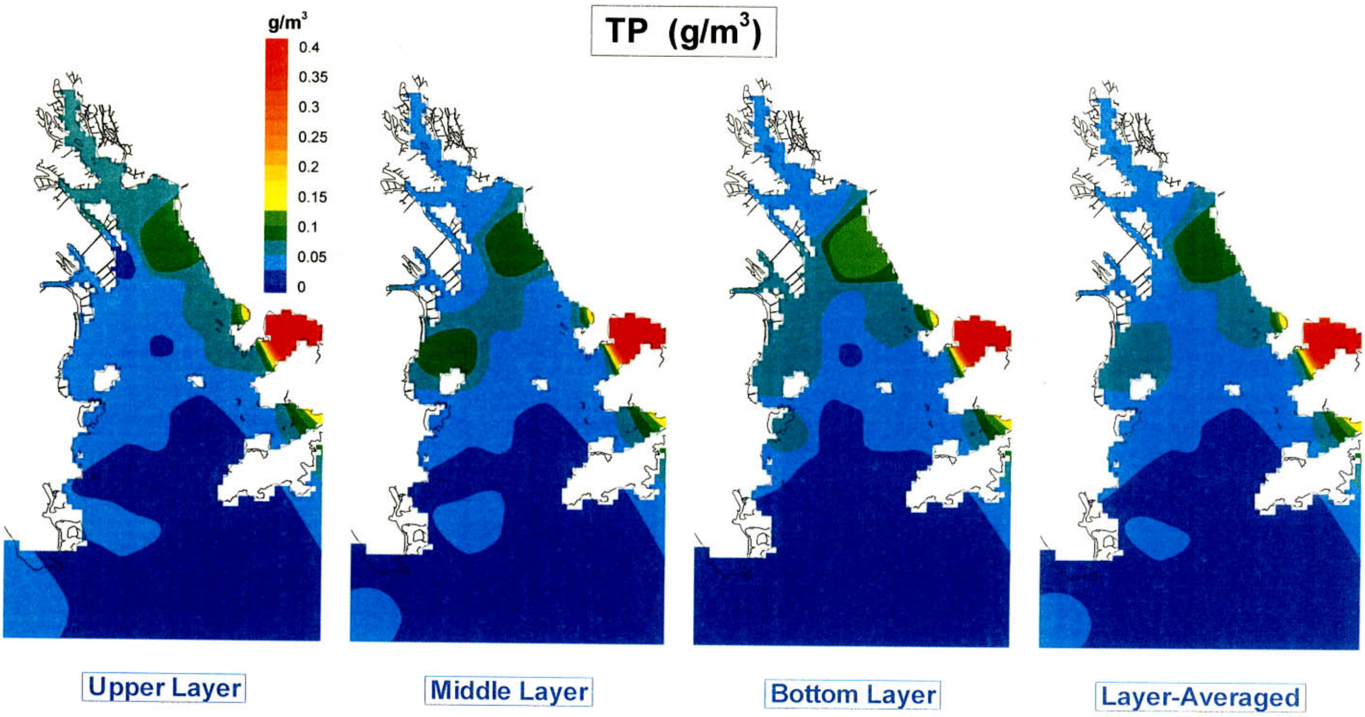
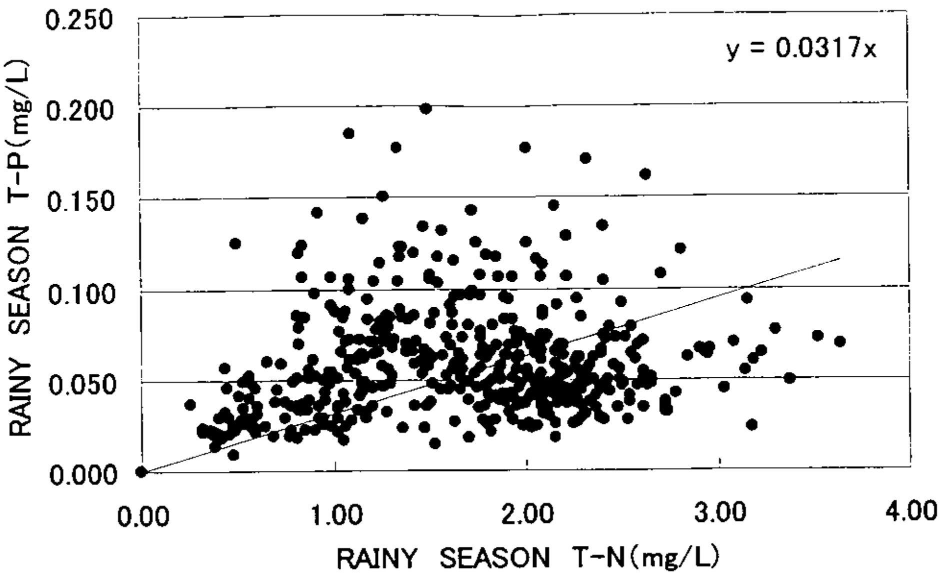


Figure 2.2.5 (5) Transient Season Water Quality Survey Results (Nonlinear Rendition by Interpolation)

Neap Tide : March 4 - 6, 2001



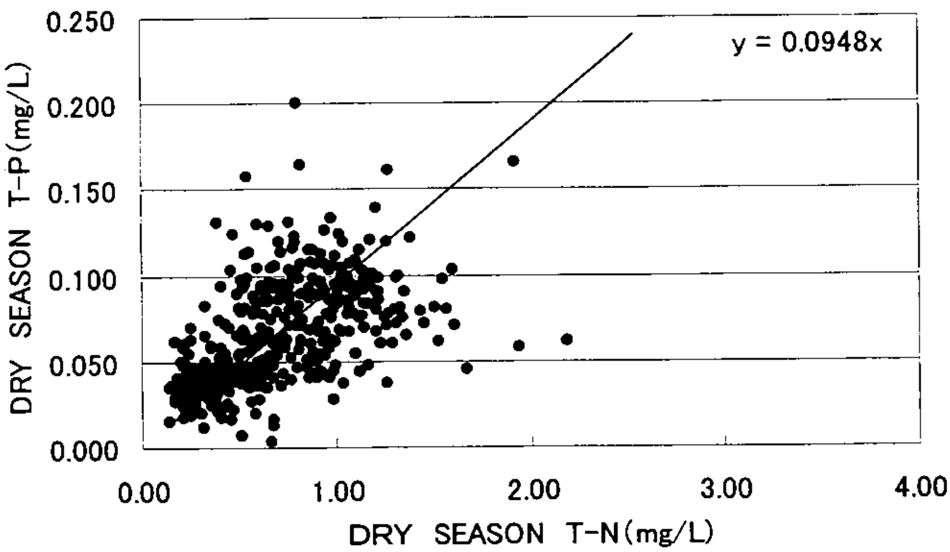


Figure 2.2.6 Relationship between T-N and T-P

2.3. Result of Principal Component Analysis for the Water Quality

Principal Component Analysis, one of the multivariate analysis methods, was used to analyze and summarize the results of water quality surveys in two seasons.

The variables and number of data used in this analysis are shown in Table 2.3.1. Heavy metals were excluded in this analysis because they had no relationship with spatial and/or seasonal distributions.

Table 2.3.1 Variables and Number of Data for Principal Component Analysis

Variables	15 items	Salinity, pH, DO, SS, BOD_5, COD_{Mn}, TOC, SiO_2-Si, T-N, NH_3-N, NO_2-N, NO_3-N, T-P, PO_4-P, Chl.-a
Number of Data	291	26 points x 2 tides x 2 or 3 layer (Rainy season) 25 points x 2 tides x 2 or 3 layers (Dry season)

The correlation matrix among these 15 items, as a base of the analysis, is shown in Table 2.3.2. Although the table includes 6 heavy metals, in addition to 15 items, interrelationships among heavy metals and with the other 15 items were not found. On the other hand, some indicators of the organic matter, i.e., nitrogen, phosphorus, and other items have notable relationships with each other.

The proportions and accumulated proportions of the 3 principal components are shown in Table 2.3.3. From the accumulated proportions, it is suggested that the 3 principal components explain 64% of 15 items.

Table 2.3.3 Eigenvalue, Proportion and Accumulated Proportion of 3 principal Components

	Eigenvalue	Proportion	Accumulated Proportion
Component No.1	4.907	0.327	0.327
Component No.2	2.761	0.184	0.511
Component No.3	1.926	0.128	0.640

Factor loadings of each item to each component are shown in Figure 2.3.1, and summarized in Table 2.3.4.

Table 2.3.4 High Correlation Items for Factor Loadings to Each Principal Component

	High Correlation Items (Positive)	High Correlation Items (Negative)
Component No.1	Salinity, pH	COD_{Mn}, T-N, NO_3-N, SiO_2-Si, BOD_5
Component No.2	PO_4-P, T-P, NH_3-N, NO_2-N	NO_3-N
Component No.3	Chl.-a, DO, pH	-

According to the relationship between the component and each item, the characteristics of each component is explained as follows:

- Component No.1: effects of the outer bay water (positive correlation) or the river water (negative correlation)
- Component No.2: effects of pollutant effluents from human activities
- Component No.3: effects of the inner production (algal blooms) in the sea area

Spatial distribution maps of the result are shown in Figures 2.3.2 to 2.3.7. These maps clearly show a trend of water quality in the estuary, which is highly dependent on seasonal and tidal characteristics.

(1) Maps of Component 1 show the effect of freshwater and seawater. The effect of river water was strengthened in the rainy season, especially during the spring tide. Seawater was dominant in the dry season, especially during the neap tide. During the neap tide in the rainy season, freshwater covered the surface layer, and seawater was pushed deeper into the lower layer of the inner bay. Conversely, vertical mixing of freshwater progressed during the spring tide in the rainy season and a vertical difference was not found. The same tendency was found in the dry season, although the distribution of freshwater was limited to a small area. In the lower layers during the neap tide in both seasons, seawater flowed into the eastern part of the bay.

(2) Maps of Component 2 show the effect of pollutant effluents from human activities. High values of Component 2 were found in Shenzhen Bay in all seasons and tides. This was the severest pollution area due to anthropogenic effluents. In the dry season, high concentrations of the effluent spread widely from the mouth of Humen River to the east of the bay. Since the dry season had lower river discharge than the rainy season, the effect of anthropogenic effluents could be separated from the other effects of river water. Consequently, the result suggests that the anthropogenic effluent load that entered into the eastern part of the bay was from the economical development zones of Shenzhen and Dongguan.

(3) Maps of Component 3 show the effect of inner production, i.e. the algal bloom. In the outer bay area, during the neap tide in rainy season and the spring tide in dry season, Component 3 shows a high value in accordance with chlorophyll-a

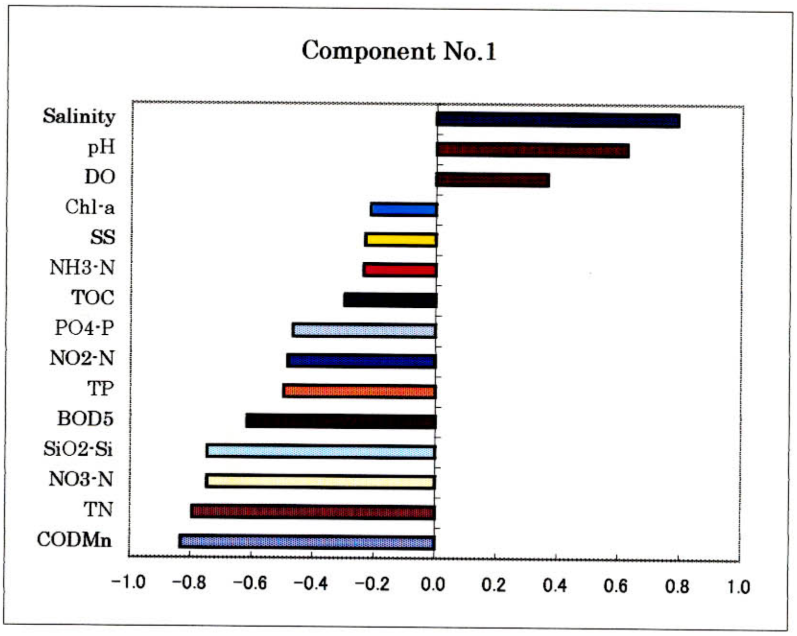
distribution. An area with high values was found in Shenzhen bay and offshore of Hengmen.

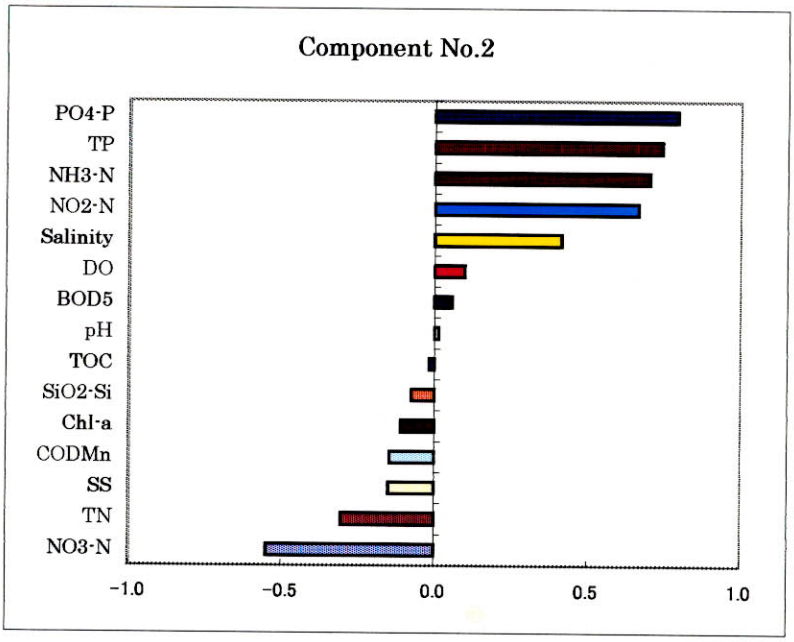
(4) According to the result mentioned above, Principal Component Analysis is a very useful method for analyzing water quality trends. Most of 15 items were summarized, and the characteristics of chemical environment in the Estuary could be explained by 3 principal components.

Table 2.3.2 Correlation Matrix for the Results of Water Quality Surveys (n=291)

	Salinity	DO	CODMn	BOD5	pH	TOC	TN	TP	PO4-P	SiO2-Si	NO2-N	NO3-N	NH3-N	Hg	Cu	Zn	Pb	Cd	As	SS	Chl-a
Salinity																					
DO	0.12																				
CODMn	***-0.68***	***-0.24***																			
BOD5	***-0.36***	-0.07	***0.59***																		
pH	***0.41***	***0.70***	***-0.44***	-0.13																	
TOC	-0.14	-0.15	***0.20***	***0.29***	***-0.20***																
TN	***-0.73***	***-0.35***	***0.59***	***0.41***	***-0.45***	***0.19***															
TP	-0.08	-0.07	***0.30***	***0.33***	***-0.27***	0.11	***0.17***														
PO4-P	-0.01	-0.06	***0.28***	***0.34***	***-0.22***	0.11	***0.17***	***0.94***													
SiO2-Si	***-0.72***	-0.02	***0.52***	***0.38***	***-0.32***	0.11	***0.60***	***0.27***	***0.24***												
NO2-N	-0.10	***-0.16***	***0.31***	***0.27***	***-0.35***	0.09	***0.15***	***0.57***	***0.62***	***0.38***											
NO3-N	***-0.86***	***-0.31***	***0.63***	***0.32***	***-0.46***	***0.17***	***0.79***	-0.01	-0.06	***0.58***	-0.01										
NH3-N	-0.04	0.05	0.04	0.07	-0.11	0.01	0.02	***0.48***	***0.53***	***0.17***	***0.57***	***-0.16***									
Hg	0.08	***-0.17***	0.10	0.06	-0.14	0.09	-0.03	-0.02	-0.07	-0.06	-0.05	-0.04	-0.13								
Cu	***-0.37***	0.06	***0.20***	0.10	-0.15	0.05	***0.22***	***0.28***	***0.20***	***0.25***	0.10	***0.24***	0.12	0.06							
Zn	0.12	0.07	0.08	-0.05	-0.06	-0.08	***-0.18***	0.11	0.06	-0.15	0.06	***-0.17***	-0.01	0.06	0.03						
Pb	0.03	***0.18***	-0.07	0.01	***0.20***	-0.07	-0.02	0.00	0.07	0.07	0.11	-0.09	0.02	***-0.17***	***0.25***	0.01					
Cd	***0.19***	***0.28***	-0.12	-0.06	0.15	-0.06	***-0.21***	0.05	0.07	-0.03	0.15	***-0.23***	0.04	0.08	0.03	***0.21***	***0.20***				
As	0.03	***0.32***	0.01	-0.09	***0.19***	***-0.18***	-0.14	0.08	0.04	0.09	0.00	-0.08	0.05	0.13	-0.08	0.04	0.00	***0.29***			
SS	***-0.17***	-0.08	***0.36***	0.08	***-0.25***	-0.06	0.08	0.10	0.00	0.12	-0.06	***0.17***	-0.07	***0.42***	0.04	***0.29***	-0.13	***0.17***	***0.43***		
Chl-a	***-0.21***	***0.30***	***0.34***	***0.45***	***0.31***	***0.19***	0.15	0.05	0.09	***0.17***	-0.06	***0.16***	-0.08	-0.13	0.03	-0.16	0.01	-0.11	-0.10	-0.11	

Notes: Bold-itaric numbers are the value more than 1% of the significant level.





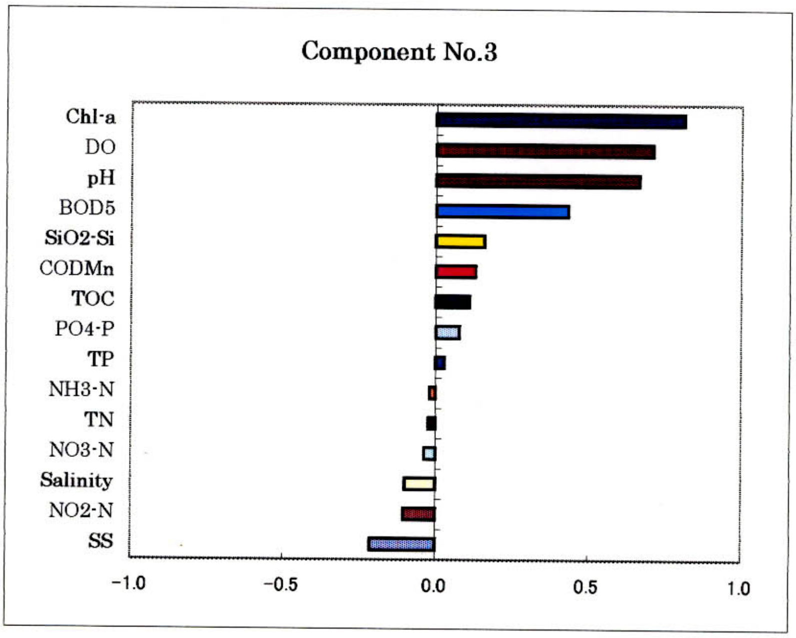


Figure 2.3.1 Factor Loadings to Major 3 Components

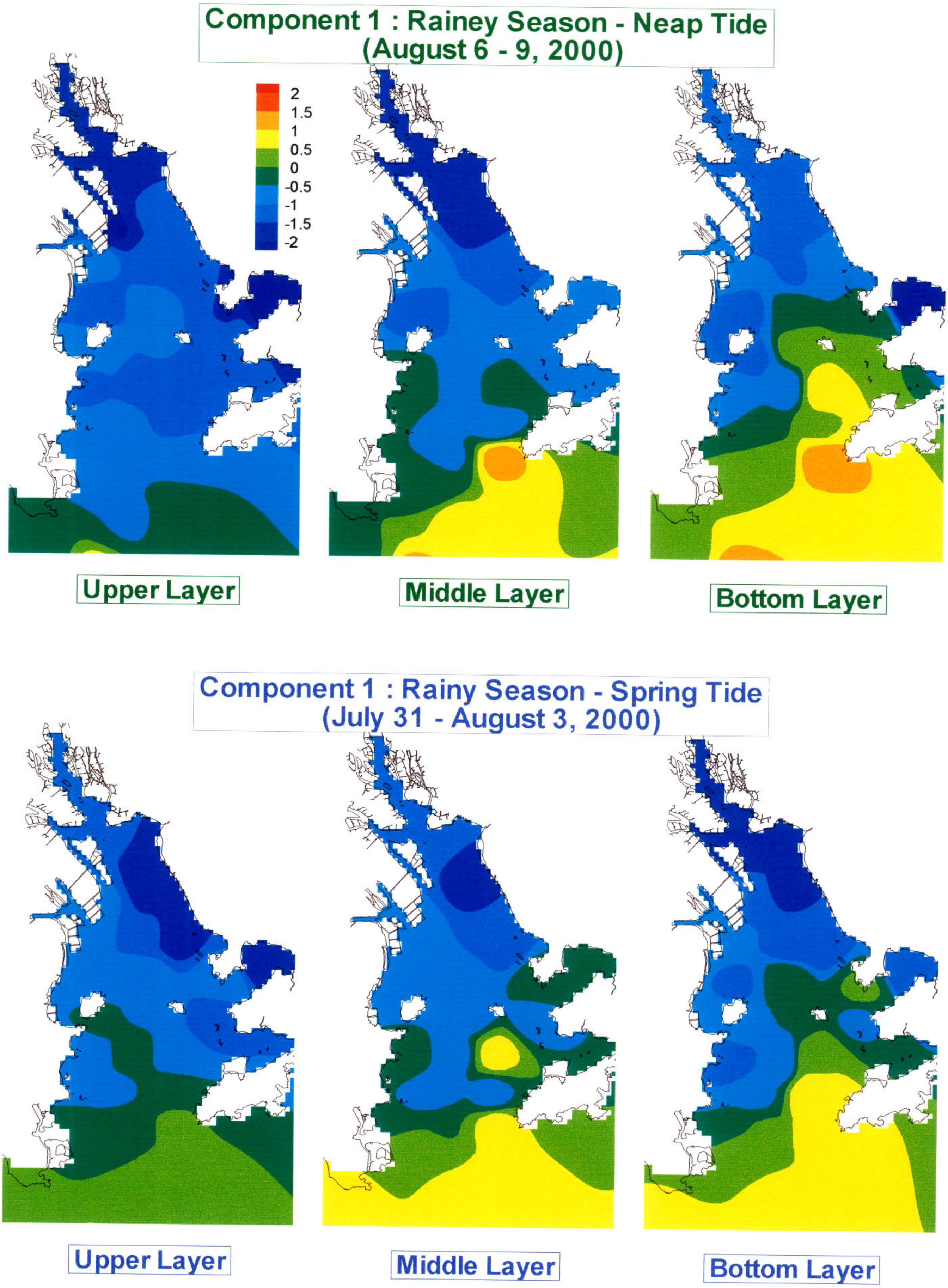


Figure 2.3.2 **Water Quality Multiple Component Analysis**

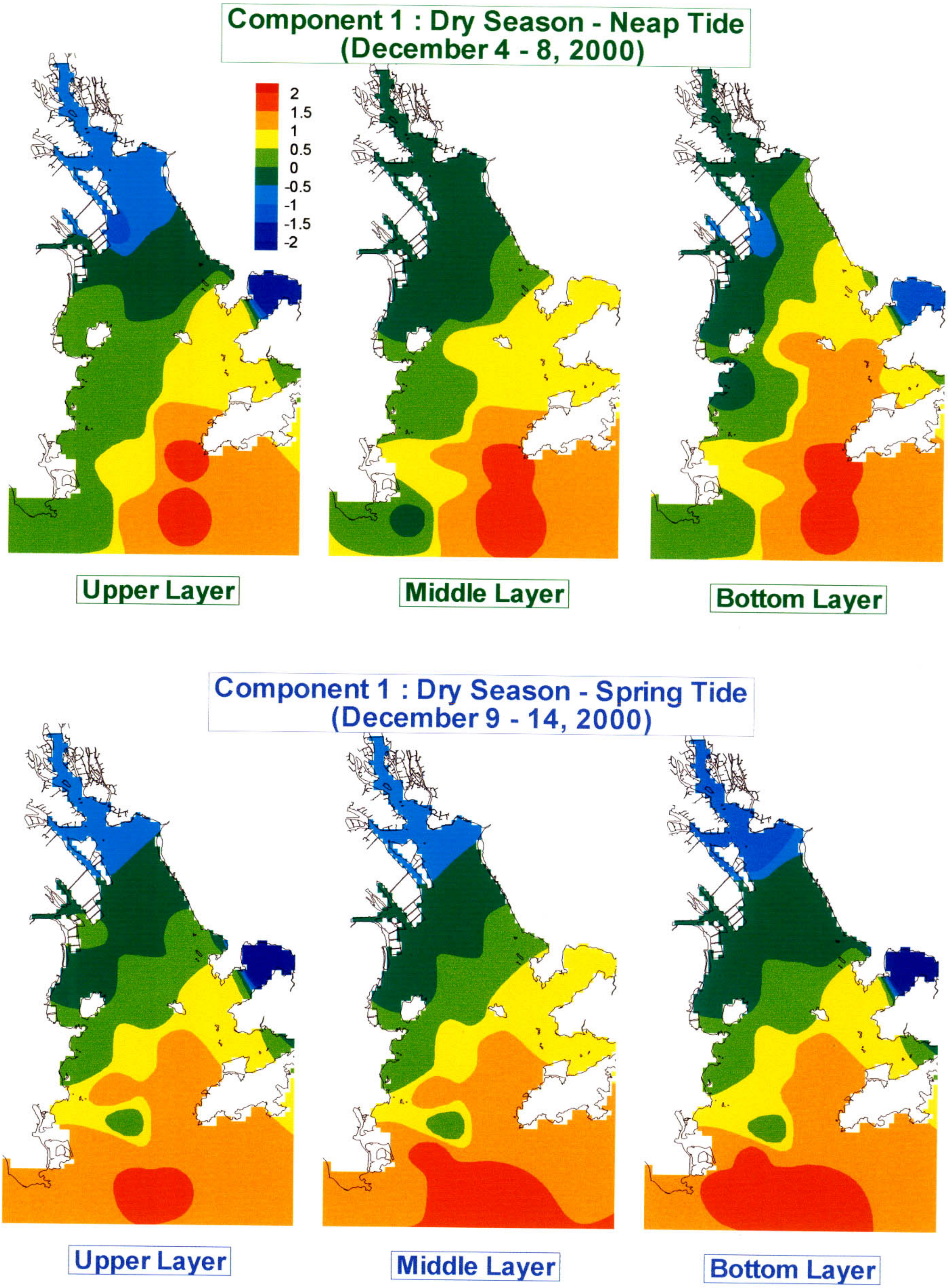


Figure 2.3.3 **Water Quality Multiple Component Analysis**