4. Aquatic Biota

4.1. Overview of Existing Information

Because of industrial development and increasing population, marine water pollution has been an issue in the Pearl River Estuary and its surrounding area. Consequently, the investigation of water quality and the ecosystem in the Pearl River Estuary has been initiated since the 1980s, and the state of environment in this area is gradually being clarified.

With the advancing eutrophication in the Pearl River Estuary and adjacent waters, phytoplankton blooms and red tides have increased since the 1980's. Many studies on red tides have been carried out since that time.

Red tide organisms in the Pearl River estuary include up to 98 species of phytoplankton, including toxic and harmful species (Qian and Liang, 1999).

Red tides were reported in the Pearl River Estuary 53 times from 1981 to 1992, excluding the Hong Kong area, but because the red tide information network has still not been constructed, more case studies on red tides are expected. (Qian and Liang, 1999)

The characteristics of red tides that occurred in Guangdong Province, including the Pearl River Estuary, in recent years are as follows (Qian, 2000).

- Increase in the number of species of red tide organisms
- Occurrences in the cage cultivation areas
- Frequent occurrences in the period from March to June, when the wind direction changes in the monsoon season

Red tides occur most frequently in Dapeng Bay in the Pearl River Estuary and its near waters. As cultivation of fish and shells is prospering in Dapeng Bay, it is considered that red tides are caused by water pollution due to the excretion of cultivated fish and shells, and the leftover from feedings. In the second half of the 1990's, a red tide of Haptophyceae (*Phaeocystis*), which had previously only been reported in Europe, occurred on the southeastern area of the coast in China. The red tide caused extensive damage to the fisheries industry (Shen et al., 2000).

A characteristic of the marine environment in the Pearl River Estuary is that nutrients flow into Pearl River more in the rainy season than in the dry season. There are seasonal variations in phytoplankton biomass and species composition. (Huang et al., 1997).

Primary productivity is higher in the dry season than in the rainy season, and so the same trend occurs for secondary productivity. Secondary productivity increases with the amount of plankton carried into the estuary by pelagic waters.

However, because primary productivity depends on the concentration of nutrients supplied by Pearl River, it is considered that the primary and secondary productions in the Pearl River Estuary are influenced by the relationship between the outflow of nutrients through the Pearl River and the oceanic water. (Huang et al., 1994).

The ecological distribution of marine zooplankton in this estuary was studied from 1991 to 1992. A total of 57 species of marine zooplankton were identified. Copepoda, represented by 28 species, was the most important group of the zooplankton in terms of both species diversity and abundance.

Common zooplankton species included *Acartia spinicauda*, *Calanus sinicus*, *Eucalanus subcrassus*, and *Labidocera euchaeta*. Other important groups included Scyphozoa and Chaetognatha.

The distribution of marine zooplankton showed seasonal and spatial variations in abundance, biomass and species composition. Abundance and biomass were highest in January and lowest in March and June. Seasonal variations in spatial distribution and species composition of marine zooplankton were mainly brought about by seasonal changes in water temperature and discharge from the Pearl River (Fu et al., 1994).

A survey of the benthos in the Pearl River Estuary by Zhou et al. (1990) identified recorded 67 genera and 130 species, mainly consisting of Bivalva, Gastropoda and *Balanus*, and belonging to India-West Pacific tropical and subtropical types. The overwhelming majority were nearshore brackish saline water species, living in intertidal to shallow water areas or in the brackish water of a river mouth.

Generally the ecological distribution of the benthos corresponds to environmental factors such as water temperature, salinity, water depth, bottom sediments, and hydrological condition.

The benthos in this area have a close relationship with salinity, water depth and sedimentation rate; that is to say, species are monotonous and in small numbers near a river mouth, increasing in number gradually with distance from river mouth, and become abundant in shallow sea areas (Zhou et al., 1990).

4.2. The Aquatic Biota Monitoring Program

The survey results from rainy, dry, and transient seasons are summarized below.

4.2.1. Chlorophyll-a

The average values of chlorophyll-a through the entire study area are shown in Table 4.2.1.

Table 4.2.1. Average Chlorophyll-a Concentration

(Unit: mg/m^3)

Season	Layer / Tide	Upper	Middle	Bottom	Overall
Rainy	Spring	3.5	3.3	2.8	3.3
	Neap	13.6	7.6	3.9	8.5
Dry	Spring	4.2	4.3	3.8	4.1
	Neap	1.8	1.7	1.4	1.7
Transient	Neap	6.9	4.2	2.9	4.6

The highest value obtained at the neap tide in the rainy season resulted from the effect of the offshore water with a very high chlorophyll-a concentration.

Horizontally, chlorophyll-a concentrations were higher outside the bay than in the estuary in both the rainy and dry seasons, although in the river mouth area, high concentrations occurred, probably due to the inflow of the freshwater phytoplankton. In the transient (spring) season, however, the horizontal distribution pattern changed, showing the chlorophyll-a abundant area in the estuary. In this season, it is possible that increasing water temperature and a lower diffusion effect by freshwater, due to less precipitation, accelerated the photosynthesis of the phytoplankton. There was little seasonal variation of chlorophyll-a concentrations in Shenzhen Bay. Levels in the bay were constantly high, probably because of the rich nutrient loads from the land and enclosed topography.

In contrast to the rainy and dry seasons, high concentrations of chlorophyll-a were recorded inside the estuary in the transient season. This was probably due to the high productivity of phytoplankton in the estuary, can be explained as follows. High concentrations of nutrients flow into the estuary in the transient season, because temperatures are relatively high but the rainy season has not yet started, and so the nutrients are not diluted by rain and runoff. This high concentration of nutrients is a rich food source for phytoplankton.

In summary, the distribution pattern of chlorophyll-a is probably affected by the supply of nutrients and freshwater plankton from the river and the dynamics of phytoplankton brought from outside the bay.

4.2.2. Coliforms

The average values of coliforms obtained by surveys show little seasonal difference, and are summarized in Table 4.2.2.

Table 4.2.2. Average number of Coliform Bacteria in each Season

(Unit: ind./1,000cm^3)

Layer / Season	Upper	Middle	Bottom
Rainy	173	265	213
Dry	161		193
Transient	143		156

There was a high abundance of coliform bacteria at stations P22 and P23 in the bay mouth area in the rainy season, and at stations in Shenzhen Bay in the dry and transient seasons, which exceeded the Chinese environmental criteria of 2,000 inds./cm^3. The number of coliforms in Shenzhen Bay remained at a high level across seasons, occasionally exceeding the environmental criteria, due to its enclosed topography and excess pollution loads. In the estuary, on the other hand, it is likely that rapid currents prevented bacteria from being constantly abundant.

4.2.3. Zooplankton

The numbers of zooplankton species were 123, 130 and 108 in the rainy, dry and transient seasons respectively, while individual numbers counted were an average of 13,000 ind./m^3, 8,900 ind./m^3 and 5,000 ind./m^3 during the same respective surveys. The differences in he counts might not be just a function of seasonal variation, because a different type of gauze was employed in rainy season (mesh opening of 168μm) from dry and transient seasons (mesh size 77μm).

In the rainy season, individual numbers were abundant in the central part of the estuary, where salinity was at an transient range between the river mouth areas and the open sea. In the dry season, numbers were generally less than that in the rainy season. The distribution of individual numbers in the dry season did not reveal any relationship with that of salinity. The transient season showed an even lower abundance of zooplankton, which were dominated by the dinoflagellate *Noctiluca scintillans,* with abundance of 10^3 – 10^5 ind./m^3 at every survey point. This species may have affected the zooplankton population through competitive grazing on phytoplankton, which many other zooplankton species feed on.

The principal zooplankton species in the Pearl River Estuary are shown in Table 4.2.3.

Table 4.2.3. Principal Zooplankton Species

Rainy season	*Acartia spinicauda, Acartiella sinensis, Paracalanus crassirostris, Schamackeria poplesia, Evadne tergesina*
Dry season	*Acartiella sinensis, Paracalanus aculeatus, Paracalanus crassirostris*
Transient	*Paracalanus crassirostris* (except *Noctiluca scintillans*)

Note: Species comprising 20% or more of all individuals are classified as principal species

The above species all belong to Copepoda except for *Evadne tergestina*, which belongs to the Cladocera. The only principal species that was common to the three survey seasons was *Paracalanus crassirostris*, which was distributed in low salinity areas and seemed to be well adapted to the study area.

4.2.4. Phytoplankton

The numbers of phytoplankton species in the survey area were 156 in the rainy season, 137 in the dry season and 234 in the transient season. The average numbers of cells found within the different sampling layers are shown in Table 4.2.4.

Table 4.2.4 Average Numbers of Cells within Different Layers

(Unit: cell/L)

Layer / Season	Upper	Middle	Bottom
Rainy	200,000	57,000	151,000
Dry	85,000	104,000	118,000
Transient	1040,000	426,000	727,000

The average numbers of cells were greater in the rainy season than the dry season. However, this result is due to the unusually high numbers of phytoplankton collected in the rainy season at P10 inside Shenzhen Bay. When the results of P10 are excluded, the average numbers of cells is greater in the dry season than in the rainy season (See Table 4.2.5.).

Table 4.2.5 Average Numbers of Cells excluding P10

(Unit: cell/L)

Layer / Season	Upper	Middle	Bottom
Rainy	37,000	57,000	37,000
Dry	84,000	104,000	116,000

The results are likely to be due to the dilution effect of the river water. According to the survey conducted in the Pearl River Estuary from 1987- 1993 by Huang et al. (1997), phytoplankton numbers were greater in the dry season than the wet season, which supports our this modified result.

In summer, the vertical distribution of phytoplankton was highly variable, due to the stratification of the water column. However, in this survey there was no significant difference in phytoplankton abundance between the layers, probably because the survey was conducted during the spring tide when strong tidal movement enhanced vertical mixing.

The number of cells in the transient season was much greater than the other seasons. This was due to the proliferation of the diatom *Skeletonema costatum* in the survey area, which thrives in closed sea areas.

A combination of environmental factors during the transition period between the dry and wet seasons must have caused the increase of *Skeletonema costatum.* During this period, the sea area became stagnant due to the rise in water temperature and reduction in river inflow (less dilution effect), favoring *Skeletonema costatum* growth. Furthermore, the survey was conducted during neap tide, a period of little water movement.

Principal species observed in the survey area are shown in Table 4.2.6.

Table 4.2.6 Principal Species of Phytoplankton

Rainy	*Chaetoceros curvisetus, Cyclotella* sp., *Fragilaria* sp., *Leptocylindrus danicus, Melosira granulata, Nitzschia delicatissima, Nitzschia pungens, Skeletonema costatum, Thalassiosira* sp., Micro-flagellates
Dry	*Cerataulina bergonii, Chaetoceros curvisetus, Chaetoceros lorenzianus, Chaetoceros pseudocurvisetus, Chaetoceros sociale, Cyclotella* sp., *Melosira granulata, Nitzschia delicatissima, Skeletonema costatum, Thalassiosira* sp., microflagellates
Transient	*Skeletonema costatum, Chaetoceros socialis*

Note: Species comprising 20% or more of all individuals are classified as principal species

The main species were Bacillariophyta (diatoms) except for microflagellates. Most of the principal species were observed in approximately equal abundance in the rainy, dry and transient seasons.

During the rainy and transient seasons, freshwater phytoplankton were observed in the central area of the survey area, and during the dry season they were observed in the north and north-eastern areas. Therefore, the range of river discharge could be deduced through the monitoring of these freshwater species.
During the field survey in the transient season, bands of colored stripes were observed over a wide area in the northern half of the survey area. From sample analyses, the coloration was found to be formed by the diatom *Skeletonema costatum.* (See Figure 4.2.1 to 4.2.6)

Approximately 12,000 cells/L of *Skeletonema costatum* were counted in one sample. Sampling was not restricted to the colored area, thus cell count in the colored area could be greater than the above figures.

Red tides mainly occur when the following conditions are met.

- When red tide-inducing plankton exist in the water column or in the bottom sediment as dormant cells
- When physical factors, such as water temperature, salinity and light levels become suitable for phytoplankton germination and growth
- When nutrients for phytoplankton are abundant.
- When several of the ideal conditions are sustained for a certain period (2-10 days).

The *Skeletonema costatum* bloom observed in the transient season probably occurred by satisfying all of the above conditions.

In the Pearl River Estuary and in the surrounding sea area, reports of red tides are increasing, due to the deterioration of water quality (Qian and Liang, 1999). However, reports of red tides in the inner bay of Pearl River Estuary are scarce. Also, red in the Pearl River Estuary are mainly caused by diatom bloom, which have little negative impacts on fisheries.

The inflow of nutrients into the Pearl River Estuary is abundant, due to discharge from Pearl River and other rivers, and many red tide-inducing species have been confirmed in the area. However, the sea area and critical time period for red tide occurrence is very restricted in Pearl River Estuary, because of the large river inflow and the strong tidal currents. When analyzing the eutrophication level of Pearl River Estuary, from the perspective of phytoplankton abundance, the number of cells during both the rainy and dry seasons were 10^1-10^2 cells/ml, which is considerably less than the eutrophication level (10^3 cells/ml) observed in some inner bays in Japan. Thus, the level of eutrophication in Pearl River Estuary is not yet in a serious situation.

4.2.5. Benthos

The composition of benthic community was 79 species in the rainy season (Mollusca: 29, Annelida: 24, Arthropoda: 15, Echinodermata: 4, others: 7); 78 species in the dry season (Mollusca: 35, Annelida: 21, Arthropoda: 15, Echinodermata: 3, others: 4); and 87 species in the transient season (Mollusca: 42, Annelida: 16, Arthropoda: 16, Echinodermata: 3, others: 7). The diversity and abundance of species were similar for the rainy and dry seasons. Because most of the benthos were marine species, few of them were identified in the low salinity area. Therefore, the distribution tendency was the same in both seasons. No difference in species composition at each survey point was recognized.

Averages of the number of individuals and their wet weight are shown in Table 4.2.7.

Table 4.2.7. Average Number and Wet Weight of Benthic Organisms

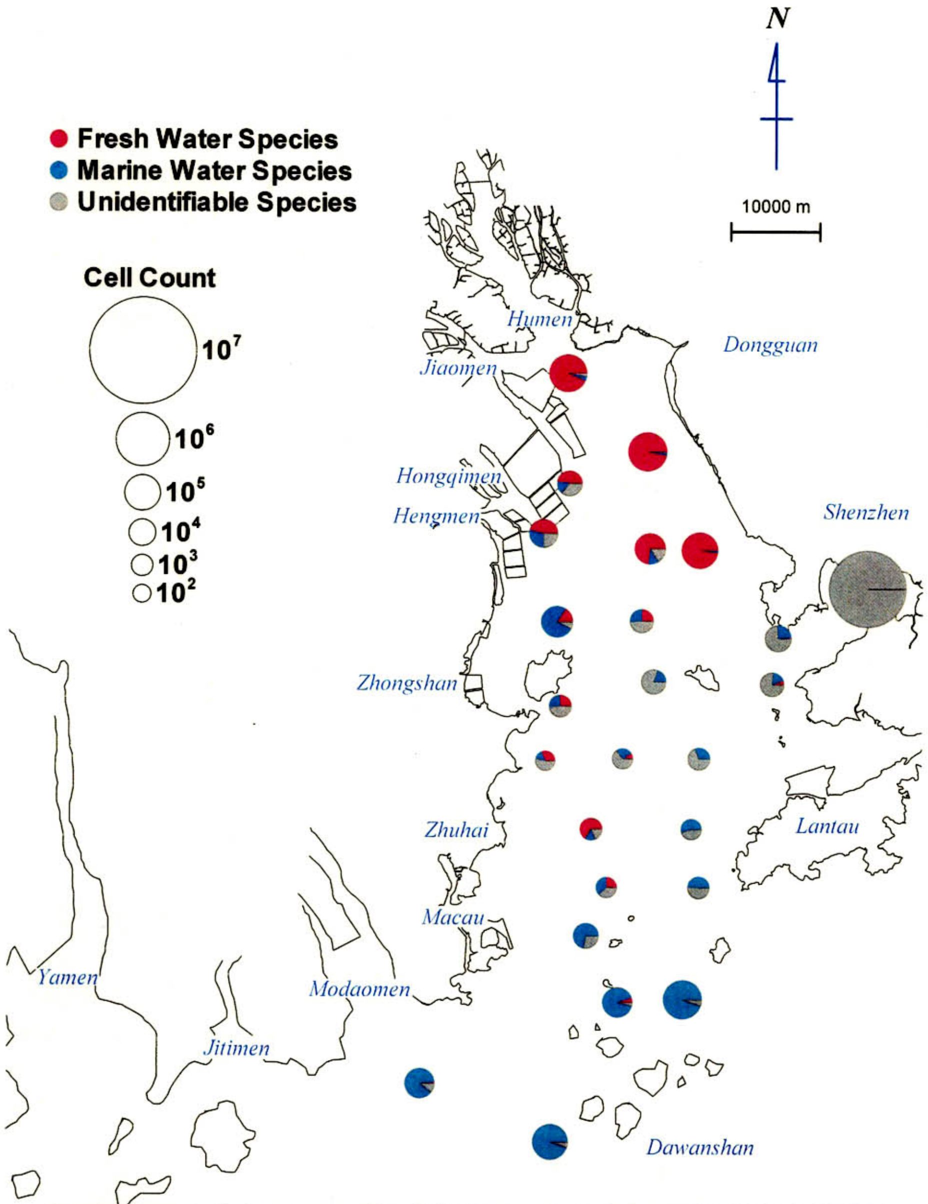
Season	Number of individuals (ind/m^2)	Wet weight (g/m^2)
Rainy	2,165	91
Dry	1,007	123
Transient	854	175

The number of individuals was greatest in the rainy season, then the dry season and least in the transient season. On the other hand, wet weight shows the opposite trend with the lowest value in the rainy season.

A large number of *Potamocorbula laevis,* (Bivalva), which is categorized as a brackish species, Bivalva, were found in all three seasons. Therefore *Potamocorbula laevis* was a important component of the benthic community.

While the average number of individuals was higher in the rainy season than in the dry season, the wet weight was higher in the dry season than in the rainy season. This is probably because *Potamocorbula laevis* grew and increased their wet weight per individual, but they were predated and, consequently, the number of individuals decreased in the growth process.

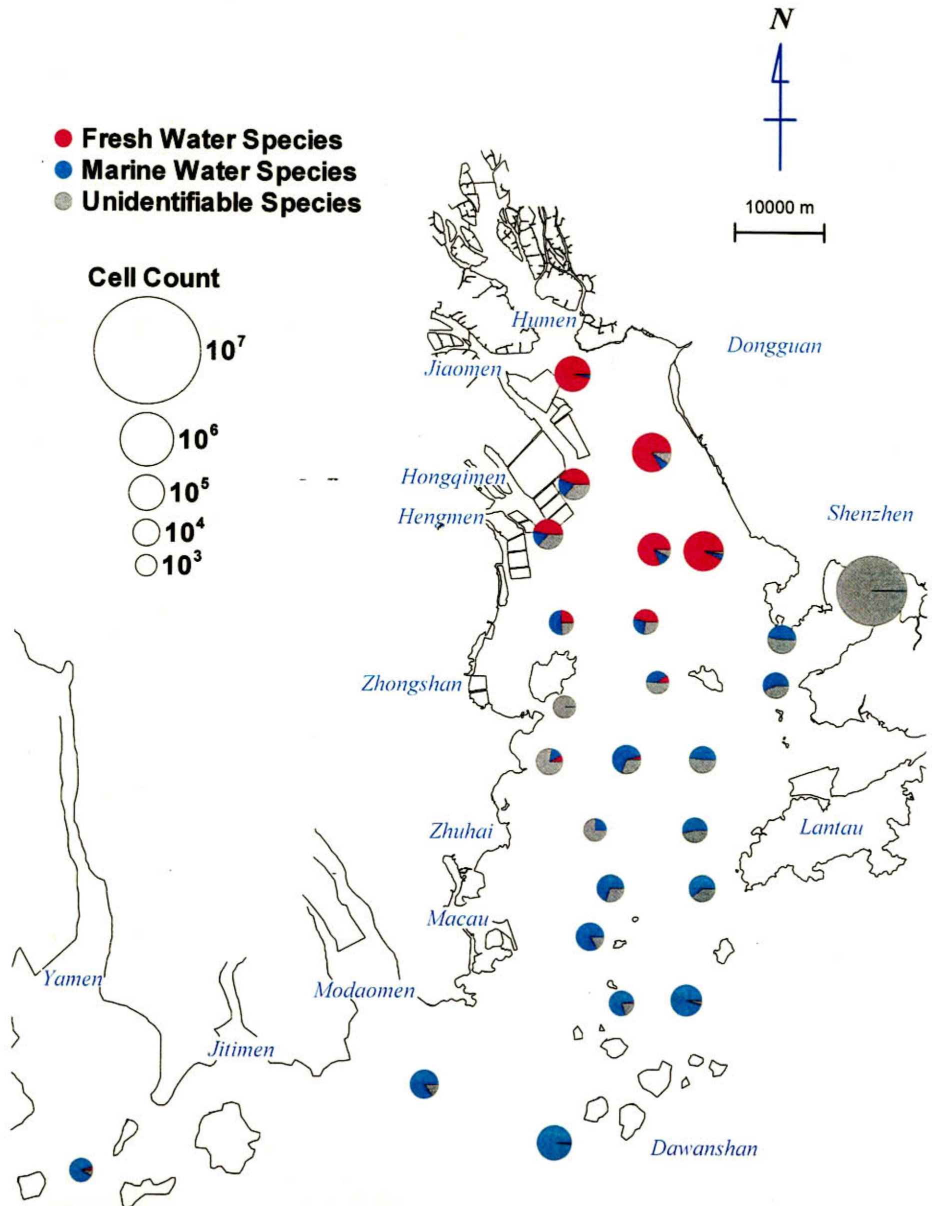
The biomass and species composition of the benthos was poor in the northern and western part of the Pearl River Estuary. This trend was especially evident in the rainy season. However, survey data on the bottom sediment did not reveal any signs of severe pollution, which might threaten the survival of the benthic community. The reason for the poor benthic fauna in the northern and western parts of the survey area may be caused by the unstable habitat condition that varies with the fluctuation of freshwater discharge, salinity and current velocity.



Composition of Phyto Plankton Species : Upper Layer

Figure 4.2.1 Rainy Season Phytoplankton Survey Results

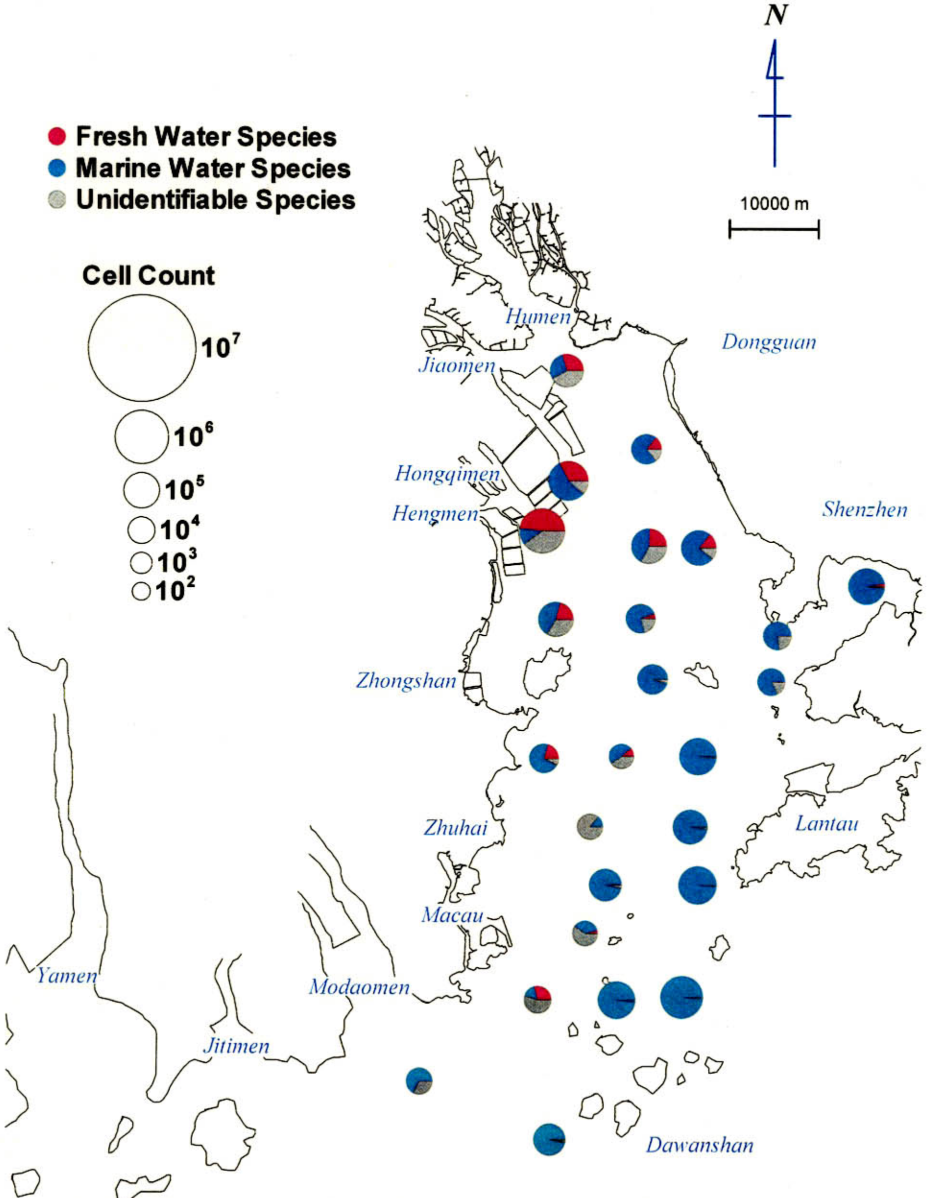
July 31 - August 10, 2000



Composition of Phyto Plankton Species : Bottom Layer

Figure 4.2.2 Rainy Season Phytoplankton Survey Results

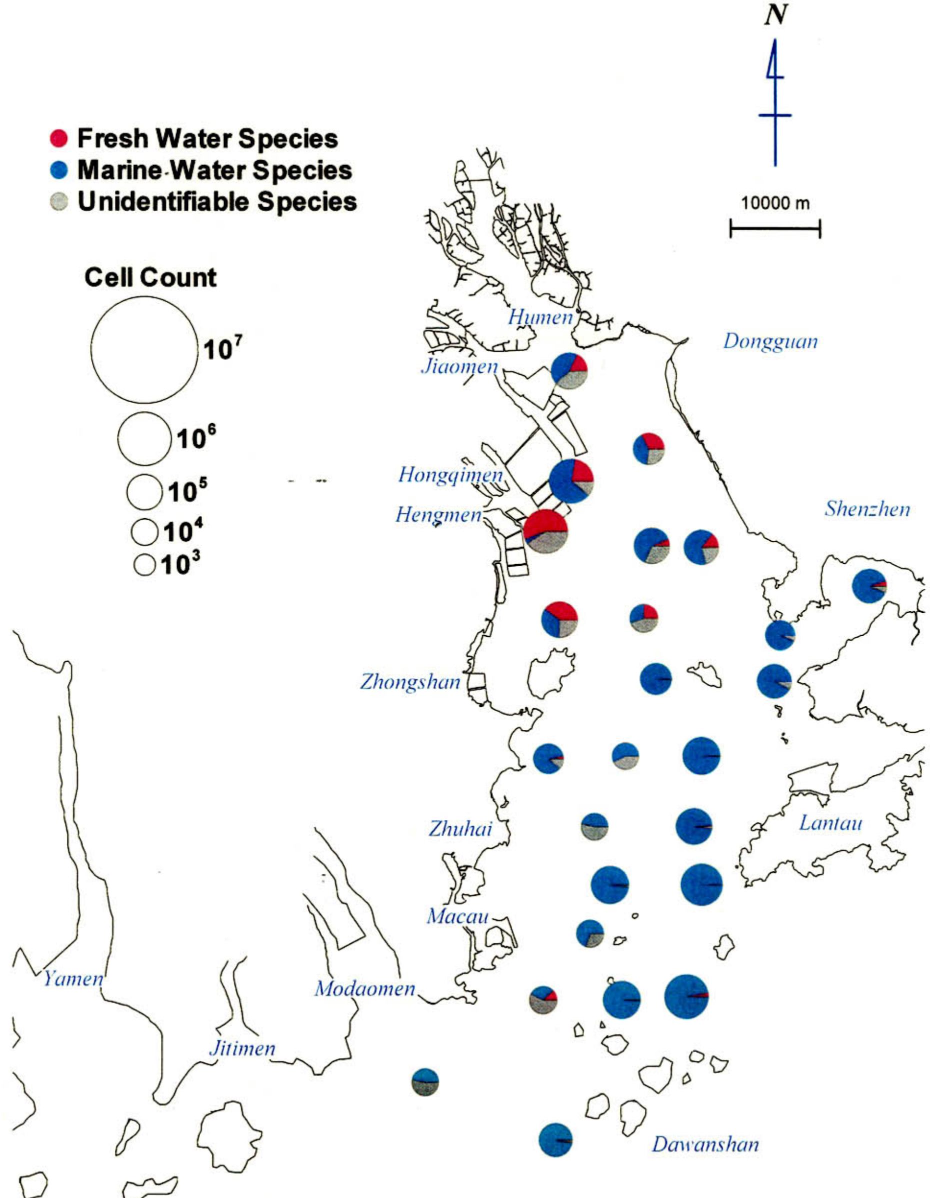
July 31 - August 10, 2000



Composition of Phyto Plankton Species : Upper Layer

Figure 4.2.3 Dry Season Phytoplankton Survey Results

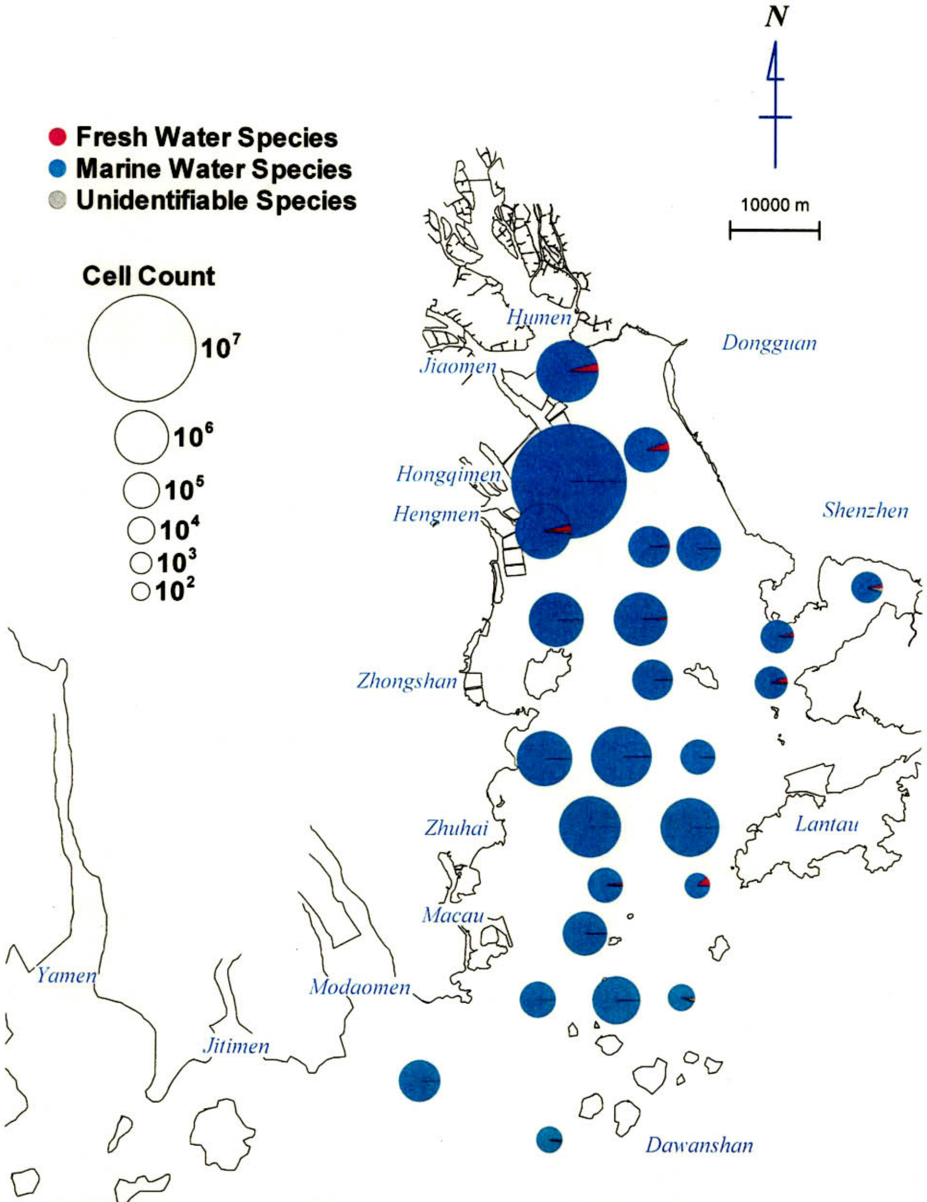
December 4 - 14, 2000



Composition of Phyto Plankton Species : Bottom Layer

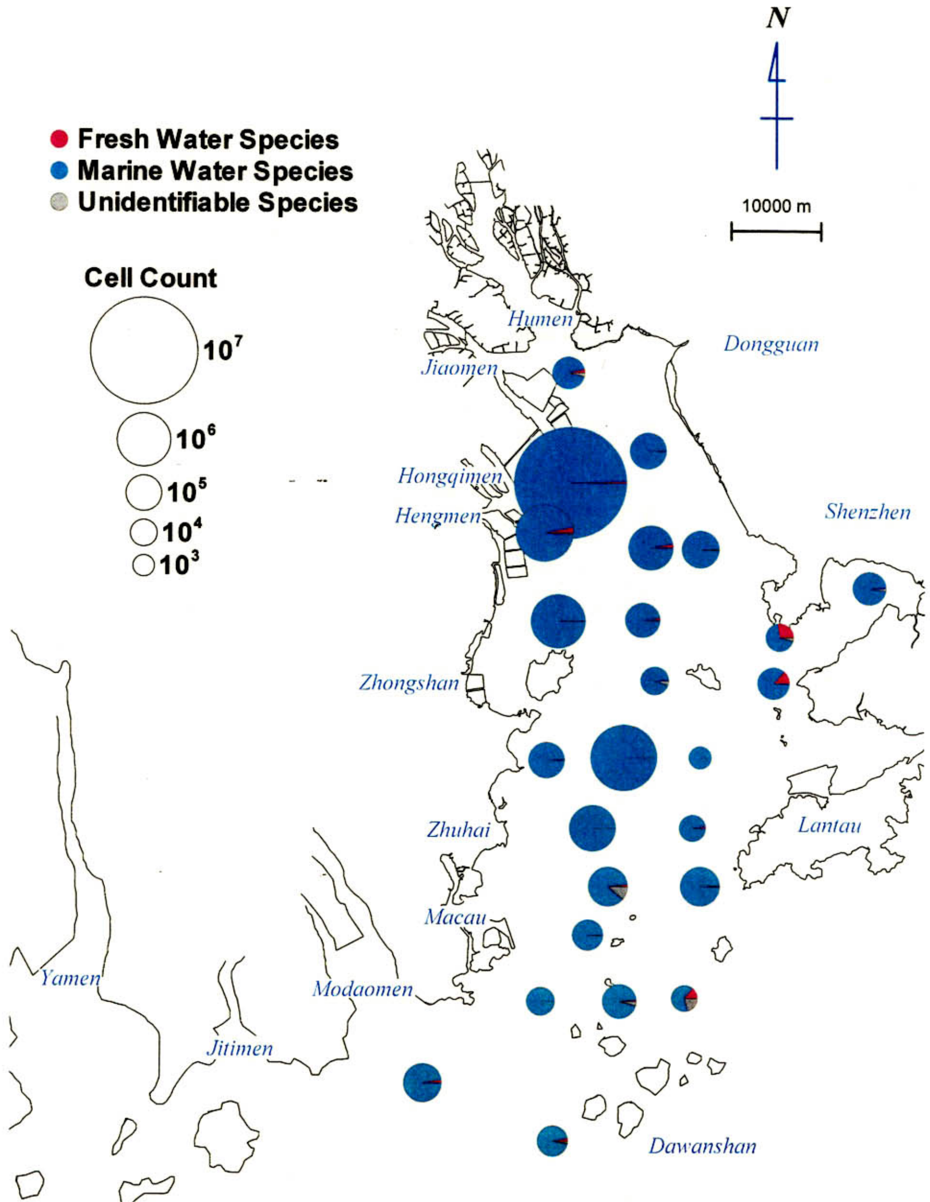
Figure 4.2.4 Dry Season Phytoplankton Survey Results

December 4 - 14, 2000



Composition of Phyto Plankton Species : Upper Layer

Figure 4.2.5 Transient Season Phytoplankton Survey Results
March 4 - 7, 2001



Composition of Phyto Plankton Species : Bottom Layer

Figure 4.2.6 Transient Season Phytoplankton Survey Results
March 4 - 7, 2001

5. Settling Rate, Decomposition, Primary Production, and Elution

In the Pearl River Estuary, where seawater is constantly mixed with freshwater, silt and clay particles are carried by riverwater, suspended above the sea bottom, and transported by tidal currents and turbulence. The nutrients contained in the water undergo various processes, such as advection, dispersion, settling and sedimentation of suspended particles, uptake in the food chain of marine biota, decomposition by bacteria, primary production by phytoplankton, mineralization, and elution of nutrients in inorganic forms from bottom sediment.

In order to construct a water quality simulation model of the Estuary, each reaction process involved in the cycle needs to be formulated and quantified.

In the survey, four key parameters that represent the nutrient cycle were experimentally investigated as described below.

5.1. Settling Rate

Numerous and various types of suspended particles are present in estuarine waters, such as zooplankton, phytoplankton, bacteria, detritus, and soil particles (silt and clay). Those suspended particles settle slowly and pile up on the bottom sediment. Particulate organic carbon, nitrogen, phosphorus, etc. that are present in seawater shift to the bottom sediment in this process. This portion of the nutrient cycle is considered as a key factor in the development of a water quality simulation model. Since the settlement rate of suspended particles is strictly a site-specific parameter, experimental determination is necessary.

The result of the settling experiment is shown in Table 5.1.1. Settling rates are very small.

Considering the high-speed tidal current conditions in the estuary, settling is unlikely to occur very much except in areas where tidal current speed is stable and low, such as in Shenzhen Bay.

Table 5.1.1. Settling Rate

(Unit: $mg/m^2/day$)

Item / Point	SS	N	P	C
P01	2.5	0.28	0.21	43
P12	0.0	0.00	0.00	0.00
P20	2.6	0.23	0.22	46

5.2. Decomposition Rate

Organic matter, in particulate or dissolved forms, constantly undergoes decomposition by bacteria in seawater, and this decreases the amount of available organic matter. In this process, the nitrogen and phosphorus contained in organic matter mineralizes at the same time. Mineralized nitrogen and phosphorus are reused for uptake in primary productivity by phytoplankton.

The processes in which organic matter is decomposed and nutrients are mineralized were investigated in the experiment.

Decomposition rates were estimated by the least square method, as shown in Table 5.2.1. Rates were small, perhaps because the organic matter content was not very large.

Table 5.2.1. Decomposition Rate

Point	COD_{JPN}	NH_3-N	NO_2-N	NO_3-N	IN	PO_4-P
	mg/L/day	mg/m^3/day	Mg/m^3/day	Mg/m^3/day	mg/m^3/day	mg/m^3/day
P01	-0.16	-0.6	8.7	0.0	8.1	-0.50
P12	-0.15	2.4	0.9	0.0	3.3	0.04
P20	-0.14	-0.9	4.0	0.0	3.1	-0.20

5.3. Primary Production (AGP Test: Algae Growth Potential Test)

When nutrient concentrations and the intensity of solar radiation are sufficient, phytoplankton photosynthesize, increasing the quantity of particulate organic matter (so-called primary production) that supports the base of the oceanic food chain.

Out of several kinds of methods for studying primary production, such as the dissolved oxygen method, isotope carbon method, AGP, etc., the primary production in this study was measured by AGP. The quantity and rate of cell proliferation by phytoplankton obtained by AGP are considered to be a governing parameter of primary production. Primary production was calculated by AGP as shown in Table 5.3.1.

The amount of primary production was estimated from the concentration of chlorophyll-a on the fifth day and C:N:P:Chl-a ratio (240 : 87 : 6 : 8) proposed by Strickland (1960). The amount of growth was largest at the P20 station, located at the bay mouth area.

Table 5.3.1 Primary Production

(Unit: mg/m^3/day)

Case No.		C	Chl-a	I-N	PO_4-P	Chl-a
P01	500lux.	0.1	0.004	-0.04	-0.003	0.00
	4000lux.	40.7	1.4	-14.8	-1.02	1.4
P12	500lux.	0.2	0.006	-0.07	-0.005	0.01
	4000lux.	16.6	0.6	-6.0	-0.42	0.55
P20	500lux.	0.2	0.008	-0.09	-0.006	0.01
	4000lux.	141	4.7	-51.0	-3.52	4.7

5.4. Elution Rate

The bottom sediment in the estuary contains a significant quantity of organic matters. Mineralized nitrogen, phosphorus and some of the organic matter are released from the bottom sediment to the overlying water because of biological processes. A Ferric phosphorus compound is released chemically from the bottom sediment when the oxidation-reduction potential is low due to low DO concentration.

This phenomenon, i.e., the process by which the nutrients are transferred from the bottom sediment to the bottom layer of water, is called elution.

Since elution is also a governing site-specific factor in the nutrient cycle of local waters, experimental determination is important.

Elution rates were estimated by the least square method as shown in Table 5.4.1. The amount of elution from the bottom sediment was very small. Thus, its influence on water quality of the bottom or lower layer was small.

Table 5.4.1 Elution Rate

(Unit: $mg/m^2/day$)

Item / Point	COD_{JPN}	NH_3-N	NO_2-N	NO_3-N	IN	PO_4-P
P01	5.52	1.70	-10.6	22.3	13.4	0.71
P12	122	1.30	2.03	14.4	17.7	0.53
P20	78.8	6.86	0.29	4.65	11.8	1.29

6. Water Pollution Mechanisms

With the exception of Shenzhen Bay, the Pearl River Estuary, in short, can be characterized by its shallowness, averaging only 5 m in depth, and strong tidal influence, and by the large quantity of freshwater inflow. The annual freshwater runoff exceeds $1.8\text{x}10^{11}$ m^3 through the four major outlets of the Pearl River system. The majority of the pollutant load is attributable to the river inflow covering the vast expanse of a densely populated and industrialized drainage basin. The basin carries approximately $4\text{x}10^5$ tons/year COD_{MN}, $4\text{x}10^5$ tons/year T-N, $1\text{x}10^4$ tons/year T-P , and over $3\text{x}10^7$ tons/year of sediment into the shallow estuary. At the same time, the tidal water exchange magnified by the shallow depth is very significant in shaping of the estuarine water quality. For example, for a tidal range of 1.0 m, conservatively averaged over the space and tidal cycles, it is estimated that approximately 40 % of the estuarine water is exchanged during a 24-hour period by the tidal flushing alone.

As a combined result of high tidal flushing rate and strong river through-flow, the detention time of water in the estuary is very short: on the order of few days. Consequently, the pollutant load does not accumulate in the basin and DO levels in the estuary remain higher than would normally be expected from the extent of the organic load. Similarly, no significant oxygen depletion takes place in the bottom sediment as evidenced by the positive red-ox potentials observed throughout the basin.

The unusually low level of primary production found in the estuary is evidently attributable to the short retention time resulting from the enhanced tidal exchange and river through-flow. Without going into detail, the dependence of primary production on detention time can be readily conceptualized by considering the following simple mass balance model in which a first-order growth kinetics is assumed for a typical phytoplankton specie:

$$\frac{dC}{dt} = GC - \frac{Q_r}{V}C + \frac{Q_t}{V}\alpha C - \frac{Q_t}{V}C + \frac{Q_r}{V}C_r$$

in which C is the phytoplankton concentration, t the time, G the net growth rate, Q_r the freshwater through-flow rate, V the average volume of the estuary, Q_t the mean tidal counter flow, α the dilution factor as a fraction of C, and C_r the phytoplankton concentration in the river freshwater. Ignoring C_r and defining $\beta = 1 - \alpha$, it yields

$$\frac{dC}{dt} = \left\{G - \frac{1}{V}\left(Q_r + Q_t\beta\right)\right\}C$$

for which the solution is

$$C = C_o \exp\left\{\left[G - \frac{1}{V}\left(Q_r + \beta Q_t\right)\right]\cdot t\right\}$$

in which C_0 is the initial concentration in the estuary. It can be seen in the above expression that the flushing rates (Q_r and Q_t) counteract the growth rate, thus suppressing the net in-situ primary production.

In addition, the huge quantity of freshwater inflow combined with the strong tidal exchange produces an unstable salinity level in the estuary, and phytoplankton species in the basin are constantly alternating from freshwater origin to seawater origin, further impeding the in-situ primary production despite the abundance of dissolved nutrients. The exceptionally high turbidity in the basin, reaching 800 FTU in the rainy season, is also unfavorable for plankton growth.

Overall, these factors jointly indicate that the estuary is biologically unproductive and its water quality is primarily governed by transport phenomena. Enhanced biochemical reactions, so commonly associated with typical estuarine bays elsewhere in the world, do not flourish in this estuary. The fate of conservative pollutants such as heavy metals can be inferred analogously: they are flushed to the outer sea without significant accumulation. In other words, the water quality of the Pearl River Estuary should immediately and almost linearly respond to load-reduction measures taken in the Pearl River drainage basin.

Shenzhen Bay is an anomaly within the Pearl River Estuary. In contrast to elsewhere in the estuary, it has an entirely different water mass exhibiting every sign of a semi-enclosed stagnant coastal basin that receives a high nutrient load. Currents in the bay are weak and the water quality is exemplified by the high levels of phosphorous, nearly 20 times the values found elsewhere in the estuary, as well as by the high chlorophyll-a concentration levels. Despite the moderate level of DO, a likely result of photosynthesis, the redox potential of the bottom sediment is significantly lower than that observed elsewhere in the estuary, suggesting the occurrence of DO depletion in the low-level bay waters.