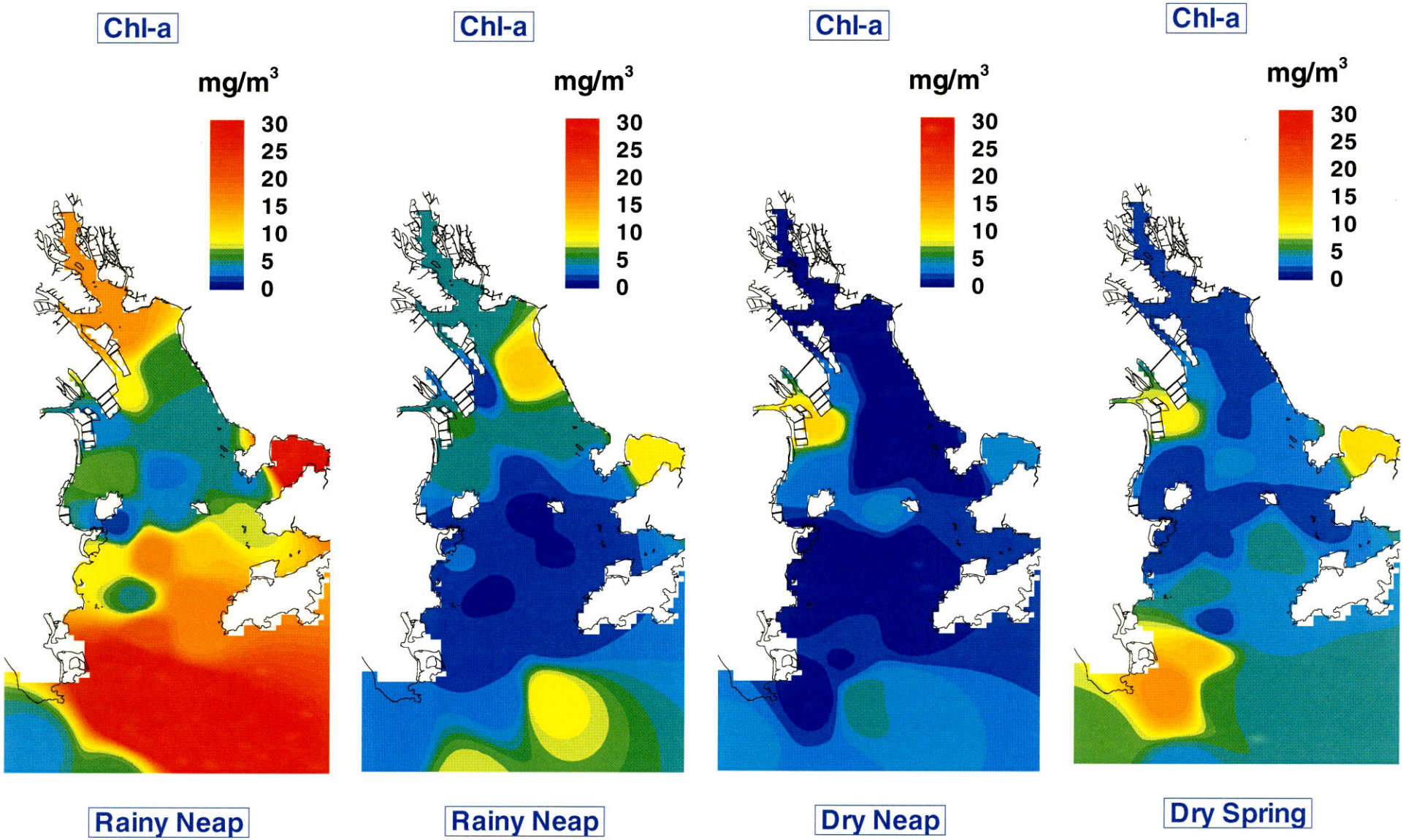


Figure 2.2.10 Chlolophyll-a in the Surface Layer

3. Socioeconomic Profile

The objective of the socioeconomic study was to investigate the present conditions and the prospects of the socioeconomics of the Pearl River Delta region, as well as to identify the data needed for the estimation of possible environmental impacts.

The present study mainly relied on the statistical yearbooks, newspaper reports, and documents for China, Guangdong Province and the cities around Pearl River Estuary.

The economic growth of Guangdong is significant in both secondary and tertiary industry, in contrast to the decline seen in the economies of Southeast Asia during the past few years. Originally, Guangzhou was developed as a trading center in Southeast Asia. Shenzhen and Zhuhai developed rapidly after China adopted a market-oriented economic policy in 1978, and the economic growth of Dongguan recently has been remarkable, particularly in heavy industrial development. The economy in the Pearl River Estuary is characterized as 'light and small- and/or medium-sized industry' and not 'heavy and large-sized industry'.

As far as the environment is concerned, Guangzhou faces problems of river and seawater contamination by domestic wastewater. The discharge of wastewater has been increasing rapidly with the increasing urbanization. The problem in Shenzhen is the water quality degradation of Shenzhen Bay, which is polluted by industrial wastewater. There is not much of an environmental problem in Zhuhai, but the government devotes efforts to maintaining seawater quality because aquaculture has recently developed rapidly in the sea area. In Dongguan, as industrial development has been significant since 1998, precise environmental monitoring is required in the coastal area.

The details of the study results are summarized below.

3.1 Administrative Divisions

Guangdong Province is in the southern part of China, at latitude 20^{O} 09' – 25^{O} 31' N, and longitude 110^{O} 45' – 117^{O} 21' E, and has land borders with Guangxi, Hunan, Jiangxi, and Fujian provinces. To the south lies the South China Sea and Hainan Province. Hong Kong Special Administrative Region (SAR) lies on the eastern part of the Pearl River Estuary, and Macao SAR is on the western side of the same estuary. The total land area of Guangdong is 178,000 km^2, including 1,600 km^2 of islands, and its coastline bordering on the South China Sea is some 2,400 km.

The Pearl River, the fourth largest river system in China, runs through Guangdong. It rises in Yunnan and traverses China for 2,200 km through six provinces, Yunnan, Guizhou, Hunan, Jiangxi and Guangdong, as well as a part of Vietnam, covering a catchment area of about 452,600 km^2. Finally, it flows into the South China Sea forming one of the extensive and most complicated deltaic regions (the Pearl River Estuary Delta) in the world. The Pearl River Estuary Delta extends from latitudes 22^{O} – 24^{O} N, and longitudes 113^{O} – 114^{O} E. The total land area of the cities facing to the Pearl River Estuary, Guangzhou, Shenzhen, Zhuhai, Zhongshan, Foshan, Dongguan and Huizhou, is 30,321 km^2.

Guangdong is one of the provinces of China, and consists of 21 administrative divisions as shown in Figure 3.1.1. Among the divisions, the seven cities in the Pearl River Delta, Guangdong, Shenzhen, Zhuhai, Zhongshan, Foshan, Dongguan and Huizhou, are relatively developed in economic terms. During the Qin Dynasty, Guangzhou was the only open trading port in China. Since then it has developed as a trading center linking Southeast Asia and Europe. After the central government's policy shift towards a more market-oriented economy, Shenzhen and Zhuhai were designated as 'Special Economic Zones', and both cities developed as manufacturing bases linked to Hong Kong and Macao. Following these cities, other cities in the Pearl River Delta showed rather high growth rates compared to other cities in Guangdong. The total land area of the seven cities in the Pearl River Delta is about 3 million hectares, which is 17 % of the area of Guangdong, and the population of the seven cities is about 17 million, which is 24 % of that of Guangdong.

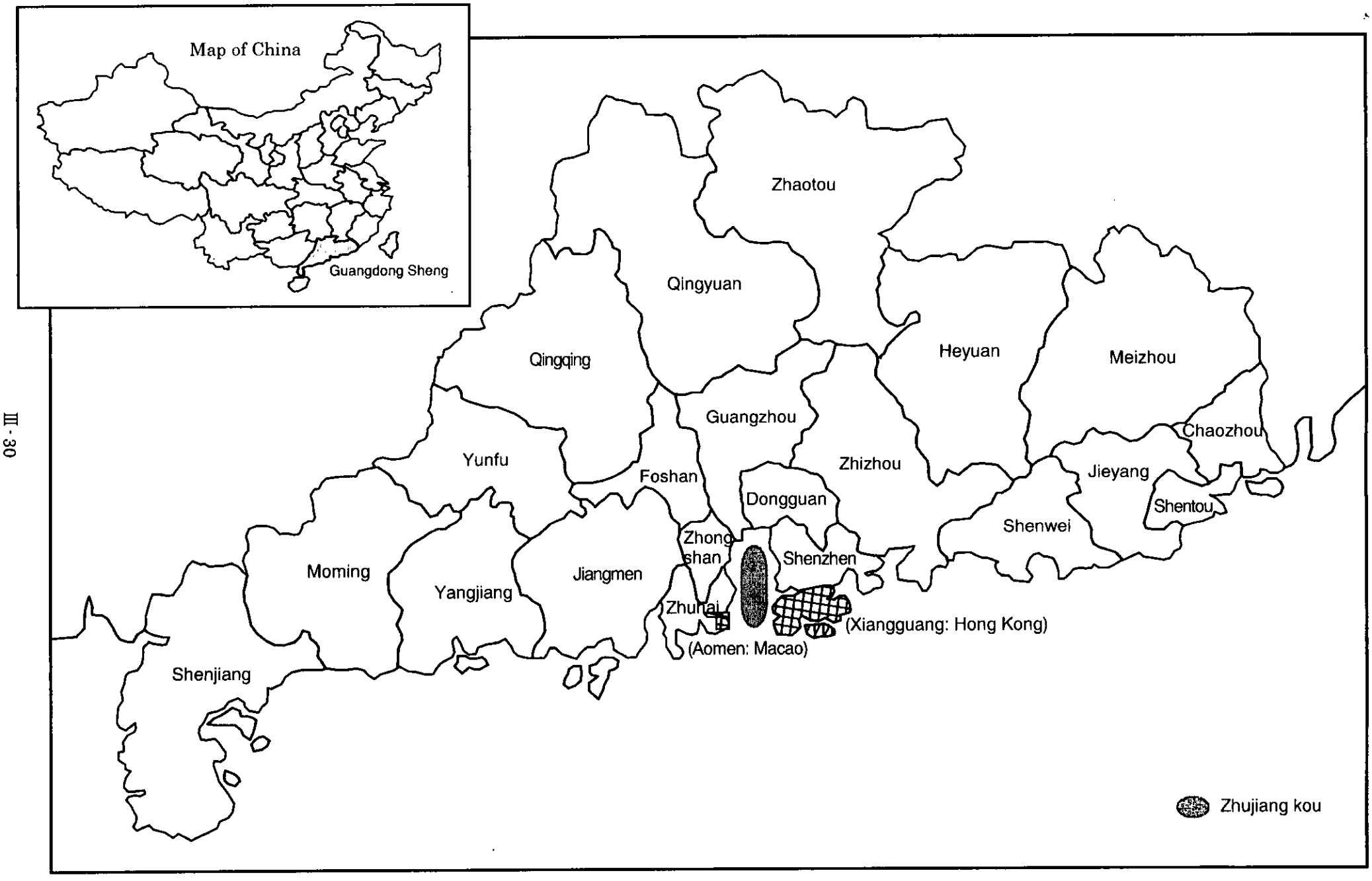


Figure 3.1.1 Administrative Divisions of Guangdong

3.2 Population

The population trends in China and Guangdong are shown in Table 3.2.1 and Figure 3.2.1. The total population in China at the end of 1999 is about 1,259 million. Thirty per cent live in urban areas and 70 % are in rural areas. The annual average rate of increase in the population has declined year by year from 1.55 % in 1985 - 1990 to 0.97 % in 1996 - 1999. The rate in urban areas was 2.54 % in 1996 - 1999, which is much higher than that (0.31 %) of rural areas.

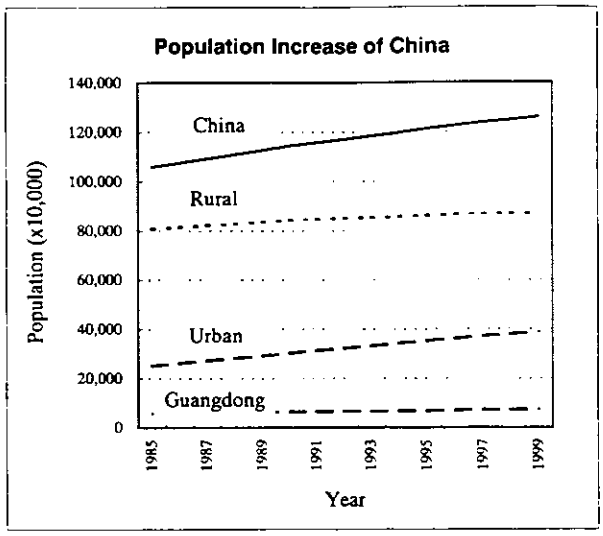
The Guangdong population at the end of 1999 and its recent annual increase rate are about 73 million and 1.83 % respectively. This rate is higher than that (0.97 %) of all China. The population of the seven main cities in the Pearl River Estuary, Guangdong, Shenzhen, Zhuhai, Zhongshan, Foshan, Dongguan and Huizhou, is about 17 million, which is 24 % of that of Guangdong. The increase rate of the population in the seven cities is 1.71 %, which is lower than that of the previous five years, when the economic growth was significant. The rate of Shenzhen and Zhuhai, where the industrial development is remarkable, is still high.

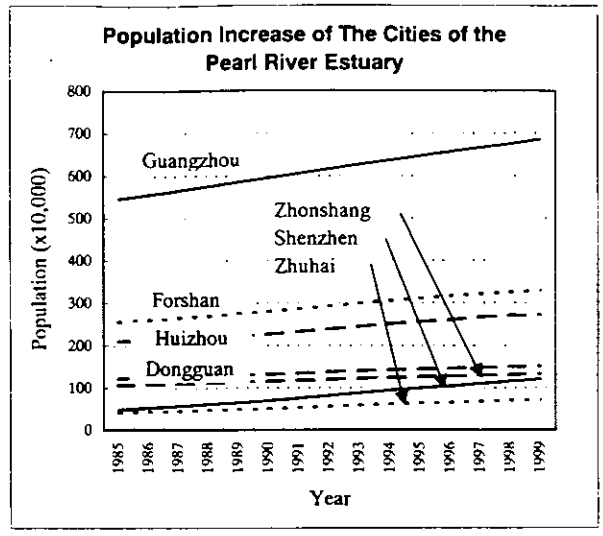
The population in urban area is growing partly by natural increase, but more by migration from rural areas. The population increase in urban areas inevitably causes an increase of wastewater discharges, which affects the quality of river and seawater.

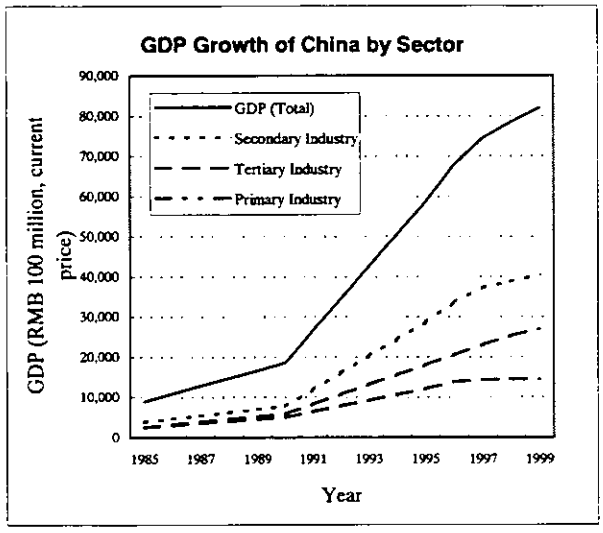
Table 3.2.1 Population by City (Year-end, 10,000 persons)

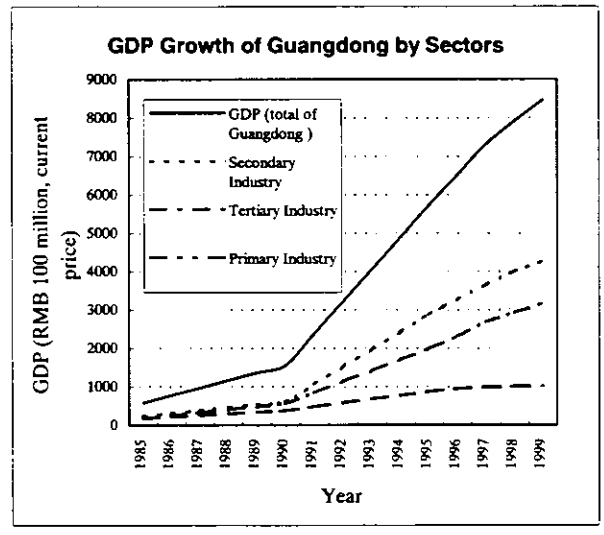
	Aggrerate Data							Average Annual Growth Rate (%)		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Population (year-end;10^4 Persons)										
China	105,851	114,333	121,121	122,389	123,626	124,810	125,909	1.55	1.16	0.97
Urban	25,094	30,191	35,174	35,950	36,989	37,942	38,892	3.77	3.10	2.54
Rural	80,757	84,142	85,947	86,439	86,637	86,868	87,017	0.82	0.43	0.31
Guangdong	5,656	6,246	6,789	6,897	7,014	7,116	7,299	2.01	1.68	1.83
Guangzhou	545	594	647	656	666	674	685	1.75	1.71	1.45
Shenzhen	48	69	99	103	109	115	120	7.48	7.63	4.85
Zhuhai	41	50	63	65	67	69	71	4.07	4.71	3.08
Zhongshan	106	115	125	127	128	130	132	1.63	1.75	1.32
Foshan	255	279	311	316	321	325	329	1.87	2.17	1.43
Dongguan	121	132	144	145	147	149	151	1.76	1.73	1.22
Huizhou	209	226	256	260	267	270	272	1.60	2.50	1.52
Sub-total of the cities around Zhujiang Estuary	1,324	1,465	1,645	1,673	1,706	1,732	1,760	2.04	2.34	1.71
Shantou	327	370	401	407	413	418	449	2.47	1.65	2.85
Shaoguan	259	279	294	296	299	303	305	1.50	1.02	0.96
Heyuan	258	276	294	299	306	311	315	1.35	1.28	1.68
Meizhou	400	434	459	265	469	473	476	1.64	1.14	0.93
Shanwei	199	226	248	252	256	258	269	2.57	1.91	2.08
Jiangmen	332	353	372	374	377	379	380	1.22	1.06	0.54
Yangjiang	206	225	240	243	244	246	248	1.78	1.34	0.81
Zhanjiang	477	546	604	616	627	637	657	2.75	2.02	2.14
Maoming	458	521	572	581	590	607	619	2.63	1.85	2.00
Zhaoqing	306	331	356	362	368	372	381	1.60	1.46	1.73
Qingyuan	314	338	360	363	369	373	378	1.48	1.24	1.22
Chaozhou	199	218	231	234	236	239	242	1.77	1.23	1.20
Jieyang	394	442	479	492	508	520	569	2.36	1.62	4.38
Yunfu	202	222	234	240	244	247	251	1.91	1.05	1.72
Sub-total of the cities and districts except around Zhujiang Estuary	4,331	4,781	5,144	5,024	5,307	5,384	5,539	2.00	1.47	1.87

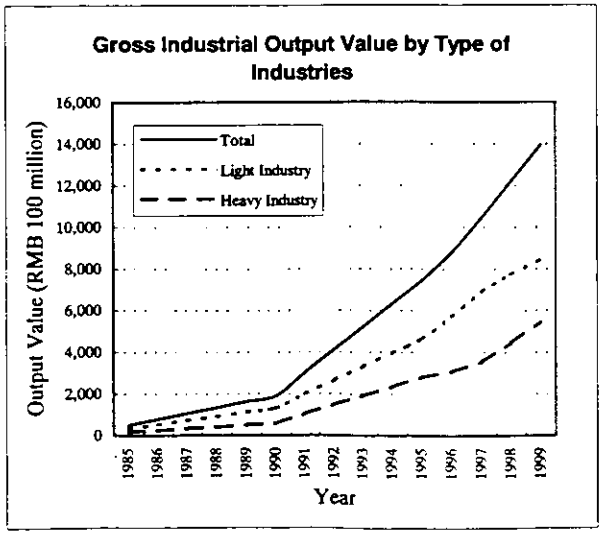
souses: China Statistical Yearbook, Statistical Yearbook of Guangdong (1998, 1999, 2000)











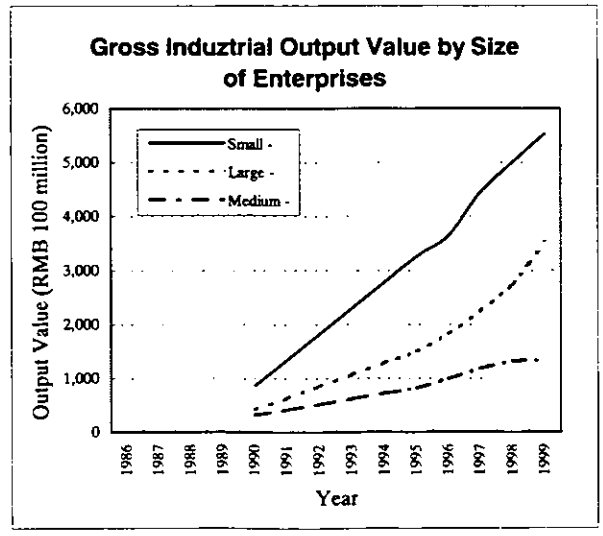


Figure 3.2.1 Socioeconomic Development of Guangdong (1985-1999)

3.3 GDP

The macroeconomic indicators of China, Guangdong and the cities of the Pearl River Estuary are shown in Tables 3.2.1, 3.3.1, 3.3.2, 3.3.3, and Figure 3.2.1.

The GDP of Guangdong in 1999 was about RMB 846 billion at current prices, and the average annual growth rate of GDP from 1996 to 1999 was 10.3 %. The rate for Guangdong is higher than that (8.3 %) of China and is relatively high in contrast to the economies of Southeast Asian countries during the same period. GDP in 2000 was estimated as RMB 950.6 billion, and per-capita GDP as RMB 12,973. These growth rates of GDP and per-capita GDP in 2000 are assumed to be 10.5 % and 8.9 % respectively (*Guangdong Daily*, Feb. 12. 2001). The Guangdong economy continues to maintain high growth, and the target growth rate (about 11 %) of GDP given in the Ninth Five-Year Plan was almost achieved in 2000.

From the viewpoint of the composition of GDP by the industrial sector, the percentage of primary industry dropped significantly, from 30 % in 1985 to 12 % in 1999. Secondary and tertiary industries increased from 40 % and 30 % in 1985 to 50 % and 38 % in 1999, respectively. In the Ninth Five-Year Plan, GDP structure is to change to 11 % for primary industry, 51 % for secondary and 38 % for tertiary industry. This target was almost achieved in 1999. The average annual GDP growth rates of primary, secondary and tertiary industries from 1996 - 1999 were 4.4 %, 11.9 % and 9.3 % respectively. In 1999, the GDP for the seven cities of the Pearl River Estuary amounted to 65 % of the total GDP in Guangdong Province. In particular, the GDP of Guangzhou and Shenzhen contributed 40 % of the total GDP in Guangdong. The GDP of secondary and tertiary industries is very high in both cities.

Guangdong, however, faces some economic difficulties. They are as follows:

1) Financial problems have emerged, and some non-depository banks and business enterprises are having problems and difficulty in repaying foreign debt.
2) Economic efficiency and profits of business enterprises are low, and some enterprises have been forced to cut down on production due to poor domestic demand.
3) The price of some products of farms, animal husbandry and fisheries are down due to a soft market.
4) Re-employment of workers who have left some state owned enterprises is not proceeding smoothly.
5) Environmental problems still remain to be solved.
(*Guangdong Daily*, Feb. 12, 2001)

Table 3.3.1 Macroeconomic Indicators of China

	Aggregate Data							Average Annual Growth Rate (%)*1		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Population and Employment (10^4 persons)										
Year-end Population	105,851	114,333	121,121	122,389	123,626	124,810	125,909	1.55	1.16	0.97
Agricultural Population										
Non-agricultural Population										
Year-end Employees	49,873	63,909	67,947	68,850	69,600	69,957	70,586	5.08	1.23	0.96
Staff and Workers	12,358	14,059	14,908	14,845	14,668	12,337	11,773	2.61	1.18	-5.73
Listed Unemployees in Urban Areas	-	383	520	553	570	571	575	-	6.28	2.57
GNP (100 million Yuan)	8,989	18,598	57,495	66,851	73,143	76,967	80,423	7.9	11.6	8.3
GDP (100 million Yuan, current price)	8,964	18,548	58,478	67,885	74,463	78,345	81,911	7.9	12.0	8.3
Primary Industry	2,542	5,017	11,993	13,844	14,211	14,552	14,457	4.2	4.2	3.7
Secondary Industry	3,867	7,717	28,538	33,613	37,223	38,692	40,418	9.1	13.1	10.1
Industry	3,449	6,858	24,718	29,083	32,412	33,387	34,975	9.3	17.7	10.3
Construction	418	859	3,820	4,530	4,811	5,232	5,443	6.9	14.9	8.1
Tertiary Industry	2,556	5,814	17,947	20,428	23,029	25,174	27,036	9.5	10.0	7.8
Farming, Forestry, Animal Husbandry and Fisheries*2	-	45	116	130	177	-	-	-	8.5	19.2
Geological Prospecting and Water Conservancy*2	-	65	253	280	302	-	-	-	11.8	4.7
Transportation, Postal and Telecommunications Services	407	1,148	3,055	3,494	3,797	4,121	4,460	9.9	11.1	9.9
Wholesale, Retail and Catering Trade	878	1,420	4,932	5,560	6,160	6,579	6,842	5.1	7.6	7.2
Banking and Insurance*2	-	1,235	3,483	4,017	4,535	-	-	-	12.0	8.0
Real Estate*2	-	325	1,059	1,149	1,259	-	-	-	16.4	4.1
Social services*2	-	328	1,546	1,718	2,178	-	-	-	15.8	6.5
Health Care, Sports and Social Welfare*2	-	174	483	564	617	-	-	-	10.1	9.2
Education, Culture and Arts, Radio, Film and Television*2	-	394	1,125	1,355	1,573	-	-	-	10.7	14.4
Scientific Research and Polytechnical Services*2	-	82	277	336	434	-	-	-	12.5	13.1
Government Agency, Parties and Social Organizations*2	-	545	1,438	1,615	1,764	-	-	-	9.0	6.7
Others*2)	-	54	181	209	232	-	-	-	14.3	9.9
Per Capita GDP (yuan)	853	1,634	4,854	5,576	6,053	6,307	6,534	6.3	10.7	7.2
Price Indices (preceding year = 100)										
General Retail Price Index	108.8	102.1	114.8	106.1	100.8	97.4	97.0	-	-	-
General Consumer Price Index	109.3	103.1	117.1	108.3	102.8	99.2	98.6	-	-	-
General Farm and Sideline Products Purchasing Price Index	108.6	97.4	119.9	104.2	95.5	92.0	98.5	-	-	-

souses: China Statistical Yearbook (1998, 1999, 2000)

Note : *1) Based on comparative price, *2) Average annual growth rate in 1996-1998 are calculated from the data of 1996 and 1997.

Table 3.3.2 Macroeconomic Indicators of Guangdong

	Aggregate Data							Average Annual Growth Rate (%)*1		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Population and Employment (10^4 persons)										
Year-end Population	5,656	6,246	6,789	6,897	7,014	7,116	7,299	2.0	1.7	1.8
Agricultural Population	4,458	4,769	4,753	4,789	4,840	4,897	5,022	1.4	-0.1	1.4
Non-agricultural Population	1,198	1,477	2,035	2,108	2,174	2,219	2,276	4.3	6.6	2.8
Year-end Employees	2,731	3,118	3,551	3,641	3,702	3,784	3,796	2.7	2.6	1.7
Staff and Workers	661	785	912	904	897	885	857	3.5	3.0	-1.5
Listed Unemployees in Urban Areas	-	19	-	-	26	26	-	-	-	-
GDP (100 million yuan; current price)	577.4	1,559.0	5,734.0	6,519.1	7,315.5	7,919.1	8,464.3	13.4	19.2	10.3
Primary Industry	171.9	384.6	869.0	941.7	986.8	1,004.9	1,021.3	7.3	4.5	4.4
Secondary Industry	229.8	615.9	2,876.7	3,269.4	3,647.8	3,992.0	4,264.3	16.4	27.4	11.9
Industry	185.8	523.4	2,413.8	2,788.8	3,158.7	3,463.1	3,705.9	18.7	27.9	12.7
Construction	44.0	92.5	462.9	480.5	489.1	528.9	558.4	5.7	24.9	4.9
Tertiary Industry	175.7	558.6	1,988.2	2,308.1	2,680.9	2,922.2	3,178.7	15.6	16.7	9.3
Service for Agriculture, Forestry, Animal Husbandry and Fisheries	0.9	4.4	11.7	13.0	14.4	16.3	18.2	19.2	9.7	9.5
Geological Prospecting and Water Conservancy	1.7	7.7	19.5	21.1	23.5	24.1	24.9	17.2	6.3	5.6
Transportation, Postal and Telecommunications Services	35.9	101.6	427.8	497.7	629.3	688.8	745.2	18.0	23.6	7.5
Wholesale, Retail and Catering Trade	79.9	152.9	568.7	671.2	760.3	827.2	866.8	7.0	17.7	10.9
Finance and Insurance	12.7	82.5	214.5	242.4	271.1	268.2	283.4	27.2	7.3	6.6
Real Estate Trade	6.2	42.9	214.5	257.6	303.4	362.8	426.7	32.0	26.9	13.0
Social Services	6.3	66.2	236.4	266.2	309.3	331.6	371.1	28.6	12.4	6.6
Health Care, Sports and Social Welfare	6.3	18.0	52.4	60.3	65.1	71.4	79.0	10.6	10.9	9.7
Education, Culture, Arts, Broadcastiong, Film and Television	12.7	33.9	101.5	119.4	133.9	146.2	161.5	13.4	12.7	12.5
Sientific Reserch and Polytechnical Services	1.7	7.1	17.8	19.3	21.3	23.9	25.4	19.9	9.9	8.9
Government Agencies, Party Agencies and Social Organizations	8.2	37.3	110.3	125.3	133.2	145.8	160.4	22.9	12.9	8.7
Others	3.4	4.2	13.1	14.6	15.6	16.5	16.0	-7.2	13.4	4.8
Per Capita GDP (yuan; current price)	1,025	2,637	8,495	9,513	10,248	11,143	11,728	11.4	17.0	8.4
Price Indices (preceding year = 100)										
General Retail Price Index	113.6	95.6	111.6	104.4	100.1	97.0	96.7	-	-	-
General Consumer Price Index	114.8	97.5	114.0	107.0	101.9	98.2	98.2	-	-	-
General Purchasing Price Index of Farm Products*2	114.9	90.3	119.0	102.0	96.0	92.2	93.8	-	-	-

souses: Guangdong Statistical Yearbook (1998, 1999, 2000)

Note: *1) Based on comparative price. *2) It is taken as 100 in calculating the general price parity index of industrial and farm products

Table 3.3.3 Economic and Social Status of the Cities of the Pearl River Estuary (1999)

	City								Total of Guangdong
	Guangzhou	Shenzhen	Zhuhai	Zhongshan	Foshan	Dongguan	Huizhou	Sub-total	
Total Land Area (1000 ha)									17,790.1
Cultivated Area	181.2	6.2	38.1	64.1	129.7	66.3	198.0	683.4	
Forested Land	308.8	87.4	50.5	33.9	73.0	60.9	713.8	1,328.3	10,820.0
Non-Forest Land	8.3	0.8	2.7	0.8	2.1	1.8	59.8	76.3	574.8
Forest Coverage Rate	41.1	47.4	32.7	22.2	20.4	28.5	57.3	-	56.8
Population (10^4 Person)	685.00	119.85	71.40	132.00	329.24	150.82	271.82	1,760.1	7,299.81
Agricultural	259.37	24.79	21.96	91.59	186.40	112.09	177.64	873.8	5,026.42
Ratio (%)	37.9	20.7	30.8	69.4	56.6	74.3	65.4	49.6	68.9
Non-agricultural	425.63	95.05	49.44	40.41	142.83	38.73	94.18	886.3	2,272.46
GDP (100 million yuan)	2,056.74	1,436.02	286.61	272.68	833.79	412.84	392.37	5,691.0	8,464.31
Primary Industry	92.85	16.53	13.05	24.26	62.46	30.68	61.87	301.7	1,021.30
Secondary Industry	939.32	727.11	153.65	143.42	436.39	224.39	223.92	2,848.2	4,264.32
Industry	807.60	587.46	128.29	134.34	410.30	209.47	209.43	2,486.9	3,705.88
Construction	131.72	139.65	25.36	9.07	26.10	14.92	14.49	361.3	558.44
Tertiary Industry	1,024.56	692.38	119.91	105.00	334.94	157.77	106.58	2,541.2	3,178.69
Transportation, Storage, Post and Telecommunications	278.35	110.78	20.31	25.03	90.44	46.59	31.55	603.0	745.15
Wholesale Retail sale Catering, and Trade	212.67	143.60	36.22	33.08	88.25	25.24	27.62	566.7	866.83
Par Capita GDP (yuan)	30,265	35,896	23,638	20,809	25,490	27,561	14,483	26,108	11,728
Gross Output Value of Agriculture (100 million yuan in current price)	160.07	29.97	20.90	35.83	120.40	53.74	98.08	519.0	1,745.0
Farming	81.83	9.16	6.99	15.95	42.88	23.64	46.97	227.4	765.66
Fishery	28.02	6.84	9.68	14.65	50.85	7.55	4.20	121.8	369.08

souses: Guangdong Statistical Yearbook (2000)

3.4 Sewage and Industrial Discharge

Indicators of urbanization are shown in sheet 2/3 of Table 3.4.1 and in Figure 3.4.1. As mentioned above, the population in urban areas has been increasing at high rates. The annual increase in the rate of population growth in city areas was 1.8 % in 1996 - 1999, and the growth rate of the number of households was even higher (3.0 % in 1998). Significantly, the increase in water consumption for residential use was 6.6 % and the increase rate of sewer pipeline length is 11.6 % during this time. These high rates have caused the volumes of domestic wastewater to increase by 10.3 % and to affect the environment of the rivers and sea. In Guangdong, the total domestic wastewater volume was 3.1 billion metric tons in 1999 and this was 2.7 times the industrial wastewater volume. In contrast to the decrease of industrial wastewater volume, the domestic wastewater volume has increased annually in proportion to urbanization. It has exceeded that of industrial wastewater since 1993. These figures suggest that domestic wastewater has to be given more attention than industrial wastewater as an environmental pollution source in Guangdong.

As a countermeasure to this large increase in domestic wastewater, Guangdong government issued the Guangdong Ordinance for Water Quality Protection in Pearl River Delta in December 1998. The ordinance prescribes the target figure that 40 % of domestic wastewater will be treated before discharge at the end of 2005 and 70 % will be treated by 2010 (*Guangdong Ordinance*, 1998). The government has planned many projects for sewage treatment plant construction and is promoting the projects in order to achieve the target. Shenzhen, Zhuhai, and Zhongshan cities have cleared the target for 2005 already. Guangzhou city is close to the 2005 target now.

The present sewage discharge volume in Guangzhou city is about 2 million tons/day, which is treated by three plants (see Figure 3.4.2). The projected sewage treatment plant constructions are as follows. By means of construction of these plants, the city intends to achieve the target figure of 70 % by 2010 (*Nanfang City Press*, Dec. 3, 2000).

Project name	Capacity	Completion
Liede No. 2 plant	220,000 tons/day	middle of 2002
Xilang No. 1 plant	200,000	September 2002
Datansha expansion	300,000	end of 2003
Lijiao No. 1 plant	300,000	end of 2003

Zhongshan city has two projects for sewage treatment plant construction, and the total capacity of the plants will be 320,000 tons/day. Foshan city has eight projects for industrial wastewater treatment, which can accommodate 68.3 % of the total volume discharged from industrial plants, and ten projects for sewage treatment. The total capacity of the industrial and domestic wastewater treatment plants is planned to be more than 400,000 tons/day, and this capacity exceeds the volume discharged to the river of Fenjiang in Nanhai district in Foshan city (*Guangzhou Daily*, Mar. 1, 2001).

Table 3.4.1 Economic and Social Development of Guangdong (1/3)

	Aggregate Data							Average Annual Growth Rate (%)[*1]		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Gross Output Value of Agriculture	245.2	600.7	1445.5	1577.9	1656.5	1705.4	1745.0	7.7	5.8	5.8
(100 million Yuan, current price)										
Farming	120.9	298.0	69.5	737.4	760.3	769.9	765.7	5.4	3.6	5.2
Forestry	21.1	28.5	46.1	49.6	52.1	54.7	58.8	6.9	2.1	3.2
Animal Husbandry	54.7	143.0	347.2	396.1	432.5	439.3	455.0	8.3	7.6	6.1
Sideline	14.6	62.1	85.1	90.3	93.2	94.4	-	11.5	2.6	2.7
Fisheries	20.4	69.2	274.5	304.5	327.3	347.2	369.1	14.7	13.3	8.4
Total Output of Farm Crops (10^4 tons)										
Grain	1,604.4	1,896.3	1,803.3	1,891.4	1,966.8	2,007.7	-	3.4	-1.0	3.6
Fruits	116.3	328.6	414.5	381.2	414.5	453.1	-	23.1	4.8	3.0
Sugercane	1,831.4	2,093.5	1,472.2	1,392.0	1,629.3	1,616.9	-	2.7	-6.8	3.2
Peanuts	57.1	58.0	70.0	73.1	74.1	78.1	-	0.3	3.8	3.7
Total Sown Area of Farm Crops (10^4mus)	8,036.8	8,507.4	7,957.2	8,156.2	8,267.3	8,310.7	7,894.2	1.1	-1.3	-0.2
Cultivated Area	3,897.8	3,793.3	3,476.0	3,456.5	3,448.0	3,438.2	3,417.1	-0.5	-1.7	-0.4
Effective Irrigated Area	2,699.7	2,692.7	2,232.4	2,233.7	2,273.9	2,253.1	2,270.7	-0.1	-3.7	0.4
As % of Total Cultivated Land (%)	69.3	71.1	64.2	64.6	65.9	65.5	66.5	-	-	-
Dried and Flooded Area Under Control and Ensuring Stable Yields	1,957.0	2,004.2	1,645.6	-	1,561.5	1,590.4	1,595.1	0.5	-3.9	-0.8
As % of Total Cultivated Land (%)	50.2	52.9	47.3	-	45.3	46.3	46.7	-	-	-
Consumption of Chemical Fertilizer (10^4tons-effective weight)	102.7	162.4	195.7	178.9	169.3	169.4	172.8	9.6	3.8	-3.1
Nitrogenous Fertilizer	69.4	95.8	99.5	93.4	95.8	96.9	95.3	6.7	0.8	-1.1
Phosphate Fertilizer	14.6	20.1	27.2	27.0	20.0	19.3	18.6	6.6	6.2	-9.1
Potash Fertilizer	14.0	27.6	34.1	31.8	32.6	34.0	34.2	14.6	4.4	0.1
Consumption of Pesticides (10^4tons)	7.3	8.0	8.0	8.2	8.0	8.5	8.9	1.8	0.2	2.5
Output of Aquatic Products (10^4tons)[*2]	109.4	207.7	354.4	509.6	521.0	554.3	576.0	13.7	11.3	12.9
Sea Water Aquatic Products	58.7	124.5	197.2	326.0	330.7	346.2	355.4	16.2	9.6	15.9
Catches	56.3	110.7	161.4	191.5	192.2	195.5	194.5	14.5	7.8	4.8
Artificially Cultured	2.5	13.8	35.8	134.6	138.5	150.8	160.9	40.9	21.0	45.6
Fresh Water Aquatic Products	50.7	83.1	157.1	183.6	190.3	208.1	220.6	10.4	13.6	8.8
Catches	1.9	4.2	7.4	15.0	10.2	12.0	13.1	16.8	11.9	15.5
Artificially Cultured	48.8	78.9	149.8	168.6	180.1	196.1	207.5	10.1	13.7	8.5
Cultured Area (10^4mus)	435.4	515.5	668.7	734.0	791.7	807.9	814.4	3.4	5.3	5.0
Sea Water	84.2	138.5	174.2	207.8	256.5	264.7	270.2	10.5	4.7	11.6
Fresh Water	351.1	377.0	494.5	526.3	535.2	543.2	544.2	1.4	5.6	2.4

Table 3.4.1 Economic and Social Development of Guangdong (2/3)

	Aggregate Data							Average Annual Growth Rate (%)[*1]		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Gross Industrial Output Value[*3] (100 million yuan)	505	1,907	7,459	8,815	10,462	12,190	13,944	30.4	31.4	16.9
Light Industry	341	1,317	4,653	5,731	6,913	7,726	8,459	31.0	28.7	16.1
Using Farm Products as Raw Materials[*4]	-	584	1,630	1,900	2,158	2,339	2,400	-	22.8	10.2
Using Non-Farm Products as Raw Materials[*4]	-	503	1,796	2,067	2,772	3,151	3,705	-	29.0	19.8
Heavy Industry	164	590	2,805	3,085	3,548	4,464	5,485	29.2	36.6	18.3
Mining and Quarrying[*4]	-	29	73	97	102	114	103	-	19.8	9.2
Raw Materials Industry[*4]	-	192	522	566	643	743	861	-	22.1	13.3
Processing industry[*4]	-	301	1,561	1,814	2,192	2,716	3,308	-	39.0	20.7
Grouped by Size of Enterprise								-	-	-
Large[*4]	-	423	1,500	1,821	2,246	2,748	3,512	-	28.8	23.7
Medium[*4]	-	318	822	985	1,180	1,313	1,332	-	20.9	12.8
Small[*4]	-	869	3,258	3,637	4,440	5,003	5,533	-	30.3	14.2
Total Number of Industrial Enterprises (units)	23,879	30,404	42,680	43,408	20,117	17,980	18,879	-	7.0	-18.4
State-Owned	-	6,886	6,873	6,783	6,203	3,683	3,303	-	0.0	-16.7
Collectively Owned	-	20,641	23,556	23,063	21,044	4,338	4,277	-	2.7	-34.7
Share Holding Cooperative	-	-	-	-	-	130	218	-	-	-
Share Holding	-	-	297	339	313	801	1,202	-	-	41.8
Foreign Funded	-	563	2,154	2,777	2,647	1,336	1,484	-	30.8	-8.9
Funded by Entrepreneurs from Hong Kong, Macao and Taiwan	-	180	8,776	7,969	7,941	6,508	6,560	-	117.6	-7.0
City Construction										
Developed Land Area (100 ha)	-	-	957	1,084	1,112	1,152	1,249	-	-	6.88
Population (10^4 persons; year-end)	-	-	1,609.2	1,615.6	1,654.4	1,688.8	1,727.7	-	-	1.79
Total Number of Households (10^4 households; year-end)	-	-	432.00	456.00	459.72	473.53	486.31	-	-	3.00
Volume of Water Supply (100 million tons)	-	20.55	34.36	34.88	35.09	35.26	38.76	-	10.83	3.06
Water Consumption for Residential Use (100 million tons)	-	-	-	17.34	18.70	19.66	21.01	-	-	6.61
Percentage of Households with Access to Tap Water (%)	-	-	83.0	86.6	89.7	91.9		-	-	3.45
Length of Sewer Pipeline (km)	-	3,682	7,373	8,794	10,137	10,421	11,431	-	14.90	11.59
Water Consumption for Industrial Use (100 million tons)										
Water Consumption for Irrigation (100 million tons)										
Proportion of Expenditure on Environmental Protection to GDP (%)	0.29	0.37	0.64	1.28	1.27	1.49	1.97	4.99	11.58	32.46

Table 3.4.1 Economic and Social Development of Guangdong (3/3)

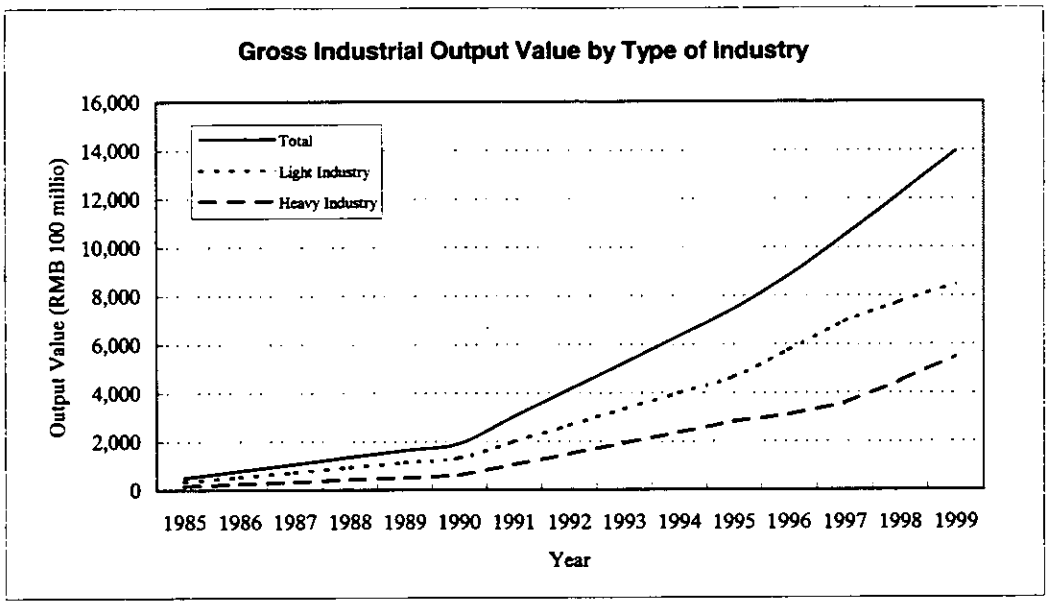
	Aggregate Data							Average Annual Growth Rate (%)*1		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Waste Water										
Total volume of waste water (10^4 tons)	195,014	251,262	381,657	371,405	418,924	434,169	428,762	5.20	8.72	2.95
Domestic water	68,412	111,012	212,369	212,222	293,449	317,432	313,918	10.17	13.85	10.26
Industrial water	126,602	140,250	160,979	150,874	125,475	117,737	114,844	2.07	2.80	-8.10
Rate of Industrial waste water treatment (%)	43.60	56.80	77.08	80.21	85.30	89.30	89.90	5.43	6.30	3.92
Rate of Industrial waste water recovered (%)	-		43.41	49.79	45.00	49.10	42.60	-	-	-0.47
Transportation										
Total Passenger Trafic (10^4 persons)	49,848	78,046	130,998	128,831	123,649	132,462		9.38	10.91	0.37
Railways	3,357	4,467	6,283	5,593	6,201	6,743	7,553	5.88	7.06	4.71
Highways	41,826	70,681	118,406	117,815	113,259	121,795		11.06	10.87	0.95
Waterways	4,427	2,428	5,146	4,232	3,032	2,729		-11.32	16.21	-19.06
Civil Aviation	238	470	1,163	1,191	1,157	1,195	1,154	14.58	19.87	-0.19
Total Freight Trafic (10^4 tons)	58,726	85,809	111,063	95,598	99,763	101,933		7.88	5.29	-2.82
Railways	3,000	4,803	7,634	8,138	8,430	8,288	9,299	9.87	9.71	5.06
Highways	42,813	63,709	68,884	60,131	62,728	65,682		8.27	1.57	-1.57
Waterways	12,045	16,198	32,952	25,699	26,873	25,669		6.10	15.26	-7.99
Civil Aviation	4	8	21	24	25	28	31	14.87	21.29	10.23
Pipelines	864	1,091	1,572	1,606	1,707	2,266	2,670	4.78	7.58	14.16
Total Import and Export (US$ 10^4 million)*5	210.4	418.9	1,039.7	1,099.6	1,301.2	1,298.0	1,403.7	25.81	19.94	7.79
Export	101.4	222.2	565.9	563.5	745.6	756.2	777.1	29.89	20.56	8.25
Import	109.0	196.8	473.8	506.1	555.6	541.8	626.6	21.77	19.21	7.24
Balances	-7.6	25.4	92.1	87.3	190.1	214.4	150.4	-	-	-
Primary Goods										
Export	15.4	21.7	37.6	37.6	47.7	39.9	30.5	12.11	11.60	-5.05
Import	7.5	16.8	35.8	41.7	51.6	53.5	64.4	30.67	16.34	15.83
Manufactured Goods										
Export	86.0	200.5	528.4	555.9	698.0	716.3	746.5	32.60	21.38	9.03
Import	101.5	180.0	438.0	464.4	504.0	488.3	562.3	12.15	19.47	6.44

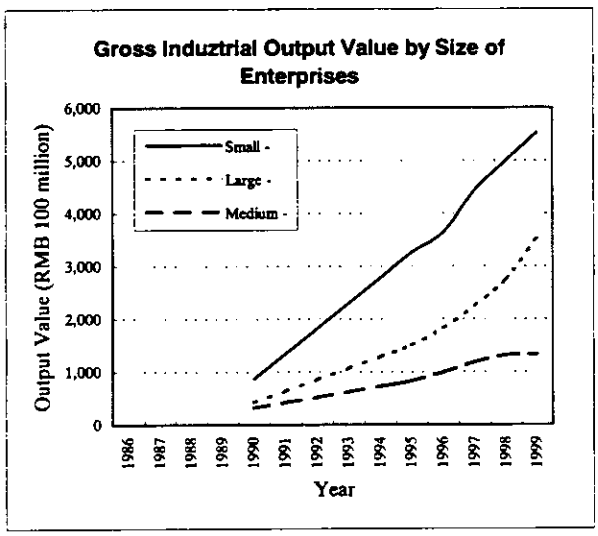
souses: Guangdong Statistical Yearbook (1998, 1999, 2000)

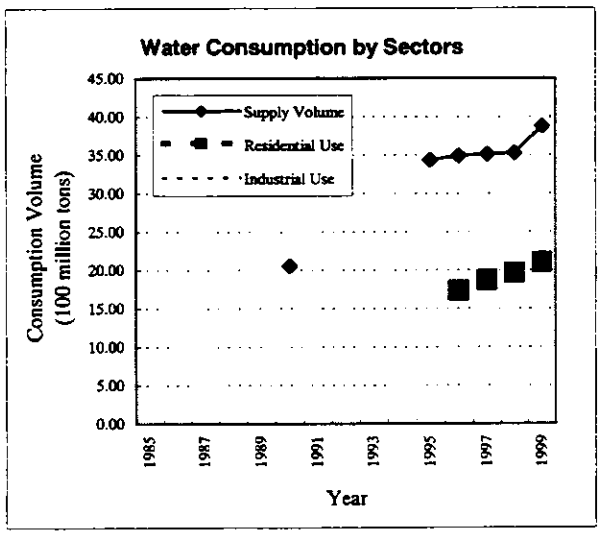
Note: *1) Based on comparative price. *2) Aquatic products since 1997 is calculated in accordance with new criteria (the weigh count system for shell fish is changed from traditional system to international system).

*4) The data cover township and higher level industries.

*5) The figures in the column of 1985 are the data of 1987.







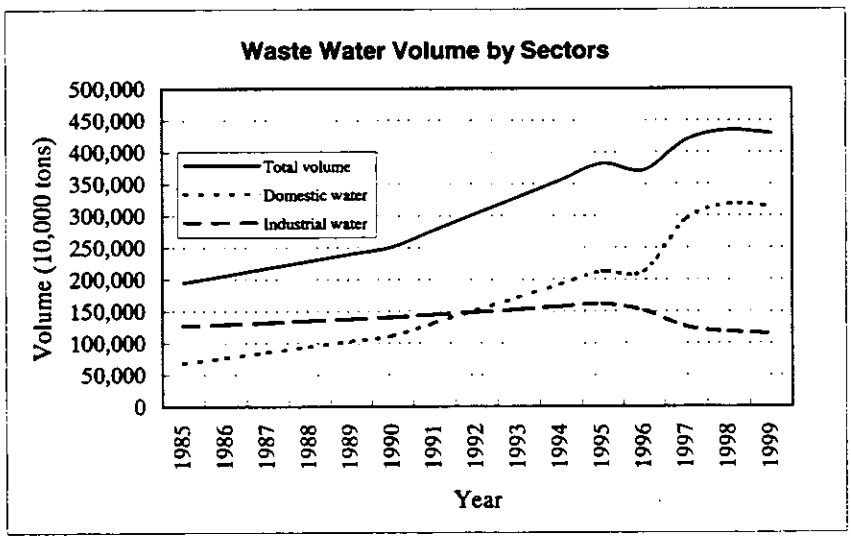


Figure 3.4.1 Industrial Development of Guangdong (1985-1999)

Liede Sewage Treatment Plant Office

Liede Sewage Treatment Plant

Liede Sewage Treatment Plant

Liede Sewage Treatment Plant

Datansha Sewage Treatment Plant Gate

Datansha Sewage Treatment Plant Gate

Datansha Sewage Treatment Plant

Datansha Sewage Treatment Water Discharge

Figure 3.4.2 Sewage Treatment Plant in Guangzhou

3.5 Agricultural Activities

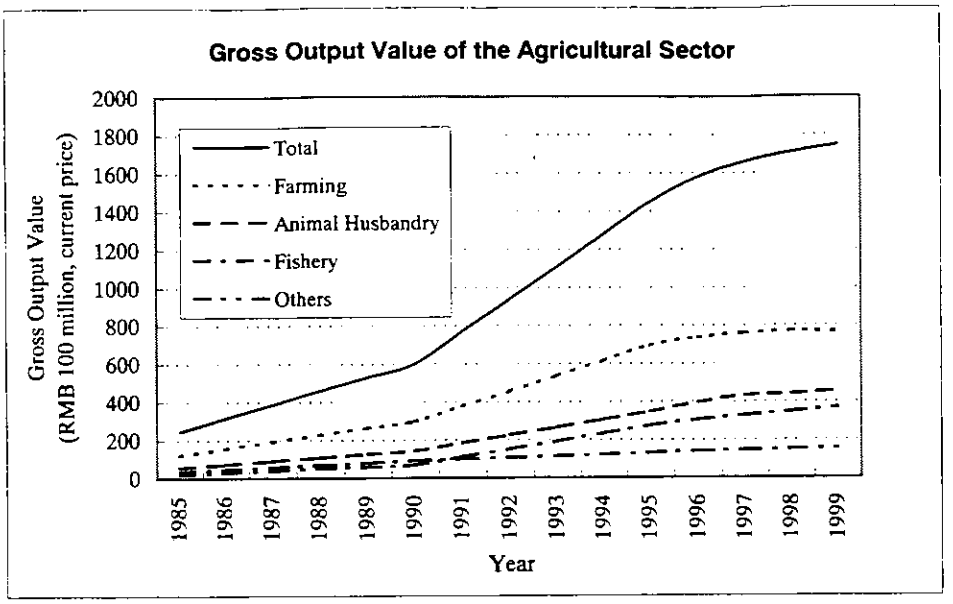
Economic development of primary industry in Guangdong is shown in sheet 1/3 of Table 3.4.1 and in Figure 3.5.1. The gross output value of agriculture in 1999 was RMB 174.5 billion at current prices, and the average annual growth rate from 1991 - 1999 was about 5.8 %. The annual growth rate is not high compared to that of secondary and tertiary industry. But the annual growth rate of the fisheries sector shows a rather high rate of 13.3 - 8.4 % from 1991 - 1999. In particular, the average annual growth rate of maricultural production was more than 45 % from 1996 - 1999, and this high growth rate has contributed strongly to the high growth rate of fisheries sector.

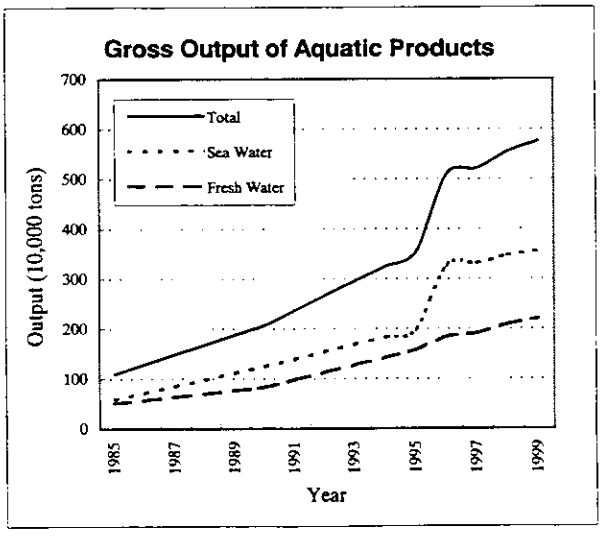
The provincial government formulated the Guangdong Ninth Five-Year Construction Plan of Wholesale Market Places for Aquatic Products and has actively worked to implement the plan. In 1998, the government invested RMB 72.6 million and constructed 29 fishing ports, 58 m of wharfs, 15 km of levees, and 17 km of banks for protecting the coastline. The maricultural area increased by 5,400 hectares in 1998 and the total area became 176,400 hectares (*Guangdong Yearbook*, 1999). These efforts by the government resulted in an increase of the gross output value of the fisheries sector from RMB 6.9 billion (11.5 % of total output value of agriculture) in 1990 to RMB 36.9 billion (21.2 %) in 1999. The output of marine fish farms increased from 138,000 tons in 1990 to 1,609,000 tons in 1999, and it is expected to be 1,750,000 tons in 2000 (*Guangdong Daily*, Feb. 15, 2001). The more the maricultural sector grows, the more important both environmental pollution control for and from the maricultural areas becomes.

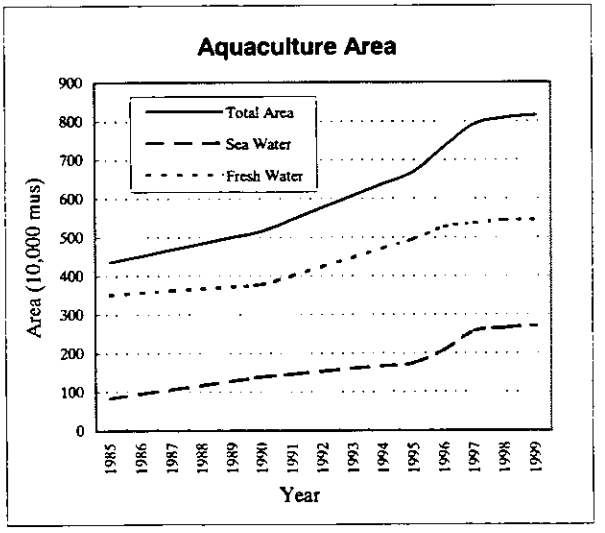
The sea fish catch increased from 1,107,000 tons in 1990 to 1,955,000 tons in 1998, but then decreased to 1,945,000 tons in 1999, and is estimated to be 1,910,000 tons at present (*Guangdong Daily*, Feb. 15, 2001). According to the fishermen met by the study team, the catch has recently been decreasing gradually because of seawater contamination, and in 2000 the conditions were the worst known. Thus, even if the market is strong, 70 % of fishermen in the village are losing money, and some of them are considering giving up fishing. The decrease in the catch is not only caused by environmental problems but also by illegal fishing, such as using poison, electricity and explosives. They strongly desire the government to increase activities on behalf of fisheries, through the following:

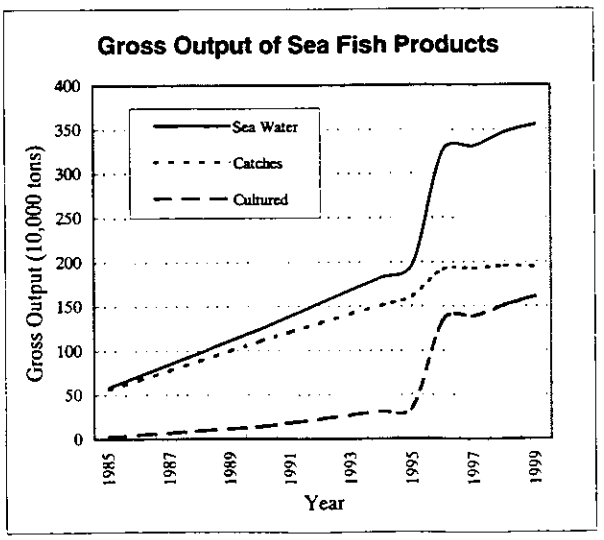
(1) Prevention of pollution
(2) Control of illegal fishing (by use of electricity, poisons and/or explosives)
(3) Extension of the enforcement of prohibition of fishing during June to July, which is now applied only in the South China Sea, to the fishermen in other provinces

With regard to the farming sector, the gross output was RMB 76.6 billion in 1999, which is 43.9 % of the total output of primary industry, and the average annual growth rate was 3.6 % from 1991 - 1995 and 5.2 % from 1996 - 1999. The growth of the farming sector has been low in recent years. The cultivated area and the application of chemical fertilizers and of pesticides, which affects pollution, has not changed much in recent year.









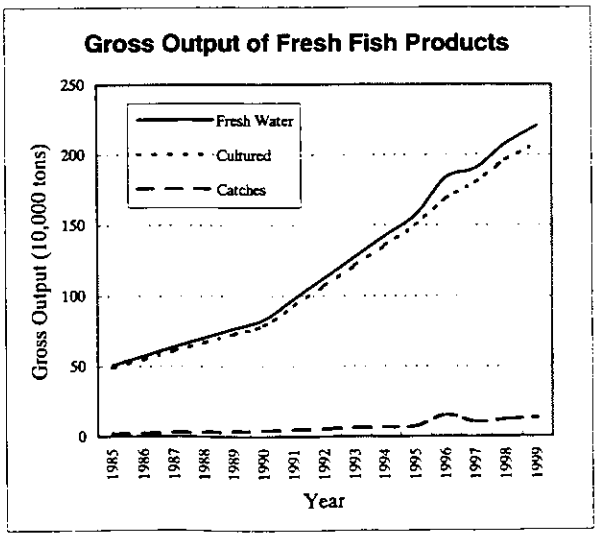


Figure 3.5.1 Agricultural Development of Guangdong (1985-1999)

3.6 Industrial Activities

The development of secondary industry is shown in Table 3.3.1, sheet 2/3 of Table 3.4.1 and in Figure 3.4.1. Gross output value by secondary industry in 1999 was RMB 1,394 billion at 1990 constant prices and, within that total, 61 % was from light industry and 39 % was from heavy industry. When grouped by the size of the enterprise, the ratio of gross output value in 1999 by small, medium and large-scale enterprises was 53 %, 13 %, and 34 % respectively. It is a distinctive feature that Guangdong industry mainly consists of light industries and small and medium scale enterprises.

The annual growth rate of the GDP and the gross output value of secondary industry were 10.1 % and 11.9 % in 1996 - 1999. In particular, the GDP growth rate of large enterprises was as high as 23.7 %. These high growth rates are significant, especially in comparison to the weakness of the Southeast Asian economies during the same period. During this period, moreover, the number of state-owned and collectively-owned enterprises decreased markedly. Some of these enterprises changed to become joint-stock companies in accordance with government policy. The number of foreign-affiliated enterprises having more than RMB 5 million of annual sales, most of which were funded by businesses from Hong Kong, Macao and Taiwan, increased from 743 in 1990 to 10,930 in 1995, but decreased to 7,844 in 1998 (*Guangdong Yearbook*, 1999) because those enterprises were affected by the economic recession in Southeast Asia.

The development of this sector directly affects the environment by increasing pollution. Specifically regarding industrial wastewater, the volume has been decreasing since 1996 and has been kept at a low level by the government's efforts at environmental management.

3.7 Transportation

The development of tertiary industry is shown in the sheet 3/3 of Table 3.4.1. The GDP of tertiary industry was RMB 318 billion (current price) in 1999, which is 38 % of the total GDP in Guangdong. It had an annual growth rate of 9.3 % between 1996 and 1999, which is a comparatively high rate. Wholesale, retail and catering trade sectors combined, account for about 27 % of the total GDP of tertiary industry, and the growth rate for these sectors is high. It is a distinctive feature that the share in the GDP of tertiary industry in Guangdong is high compared to the ratio of China as a whole.

The growth rate of total freight traffic and total imports and exports was not high between 1996 and 1998.

The delta area has a well-developed water transport system. Guangzhou and Huangpu Harbors serve as its water transport centers. Ocean going vessels can sail from these ports to major ports in China and other countries. There are more than 50 medium and small-sized ports in the area.

Railways and highways, with Guangzhou as their hub, lead in all directions. They include the Beijing - Guangzhou, Guangzhou - Kowloon, Guangzhou - Moaming railways and the newly built Beijing - Kowloon Railway, Guangzhou - Meizhou - Shantou Railway as well as number of national highways and expressways.

Guangzhou, Baiyun, Shenzhen and Foshan airports operate flights to many cities, both domestic and international. The Zhuhai airport has been built and is open to air traffic.

As far as water pollution is concerned, the industrial development in this sector is not so important.

3.8 Production Activities

The basin of which pollutant loads run out directly into the Pearl River Estuary is only along the coastal areas, because the major loads run out through the Pearl River and its tributaries.

The basin includes the following areas; Panyu (a county-level city inside Guangzhou), part of Dongguan, part of Zhongshan, most of Shenzhen and Zhuhai.

Major products of this coastal area are shown in Table 3.8.1.

The Pearl River Delta area ranks as one of China's famous commodity agriculture product bases. It is Guangdong's major producer of agricultural and other sideline products such as grain, sugarcane, freshwater fish and shrimp, silkworm cocoon, fruits (bananas, oranges, tangerines, lychees, pineapples, etc.), flowers, poultry and eggs.
Its fresh subsidiary agricultural products from here can be exported to Hong Kong, Macao and many places in Southeast Asia as well.

The rural area of the delta is known as the 'Water Country'. In this area, people dig ponds to breed fish, build dikes to plant mulberry for silkworm raising and grow sugarcane and fruit trees, with mud dug out of the ponds as fertilizer. The man-made eco-cycle system and farm-working mode are renowned at home and abroad.

The delta area also ranks as one of China's centers of electricity generation, and of textile and handicraft industries. It has a diversified and broad-range industrial system. Its household appliances, miscellaneous hardware, pharmacy, textile products, as well as chemicals, sundry small articles, plastics, sugar refining and canned food industries, have important positions in the industry of China.

Table 3.8.1 Production Activities in Coastal Areas of the Pearl River Estuary (1/2)

City name	Agriculture & Fishery	Industry	Special Mention
Panyu (County level city inside Guangzhou)	-Grain -Sugarcane -Peanuts -Banana -Lychee -Longan -Papaya	-Sugar refining -Papermaking -Textile -Chemical fiber -Printing and Dyeing -Clothing -Shoemaking -Food-processing -Machinery -Electronics -Automotives -Chemical fertilizer -Building materials	Major production bases for grain and sugarcane
Shenzhen		-Electronics -Textile -Garments -Food-processing -Beverage -Plastics industries -Building materials -Machinery -Petrochemicals -Furniture -Medicine -Handicraft -Decor works	Special Economic Zone A base for processing export products, which has been established over the past few years, using foreign funds Electronics industry has developed rapidly.
Zhuhai	-Black scale fish -Butterfish -Shark -Oyster -Sea crab -Fruits and Vegetables -Flowers and plants -Livestock- breeding -Aquaculture	-Electronics -Textile -Clothing -Building materials -Machinery -Food-processing -Furniture -Packing -Plastics industries	Special Economic Zone Several bases for producing export commodities in the last years, including fruit and vegetable farming, flowers and plant cultivating, livestock-breeding and aquaculture
Dongguan	-Rice -Sugarcane -Vegetables -Peanuts -Lychee -Banana -Orange -Pineapple -Poultry -Fish -Shrimp -Crab -Eel	-Textile -Food-processing -Electronics -Machinery -Building materials -Clothing -Printing -Arts and Crafts -Leatherwear -Plastics -Toy -Furniture	Growth in the economy of the city has advanced rapidly in recent years. Local special products such as rice-flour noodles, sausages, oil-duck, cream-crab, maltose, fireworks and grass-mats

Table 3.8.1 Production Activities in Coastal Areas of the Pearl River Estuary (2/2)

City name	Agriculture & Fisheries	Industry	Special Mention
Zhongshan	-Rice -Sugarcane -Peanuts -Lotus loot -Mushroom -Litchi -Banana -Orange -Longan -Silkworm cocoon -Chicken -Shell-duck -Goose -Edible pigeon -Pond-fish	-Sugar refining -Building materials -Electronics -Domestic appliances -Printing -Food processing -Medicine -Textiles	The natural conditions are most favorable for the development of its diversified agricultures.

source: Guide Atlas to the Pearl River Delta of China (1999)

3.9 Socioeconomic Development of Major Cities of the Pearl River Estuary

3.9.1. Guangzhou

The economic development of Guangzhou is shown in Table 3.9.1 and Figure 3.9.1. The GDP of Guangzhou in 1999 was RMB 206 billion at current prices and its average annual growth rate from 1996 to 1999 was 13.4 %, which is higher than that of Guangdong (10.3 %). The GDP and its annual growth rate in 2000 are expected to be RMB 238 billion and 13.6 %, and per-capita GDP is expected to reach to RMB 34,500, which is equivalent to US$4,175 at the current exchange rate (*Guanzhou Daily*, Nov. 16, 2000, Feb. 22 and 23, 2001).

The GDP amounts and shares of primary, secondary, and tertiary industry in 1999 were RMB 9.3 billion (4.5 %), 94 billion (45.7 %) and 102 billion (49.8 %), respectively. The percentage of GDP accounted for by primary industry in the total GDP is 4.5 % and is much lower than that of Guangdong (12 %). A high percentage of secondary and tertiary industry GDP is a notable feature of Guangzhou. In particular, tertiary industry has grown at a high rate (14.8 % p.a.) and its GDP exceeds that of secondary industry. The gross industrial output value is RMB 251 billion and that of light industry and heavy industry in 1998 were RMB 157 billion (62.3 %) and RMB 95 billion (37.7 %), respectively. The average annual growth rate of gross industrial output value was 13.4 % during the same period. The growth rate of light industry was 15.1 % and the rate of heavy industry was 10.8 %.

Even though the majority of industries in Guangzhou are categorized as belonging to light industry, the recent development of heavy industry is significant. The gross industrial output value in 2000 was recorded as RMB 309 billion and its year-on-year growth rate was 14.7 %. The gross industrial output and the annual growth rate of heavy industry were RMB 125.3 billion and 21.8 %, respectively. Conversely, those of light industry were RMB 183.6 billion and 11 %. The growth rate of heavy industry has recently exceeded the rate of light industry by about 11 % (*Guangzhou Daily*, Feb. 22, 2001).

Regarding environmental problems in Guangzhou, attention must be given to the large volume of household water consumption, which exceeds that of industrial use. Water consumption by industry has been decreasing since 1996 as a result of efforts by the municipal governments to have business enterprises recycle water and thereby decrease freshwater consumption. At present in Guangzhou, further efforts by the government are needed for the construction of sewage treatment plants. The future plans for this are mentioned in Section 3.4.

3.9.2. Shenzhen

The economic development of Shenzhen is summarized in Table 3.9.2 and Figure 3.9.2. The GDP of Shenzhen in 1999 was about RMB 144 billion at current prices and its average annual growth rate from 1996 to 1999 was 15.9 %, which is higher than that of Guangzhou (13.4 %).

Shenzhen is a highly industrialized city. The GDP amounts and shares of primary, secondary, and tertiary industry in 1999 were RMB 1.7 billion (1.1 %), 72.7 billion (50.6 %), and 69.2 billion (48.2 %) respectively. The percentage of GDP

accounted for by primary industry was much lower than that of Guangdong (12 %). The high percentage of secondary and tertiary industry is a notable characteristic of Shenzhen. Tertiary industry is growing a high rate of 17.3 % p.a.

In the aquaculture sector, the area for sea fish farms increased in Shenzhen Bay from 1985 to 1990. However, the bay was subsequently contaminated by effluent from many newly constructed industrial plants, and the sea area became unsuitable for aquaculture. The aquaculture area in the bay decreased gradually, starting in 1990, and it dropped sharply in 1997 because some public works projects were started in the sea area and many aquaculture enterprises had to suspend operations. Given these environmental and political conditions, the Guangdong Ocean and Fishery Department started new project for aquacultural development in Dapeng Bay from 1996. Many aquacultural enterprises are shifting their operations from Shenzhen Bay to Dapeng Bay or other places, such as in Zhuhai.

As far as environmental aspects are concerned, a major problem in Shenzhen is industrial effluent discharge, which causes the contamination of Shenzhen Bay. The color of the Shenzhen River is blackish and has a foul smell. The majority of business enterprises in Shenzhen are categorized as light industry and medium- or small-scale industry, and most of all these enterprises seem to discharge the effluent directly to the river or directly into the bay without appropriate treatment.

The Environmental Protection Bureau of the Shenzhen city government is concentrating on decreasing industrial wastewater discharge volume by requiring the polluting enterprises to install wastewater treatment facilities and to recycle water.

In the private sector, large-scale enterprises are seen to be taking measures for environmental protection. For instance, a Japanese electric and electronics goods factory, which has more than 30 brother factories in Mainland China and started operation in Shenzhen 16 years ago, has some metal plating lines that discharge about 300,000 tons/year of process water. There the company has installed an integrated wastewater treatment facility, developed by the company, called 'high functional and saving space type'. The factory is controlling the content of effluent in terms of several indicators such as pH, COD, Cu, SS, oils, etc. so as to keep the levels within the limits required by law. The factory acquired the ISO 14001 certificate in 1998 because of its environmental management system and is recognized as an Excellent Factory of Environmental Management by the Environmental Protection Bureau of the Shenzhen city government. Another example of an enterprise that is doing well in terms of impact on the environment, there is an enterprise that is categorized as medium-scale and light industry. The enterprise has several plastic compounding lines and has installed two filter tanks for cutting down SS in effluent. The company monitors COD and total quantity of SS periodically by outsourcing to an environmental service company.

To prevent and to mitigate industrial pollution, further government efforts that stress the importance of ISO 14001 and strict environmental control at the pollution sources mentioned above are required. Also, precise monitoring of environment and pollution sources is necessary to clarify the effects of the measures.

3.9.3. Zhuhai

Economic development of Zhuhai is shown in Table 3.9.3 and Figure 3.9.3. The GDP of Zhuhai was about RMB 29 billion in 1999, and its average annual growth rate from 1996 to 1999 was 11.6 %, which is higher than that of Guangdong (10.3 %) but lower than Guangzhou (13.4 %).

The GDP amounts and shares of primary, secondary, and tertiary industry in 1999 were RMB 1.3 billion (4.6 %), 15.4 billion (53.6 %), and 12.0 billion (41.8 %), respectively. The percentage of GDP accounted for by primary industry was 4.6 %, which is lower than that of Guangdong (12 %). The high percentage of GDP of the secondary and tertiary industry is notable in Zhuhai as was seen in Shenzhen. The average annual growth rate of GDP in each sector from 1996 to 1999 was 5.4 % for primary industry, 11.8 % for secondary industry, and 12.0 % for tertiary industry.

In the aquacultural sector, the gross output value of fisheries has grown since 1990, and it has exceeded that of land crops since 1995. Recently, the aquacultural businesses have been active in the Zhuhai sea area, and they contribute to this high growth rate of gross output value of fisheries and high growth rate of GDP of primary industry. The gross industrial output was RMB 43 billion in 1997, of which RMB 31 billion (73.3 %) was from light industry and RMB 11 billion (26.6 %) was from heavy industry. The majority of the industries in Zhuhai are in the category of light industry.

As far as environmental aspects are concerned, according to the members in charge in the Zhuhai Oceanic Administration Office, there is not so much of a problem in Zhuhai. The government does not permit enterprises to construct manufacturing plants that are not equipped well in terms of environmental considerations. These constraints are effective for protection of the marine environment from industrial pollution.

3.9.4. Dongguan

The economic development of Dongguan is summarized in Table 3.9.4 and Figure 3.9.4. The GDP of Dongguan was about RMB 41 billion in 1999, and its average annual growth rate from 1996 to 1999 was 19.0 %, which is higher than that of Guangdong (10.3 %) and Guangzhou (13.4 %).

The GDP amounts and shares of primary, secondary and tertiary industry in 1999 were RMB 3.1 billion (7.4 %), 22.4 billion (54.4 %), and 15.8 billion (38.2 %), respectively. The percentage of GDP accounted for by primary industry was 7.4 %, which is lower than that of Guangdong (12 %). The GDP shares of secondary and tertiary industry in Dongguan are relatively high among the cities in Guangdong. The average annual growth rate of GDP in each sector from 1996 to 1999 was 5.6 % for primary industry, 18.9 % for secondary industry, and 23.0 % for tertiary industry. The growth rate of secondary and tertiary industries in Dongguan is the highest in Guangdong.

In the agricultural and aquacultural sectors, the gross output value of land crops is greater than that of fisheries, but the average annual growth rate of fisheries is

higher than that of land crops. The gross output value of land crops decreased in 1998, while that of fisheries grew. The gross output of fresh water fish has exceeded that of seawater fish since 1994. This is due to the development of additional areas for fresh water fish farms.

The gross output value of the industrial sector was RMB 73.2 billion in 1998, and its average annual growth rate from 1996 to 1998 was 21.8 %, which is the highest in Guangdong. The gross output value of light industry is more than that of heavy industry, but the growth rate of heavy industry increased sharply in 1998. New manufacturing plant constructions were concentrated in Shenzhen city when the city was named a Special Economic Zone. Recently, however, the city has lost attractiveness to investors, due to the high labor cost there. Many investors have moved from Shenzhen to Dongguan.

As far as environmental aspects are concerned, Dongguan is one of the highly industrialized cities in Guangdong, and heavy industry in particular has grown rapidly recently. Precise monitoring of industrial pollution and strict controls over plant construction and operating conditions are required.

Table 3.9.1 Economic and Social Development of Guangzhou

	Aggregate Data							Average Annual Growth Rate (%)		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Population and Employment (10^4 persons)										
Year-end Population	545	594	647	656	666	671	685	1.7	1.7	1.4
Agricultural Population	249	253	251	253	256	257	259	0.3	-0.1	0.8
Non-agricultural Population	296	341	395	403	411	414	426	2.9	3.0	1.9
Year-end Employees*1	313	341	391	393	428	445		1.7	2.8	4.4
Staff and Workers*1	176	189	208	203	200	197		1.5	1.9	-1.8
GDP (100 million yuan; current price)	124.4	319.6	1,243.1	1,444.9	1,646.3	1,841.6	2,056.7	20.8	31.2	13.4
Primary Industry	12.0	25.7	73.5	81.2	85.7	88.9	92.9	16.4	23.3	6.0
Secondary Industry	65.8	136.3	580.2	675.4	766.2	826.4	939.3	15.7	33.6	12.8
Industry	57.7	118.1	495.9	581.5	666.2	714.3	807.6	15.4	33.2	13.0
Construction	8.1	18.2	84.3	93.9	100.0	112.1	131.7	17.6	35.9	11.8
Tertiary Industry	46.5	157.6	589.4	688.4	794.4	926.3	1,024.6	27.6	30.2	14.8
Gross Output Value of Agriculture (100 million, current price)										
Total of Agriculture	18.0	43.9	126.8	142.9	150.8	154.0	160.1	19.5	23.6	6.0
Planting	11.7	28.0	63.4	70.2	74.8	77.0	81.8	19.0	17.7	6.6
Fisheries	1.0	2.8	18.5	27.5	25.5	26.6	28.0	24.2	45.8	10.9
Water Supply and Consumption (10,000 m^3)										
Supply Capacity*1	73,730	94,900	132,860		135,780	128,115		5.2	7.0	-1.2
Supply Volume*1	62,469	86,136	124,184		122,953	122,294		6.6	7.6	-0.5
Consumption for Residential Use*1	34,994	54,405	73,522		78,098	80,453		9.2	6.2	3.0
Consumption for Industrial Use*1	23,639	27,902	37,377		30,412	28,149		3.4	6.0	-9.0
Gross Industrial Output Value (100 million, current price)										
Total of Industry*1	177.9	442.4	1,722.5	2,068.6	2,373.9	2,512.7		20.0	31.2	13.4
Light Industry*1	116.4	283.0	1,026.4	1,264.1	1,439.6	1,566.2		19.5	29.4	15.1
Heavy ndustry*1	61.6	159.4	696.1	804.5	935.8	946.5		21.0	34.3	10.8
Per Capita GDP (yuan; current price)	2,302	5,418	19,366	22,025 *2	24,895	27,474	30,265	18.7	29.0	11.8
Price Indices (preceding year = 100)										
General Retail Price Index			109.7	104.3	99.4	96.3		-	-	-
General Consumer Price Index	121.5	97.3	113.5	108.2	102.2	97.7		-	-	-

souses: Guangzhou Statistical Yearbook (1999), Guangdong Statistical Yearbook (2000)

Note: *1) The data of Average Annual Growth Rate marked by *1 are for 1996-1998.

*2) The data is calculated by dividing the date of GDP by the data of population.

Table 3.9.2 Economic and Social Development of Shenzhen

	Aggregate Data							Average Annual Growth Rate (%)*1		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Population and Employment (10^4 persons)										
Year-end Population	48	69	99	103	109	115	120	7.5	7.6	4.9
Agricultural Population	25 *2	26	24	24	25	25	25	0.6	-1.0	0.4
Non-agricultural Population	26 *2	43	75	79	85	90	95	12.9	11.7	6.2
Year-end Employees*2	33	109	245	255	272	286		27.3	17.5	5.3
Staff and Workers*2	23	55	89	89	91	92		19.6	9.9	1.2
GDP (100 million yuan; current price)	39	172	796	950	1,130	1,289	1,436	34.5	35.9	15.9
Primary Industry	2.6	7.0	12.9	15.7	15.8	16.5	16.5	21.9	13.0	6.3
Secondary Industry	16.4	76.9	416.9	478.1	556.6	644.6	727.1	36.3	40.2	14.9
Industry	10.2	64.5	326.3	382.4	447.6	517.4	587.5	44.6	38.3	15.8
Construction	6.1	12.4	90.7	95.7	109.0	127.1	139.7	15.1	48.8	11.4
Tertiary Industry	20.5	87.7	365.8	456.2	557.6	628.0	692.4	33.7	33.1	17.3
Gross Output Value of Agriculture (100 million, current price)										
Total of Agriculture	4.6	11.9	23.3	27.3	27.1	29.8	30.0	21.1	14.3	6.5
Planting	1.6	3.8	5.8	7.1	7.3	8.0	9.2	19.2	9.2	11.9
Fisheries	0.8	2.4	4.3	5.2	6.5	6.6	6.8	25.0	12.4	12.2
Total Output of Aquatic Products (tons)*2	16,762	38,587	37,394	41,183	55,569	58,315		18.1	-0.6	16.0
Sea Water*2	4,485	24,239	30,041	21,957	47,687	50,352		40.1	4.4	18.8
Fresh Water*2	12,277	14,348	7,353	19,226	7,882	7,963		3.2	-12.5	2.7
Cultured Area (10,000 mus)*2	19.3 *3	21.9		16.0	13.5	13.6		3.1	-5.1	-7.8
Sea Water*2	7.9 *3	14.7		13.6	10.8	10.5		16.9	-1.3	-12.0
Fresh Water*2	8.8	7.2		2.4	2.7	3.1		-4.2	-16.6	13.5
Gross Industrial Output Value (100 million, current price)										
Total of Industry*2	24.7	220.2	1,226.5	1,427.7	1,666.1	1,943.5		54.9	41.0	16.6
Light Industry*2	19.4	165.8	665.2	800.3	930.5	1,003.7		53.6	32.0	14.7
Heavy ndustry*2	5.3	54.4	561.3	627.4	735.6	939.8		59.6	59.5	18.7
Per Capita GDP (yuan; current price)	4,809	8,724	23,381	27,005	30,619	33,282	35,896	12.7	21.8	11.3
Price Indices (preceding year = 100)										
General Retail Price Index	123.2	97.7	110.8		100.0	97.5		-	-	-
General Consumer Price Index	122.5	101.6	112.4		103.3	99.3		-	-	-

souses: Shenzhen Statistics and Information Yearbook (1999)

Note: *1) Annual growth rate of cultured area in 1991-1995 and 1996-1998 are in 1991-1996 and 1997-1998.

*2) The Annual Growth Rate the items marked *2 are the data in 1996 -1998.

*3) The data are as of 1986, and annual growth rates of them are from 1986 to 1990.

Table 3.9.3 Economic and Social Development of Zhuhai

	Aggregate Data							Average Annual Growth Rate (%)*2		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1999
Population and Employment (10^4 persons)										
Year-end Population	41.17	50.25	63.24	65.37	67.34	69.48	71.40	4.1	4.7	3.1
Agricultural Population	27.65	28.35	20.33	20.76	21.12	24.69	24.79	0.5	-6.4	5.1
Non-agricultural Population	13.52	21.90	42.91	44.61	46.22	44.79	46.61	10.1	14.4	2.1
Year-end Employees	25.36	39.27	63.32	63.17	69.00			9.1	10.0	4.4
Staff and Workers	9.62	16.19	26.86	27.73	28.64			11.0	10.7	3.3
GDP (100 million yuan; current price)	9.8	41.4	185.1	207.3	235.2	263.9	286.6	33.4	34.9	11.6
Primary Industry	2.1	5.9	10.6	11.6	12.3	23.6	13.1	22.6	12.4	5.4
Secondary Industry	4.1	18.1	98.2	107.4	122.4	137.8	153.6	34.6	40.3	11.8
Industry	2.2	15.1	74.6	88.4	101.5	114.7	128.3	47.7	37.6	14.5
Construction	1.9	2.9	23.5	19.0	20.9	23.1	25.4	8.8	51.6	1.9
Tertiary Industry	3.6	17.5	76.3	88.3	100.6	113.2	119.9	37.2	34.3	12.0
Gross Output Value of Agriculture (100 million, current price)										
Total of Agriculture	3.6	9.9	17.4	18.5	19.3	19.9	20.9	22.2	11.9	4.7
Planting	2.4	5.4	6.6	7.2	7.4	7.6	7.0	17.8	4.3	1.3
Fisheries	0.6	2.4	7.1	7.5	7.9	8.3	9.7	32.2	23.7	8.1
Total Output of Aquatic Products (tons)	22,876	50,820	68,903	72,155	95,048			17.3	6.3	17.4
Sea Water	12,631	9,248	28,646	29,887	47,147			-6.0	25.4	28.3
Fresh Water	10,245	20,842	40,257	42,268	47,902			15.3	14.1	9.1
Cultured Area (10,000 mus)	8.7	15.2	20.7	22.1	22.9			15.1	6.4	5.2
Sea Water				9.9	10.5					6.3
Fresh Water				12.2	12.4					1.9
Gross Industrial Output Value (100 million, at 1990 constant price)										
Total of Industry Over Levels	8.0	55.8	303.6	342.6	427.2			47.7	40.3	18.6
Light Industry	6.5	45.8	214.0	256.7	313.1			47.7	36.1	21.0
Heavy ndustry	1.4	10.0	89.6	85.9	113.6			47.7	55.0	12.6
Per Capita GDP (yuan; current price)	2,383	5,549	17,552	19,827	20,121	22,348	23,638	18.4	25.9	7.1
Price Indices (preceding year = 100)										
General Retail Price Index	103.7 *1	99.8	110.2	104.2	101.0			-	-	-
General Consumer Price Index	104.1 *1	101.4	111.8	106.3	103.3			-	-	-

souses: Zhuhai Statistical Yearbook (1998), Guangzhou Statistical Yearbook (1999, 2000)

Note: *1) The data are from 1986.

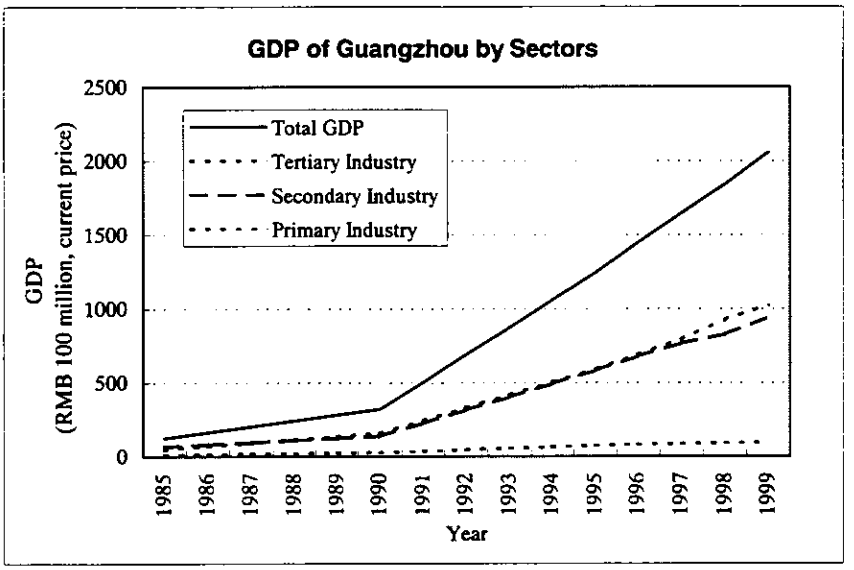
*2) The growth rate of 1996-1999 for the items, which are not available in 1998 and 1999, are for 1996-1997.

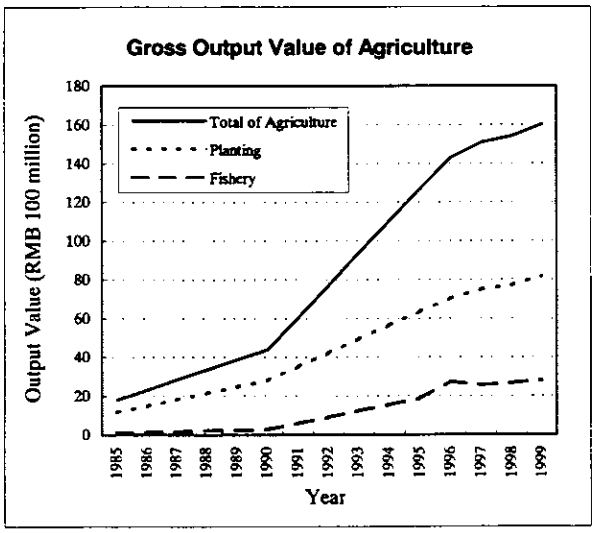
Table 3.9.4 Economic and Social Development of Dongguan

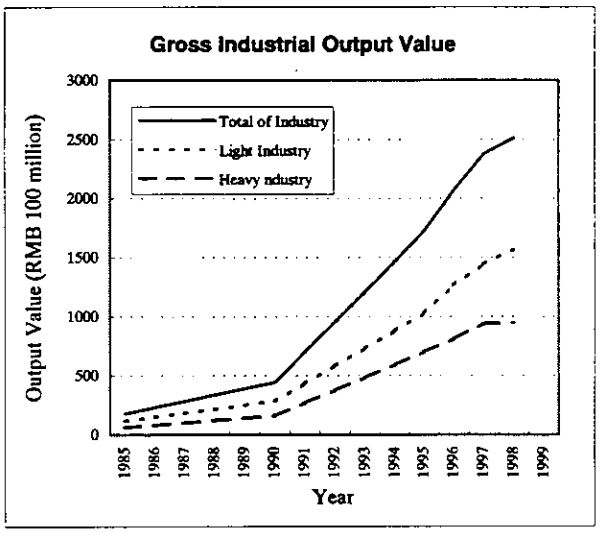
Item	Aggregate Data							Average Annual Growth Rate (%)*1		
	1985	1990	1995	1996	1997	1998	1999	1986-1990	1991-1995	1996-1998
Population and Employment (10^4 persons)										
Year-end Population	121	132	144	145	147	149	151	1.8	1.7	1.2
Agricultural Population	95	101	108	109	110	111	112	1.2	1.4	0.9
Non-agricultural Population	25	31	35	36	37	38	39	3.9	2.8	2.3
Year-end Employees	67	75	87		68	88		2.2	3.0	0.3
Staff and Workers	12	13	18		17	16		1.4	6.3	-2.8
GDP (100 million yuan; current price)	20.4	64.6	205.6	245.1	294.7	355.5	412.8	26.0	26.1	19.0
Primary Industry	6.5	14.7	24.7	28.9	30.0	30.6	30.7	17.6	11.0	5.6
Secondary Industry	9.9	30.6	112.1	130.8	155.9	191.3	224.4	25.3	29.7	18.9
Industry		29.5	101.4		145.3	178.6	209.5		28.0	19.9
Construction		1.1	10.7		15.2	12.7	14.9		56.9	8.6
Tertiary Industry	4.0	19.4	68.9	85.4	108.8	133.6	157.8	37.3	28.9	23.0
Gross Output Value of Agriculture (100 million, current price)										
Total of Agriculture	9.1	23.6	42.7	49.7	51.4	53.6	53.7	21.0	12.5	5.9
Planting	5.8	12.9	19.5	21.3	23.3	22.1	23.6	17.5	8.6	4.9
Fishery	0.6	3.1	6.9	8.7	8.2	9.3	7.6	38.3	16.9	2.4
Total Output of Aquatic Products (tons)	32,614	68,508	74,778	81,067	91,901	96,872		16.0	1.8	9.0
Sea Water	15,422	41,002	32,132	33,363	35,407	33,618		21.6	-4.8	1.5
Fresh Water	17,219	27,506	42,646	47,704	56,494	63,254		9.8	9.2	14.0
Cultured Area (10,000 mus)	13.1	13.6	16.3	17.3	18.5	19.2		0.9	4.0	5.6
Sea Water	0.5	1.9	2.8	2.8	3.0	2.9		38.1	6.3	2.5
Fresh Water	12.6	11.7	13.5	14.5	15.5	16.3		-1.5	3.6	6.1
Gross Industrial Output Value (100 million, current price)										
Total of Industry	15.6	82.4	405.2		600.9	732.2		39.4	37.5	21.8
Light Industry	11.7	50.4	255.9		396.8	430.8		34.0	38.4	19.0
Heavy ndustry	4.0	32.0	149.3		204.1	301.4		51.8	36.1	26.4
Per Capita GDP (yuan; current price)	1,700	4,958	14,428	16,969	20,160	24,031	27,561	23.9	23.8	18.5
Price Indices (preceding year = 100)										
General Retail Price Index	106.9	94.9	109.7		99.7	98.7		-	-	-
General Consumer Price Index	106.5	96.6	113.9		101.5	99.9		-	-	-

souses: Statistical Yearbook of Dongguan (1999)

Note: *1)The average annual growth rate of the items in 1996-1999 in which the data in 1999 is not available, show the rate in 1996-1998.







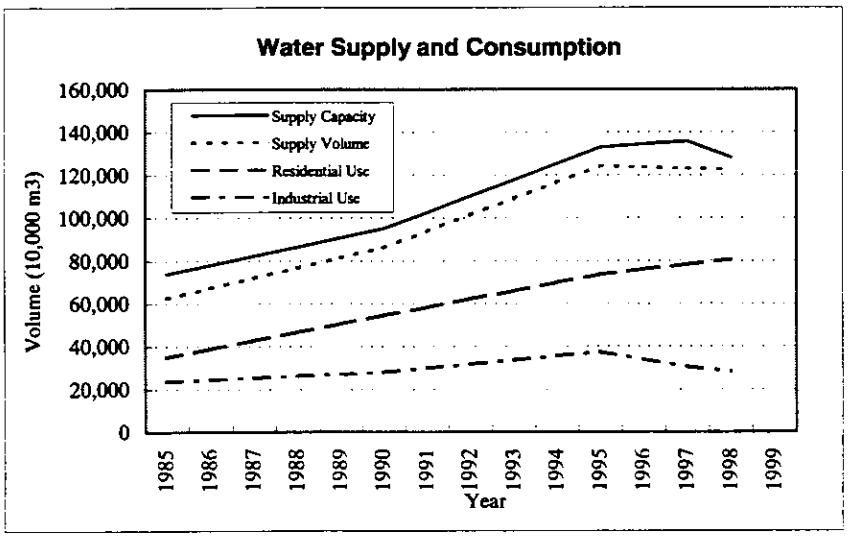
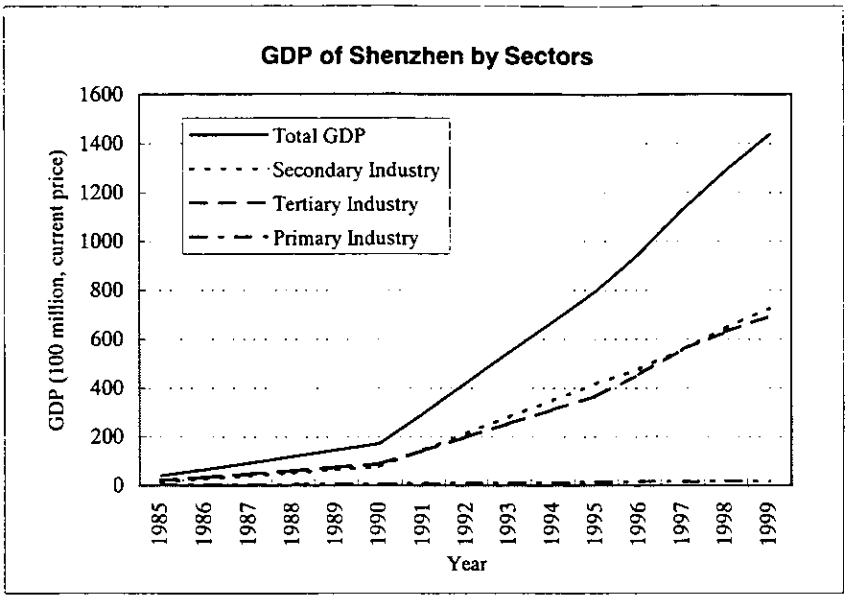
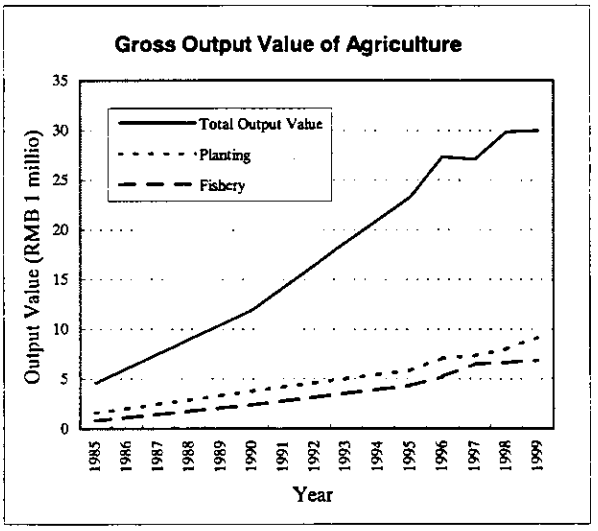
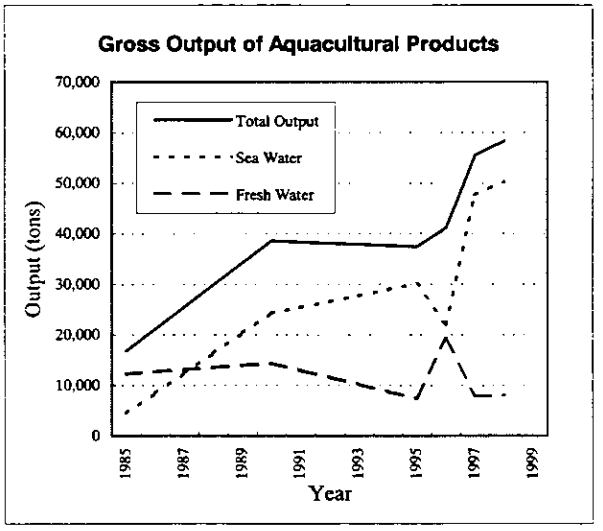
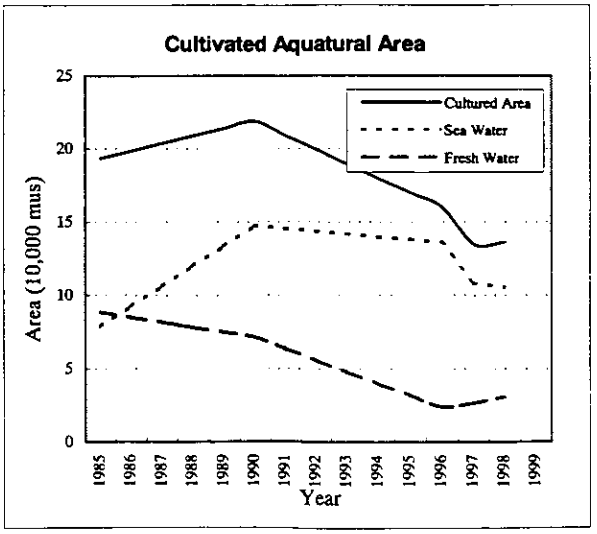


Figure 3.9.1 Economic Development of Guangzhou (1985-1999)









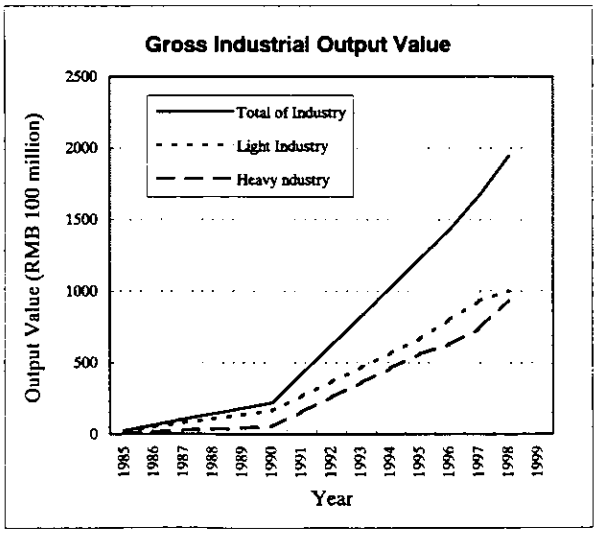
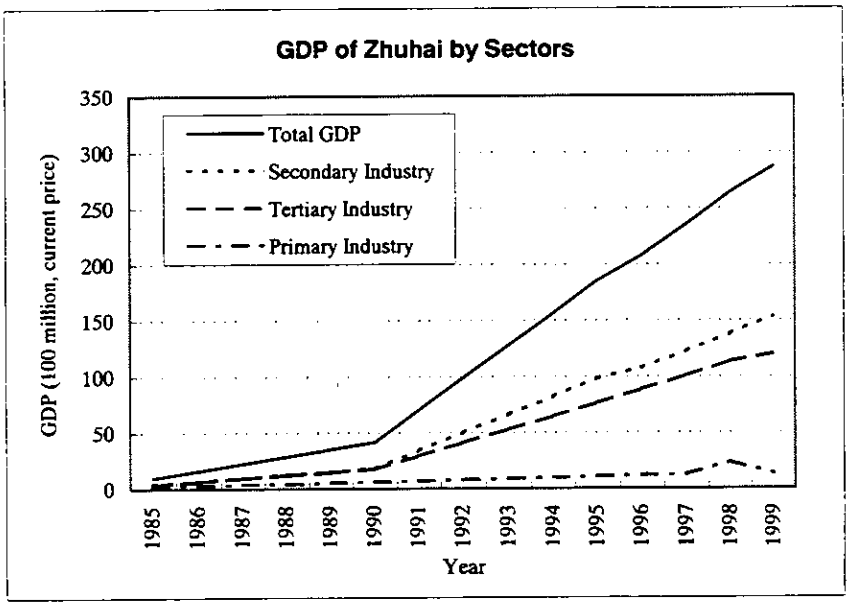
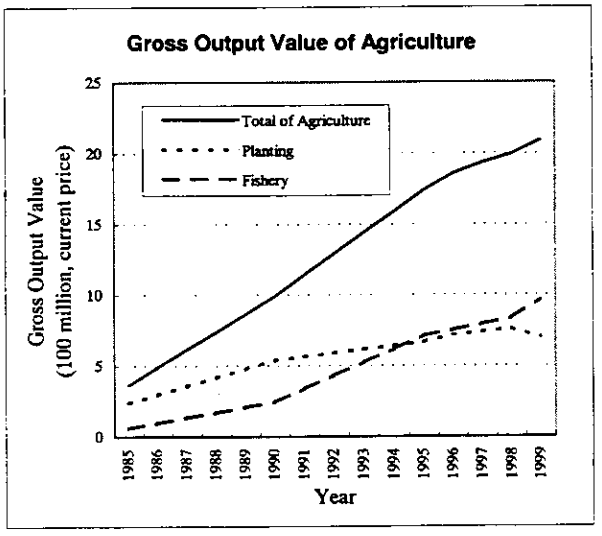
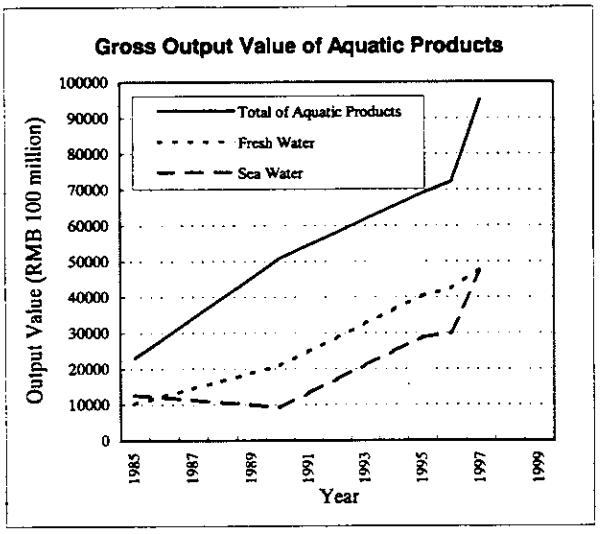


Figure 3.9.2 Economic Development of Shenzhen (1985-1999)







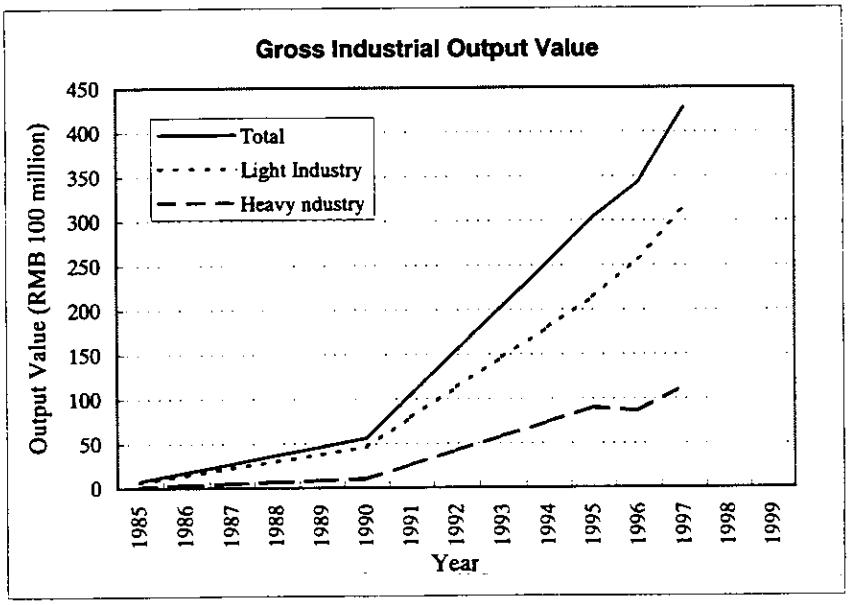
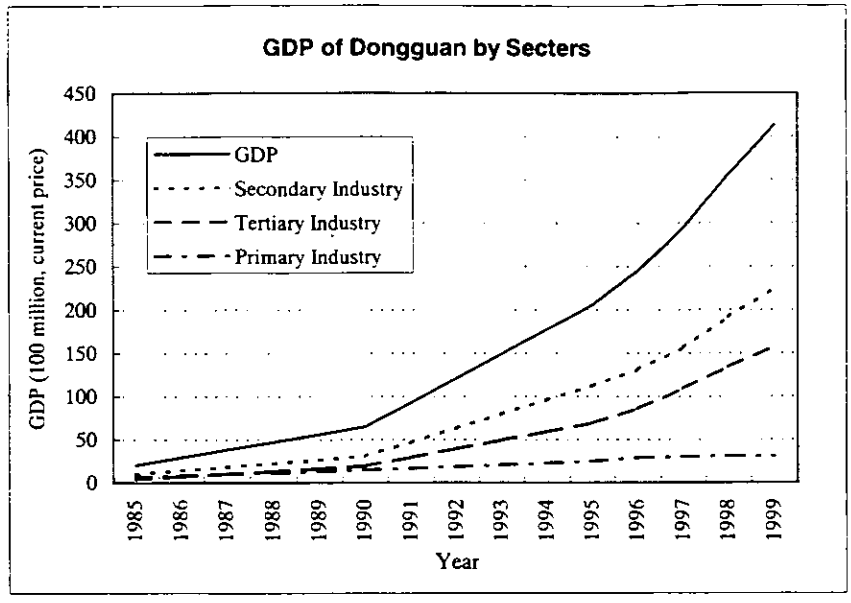
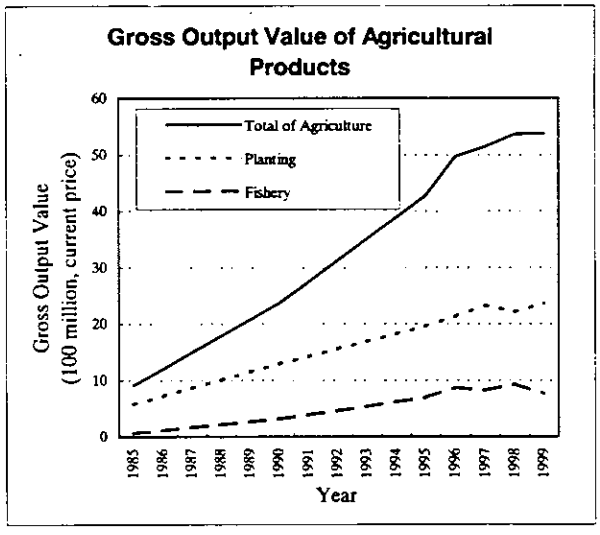
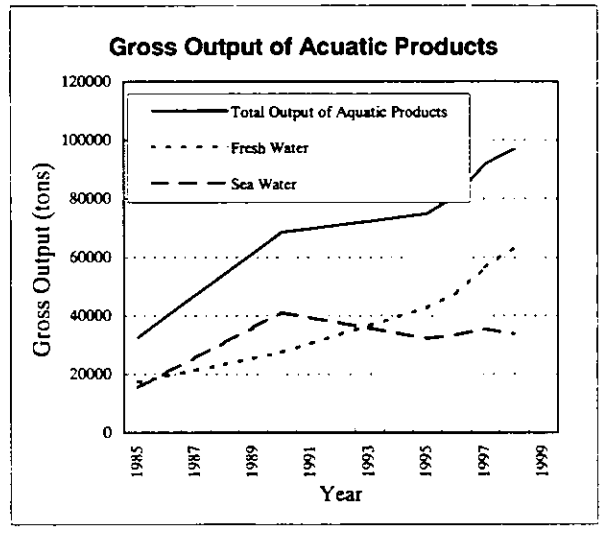
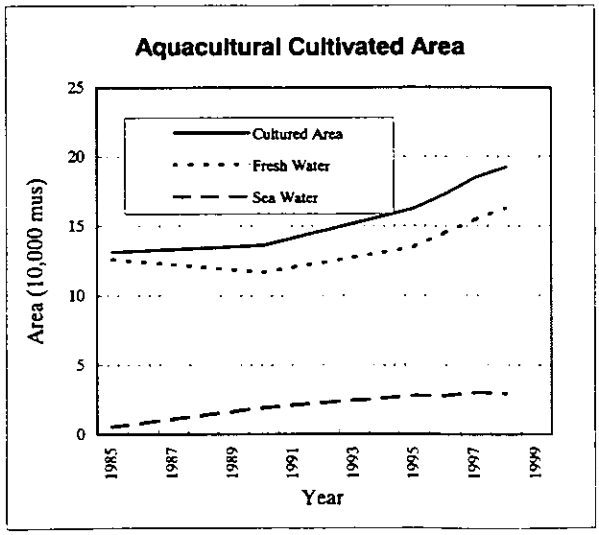


Figure 3.9.3 Economic Development of Zhuhai (1985-1999)









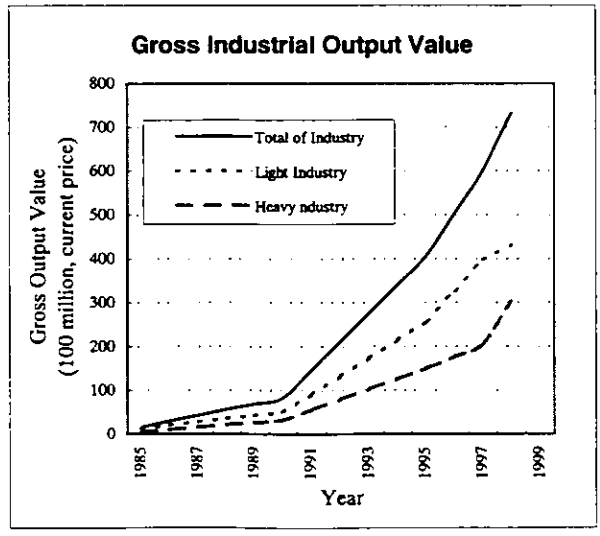


Figure 3.9.4 Economic Development of Dongguan (1985-1999)

3.10 Current Development Plans

The Ninth Five-Year Plan and Tenth Five-Year Plan of China and Guangdong are summarized in Table 3.10.1. In the National Ninth Five-Year Plan, the government stressed importance on economic growth, establishment of the socialism market economy system, and enhancement of science, technology and human resources. The Guangdong provincial government also formulated its plan, following the policy of the central government, and adopted the target figures for each item as objectives of its action plan.

In the Tenth Five-Year Plan, it is notable that the creation of a healthy ecosystem and environmental protection were added to the contents of the previous plan, which did not deal with these matters in detail.

3.10.1. Population

The population of China and Guangdong was projected as being below 1,300 million and 73 million as of the end of 2000, and the annual growth rates were given as less than 0.83 % and 1.5 % in the Ninth Five-Years Plan (*China Yearbook*, 1996, *Nanfang Riban*, Feb. 12, 1996). In the Tenth Five-Year Plan of China and Guangdong, population growth is projected to be below 1.0 % p.a. and 0.95 % p.a. (*Chinese Economy and Society for New Century*, and *Guangzhou Daily*, Feb. 12 and Mar. 7, 2001). In the 2010 Long Term Aim of China, the total population at the end of 2010 is projected to be below 1.4 billion (*China Yearbook*, 1996).

Basic recognition of the government's role regarding the interrelation between sustainable social development and population are: 1) birth control, 2) conservation of national resources and 3) environmental protection. These factors are essential in order to: a) match the population increase to the social development and the increase of production capacity, b) harmonize economic development and the conditions of resources and the environment, c) unify economic and social development, d) promote a healthy cycle of urbanization, and e) achieve the final target of integrated development of human beings. The government's practical policy is as follows (*Chinese Economy and Society for New Century*).

(1) Continuation of strict population control
(2) Improvement of human qualities
(3) Stabilization of present planned childbirth policy
(4) Maintaining low birth rate
(5) Promotion of 'well-childbirth and well-bred'

In conjunction with these central and provincial government policies for population control, each city in Guangdong has formulated their own distinctive plan. For instance, Guangzhou government puts stress on the following items (*Guangzhou Daily* Nov. 21, 2000).

(1) Promotion of planned childbirth in rural areas, especially in the middle and western areas
(2) Enforcement of planned childbirth among immigrants from other provinces

(3) Strengthening of efforts at propaganda, education and setting of regulations regarding planned childbirth
(4) Enhancement of human qualities and health by setting up of Guangzhou Childbirth Service Center
(5) Strict control of floating population
(6) Solving the problems of social security and spiritual and cultural life for elderly people

3.10.2. Economic Development

In the Ninth Five-Year Plan, China set the target figure for GNP as RMB 8,500 billion in 2000, which is four times of that of 1980 (*China Yearbook*, 1996). The GDP annual average growth rate of Guangdong was set as 11 % in the same plan, which was basically achieved in 2000 (10.5 %) as mentioned above (*Guangzhou Daily*, Feb. 21, 2001).

In the Tenth Five-Year Plan, the central and Guangdong governments have advanced economic development, planning one more step compared to the previous plan, by including 1) a shift from a planned economy to a socialism market economy, 2) harmonized development of the three industrial sectors, 3) enhancement of science and technology, and human resources, and 4) dissemination of social security system. Furthermore, the central government is planning to develop the western parts of China and to urbanize the rural areas, with the intention of harmonizing development between urban and rural areas in the new plan. The GDP growth rate of China and Guangdong were set as 7 % and 9 % a year (*Guangzhou Daily*, Feb. 21 and Mar. 7, 2001). The following items are listed in the new plan of Guangdong (*Guangzhou Daily*, Feb. 21, 2001).

(1) Strengthening of secondary industry
(2) Development of new and high-technology industries such as information technology, biotechnology, photo-electronics and new materials
(3) Development of three new core industries of electronics information, electric equipment and petrochemicals
(4) Re-engineering and enhancement of three traditional industries of textile and apparel, foodstuffs and beverages, and construction materials
(5) Developing potential industries such as motor vehicle assembly, pharmaceuticals, paper manufacturing and environmental protection industries

Guangzhou city government has adopted the high GDP growth rate of 12 % (*Guangzhou Daily*, Feb. 16, 2001).

In the 2010 Long Term Aim of China, the target figure of the GNP is set as RMB 17 billion in 2010, which is twice as large as of the GNP in 2000 (*China Yearbook*, 1996).

3.10.3. Environmental Protection

The government has been advancing its policies for environmental protection as an important national undertaking for a long time. But it was not taken up in great detail in planning documents until the Tenth Five-Year Plan, where the

Guangdong government clearly describes its policy for environmental protection, namely to preserve and develop the natural resources, and to strictly control the increase of population. The action plans based on this policy are as follows (*Guangzhou Daily*, Feb. 21, 2001).

1) Speeding up of the progress of the 'Blue Water and Blue Sky Project'.
   (1) Improvement of water and air pollution
   (2) Integrated reform and improvement of the seven rivers (Zhujiang, Dan Shui He, Guan Lan He, Qijiang, Rongjiang, Fengjiang and Xiao Dong Jiang)
2) Construction of sewage treatment plants and solid waste treatment plants
3) Introduction of a control system for total discharge quantity of SO_2 and dust from manufacturing plants, and reduction of the amounts discharged
4) Ending construction of coal-burning power stations in the Pearl River Delta
5) Establishment of regulations to preserve and/or recreate healthy ecosystems
6) Increase the SO_2 discharge tax and the standard fee for sewage discharge
7) Step-by-step realization of construction of sewage and solid waste treatment plants and commercialization of their operation
8) Strict implementation of environmental assessment for new projects
   (1) EIA (Environment Impact Assessment)
   (2) Formulation of a master plan
   (3) Public consultant system and supervising a responsible care system for the important plan
9) Establishment of an environmental monitoring network and cooperation system
10) Establishment of the environmental compensation system to the lower stream area from upper stream area

To implement the above plans, the government is going to allocate the equivalent of 2.5 % of GDP for the expenditure on the environmental protection projects (*Guangzhou Daily*, Feb. 14, 2001).

Table 3.10.1 Socioeconomic Development in '9th 5 Years Plan' and '10th 5 Years Plan'

	National Development Plan		Guangdong Provincial Development Plan	
Basic Policy	・Sustainable national socioeconomic development ・Shift from planned economy to socialism market economy ・Shift from extensive economic growth to intensive economic growth			
Development Plan	9th 5 Years Plan*1	10th 5 Years Plan*2	9th 5 Years Plan*3	10th 5 Years Plan*4
Basic Aim	・Improvement of national economy -Population: < 1.3 billion (annual increase rate; 0.083%/y) -GNP: 4 times of GNP in 80's (8,500 billion yuan at 2000) -Improvement of national living standard ・Establishment of socialism market economy system -Establishment of macro control system and institutional frame work, and improvement of industrial structure -Enforcement of primary industry -Enhancement of infra-structure and core industries -Advancement of economic growth and development of pillar industries ・Enhancement of science and technology, and human resources -Improvement of industrial technology -Dissemination of 9 years compulsory education system -Dissemination of social security system (urban; 80%, rural; 30%)	・Improvement of national economy -Population: Increase rate 1.0% -Annual average growth rate of GDP: 7% ・Enforcement of agricultural fundamentals ・Speed up of reorganization and re-engineering of industry and improvement of industrial structure ・Development of service businesses ・Speed up of development of national economy and social information system ・Enforcement of infra-structure such as water supply, transportation and energy ・Development of western area and promotion of harmonized development between urban and rural areas ・Progress of intensive and gradual urbanization of country areas ・Promotion of scientific and technological development and new creation ・Development of human resources and promotion of education businesses ・Enforcement of population and resource control, ecosystem creation, and environmental protection ・Promotion of restructuring and completion of socialism market economy system ・Enlargement of foreign trade and development of open market economy system ・Enlargement of employment and completion of social security system ・Improvement of urban and rural life style ・Enforcement of creation of socialism and spiritual culture ・Enforcement of creation of democratic socialism institutional regulation	・Improvement of provincial economy -Population: < 73 million -GDP growth rate: 11%/year -Annual growth rate of gross output value Industrial output: 15%/year Agricultural output: 5%/year ・Steady progress of shifting from traditional planned economy system to socialism market economy system -Establishment of macro control system and institutional frame work ・Harmonized development of 3 industrial sectors -Primary industry: 11% (Gross output of foodstuff: 19 million tons/year) -Secondary industry: 51% (Development of 10 core industries, 50 large-scale enterprises and establishment of competitive brand goods) -Tertiary industry: 38% (Value added growth: 11.5%) ・Enhancement of agriculture, infrastructure, and science and technology education -Power supply capacity: 33.64 MKWH -Construction of new road (10,000 km), new railway (727 km) and ship sailing routes and ports -Telephone dissemination rate: 21.8% -The percentage of production output by high-technological industries: >16% ・Creation of big market and development of large scale transportation system ・Creation of wealth material and spiritual life -Dissemination ratio of tapped water and city gas: >98% and 80% -Annual income: 9,600 yuan in urban and 3,500 in rural	・Improvement of provincial economy -Population: < 0.95%/year -GDP growth rate: 9%/year ・Improvement of industrial structure -Enforcement of three pillar industries (electronics, machineries and chemicals) -Enhancement of foreign and local investment for tertiary industry -Enforcement of primary industry Cultivated area: 2.85 million ha Gross output of foodstuffs: 175 million tons ・Progress of construction projects -Five nets: highway, information, water supply, city gas, electricity -Two ways: subway and railway -Two ports: air and sea ports ・Introduction of market competition system to the national enterprises -Introduction of stock sharing system -Shift to market economization -Shift to indirect control ・Progress of 'blue water' and 'blue sky' project -Improvement of water and air pollution -Integrated improvement of important rivers such as Zhujiang, Liu Xi He, Xiao Dong Jiang, Qijiang, etc. -Construction and industrialization of sewage and waste treatment plants -Introduction of total control system of SO_2 and dust, and no more construction of coal power stations in Pearl River Delta -Improvement of the regulations for creation of ecosystem -Enforcement of execution of EIA, etc. -Establishment of environmental monitoring net ・Disclosure of standard prices and expenses

Sources: *1) China Year Book (1996), *2) Chinese Communist Party School Publication, "Chinese Economy and Society for New Century" (2000), and Guangzhou Daily Mar. 7, 2001
*3) Nanfang Riban (Feb. 12, 1996), *4) Guangzhou Daily (February 12, 2001)

4. Existing Marine Environmental Monitoring System

4.1 Institutional Framework of Marine Environmental Monitoring

The primary objective of the study on the existing marine environmental monitoring system of the Peal River Estuary was the identification of the problems and subjects to be improved in the present organizational structure, and the activities relating to marine administration, survey and environmental monitoring. The secondary objective of the study was used this information to formulate a master plan for an optimal marine environmental monitoring system. The study was based on interviews at administrative organizations, the research institutes of the government and universities, and the private association concerned, and was also based on visits to the laboratories, experimental stations and monitoring stations, as follows.

1) Administrative Organizations
   (1) State Oceanic Administration (SOA)
   (2) South China Sea Branch of SOA (SCSB)
      a) South China Sea Environmental Monitoring Center (SCSEMC)
      b) Guangzhou Marine Observatory (GMO)
      c) South China Sea Exploitation Engineering Center (SCSEEC)
      d) South China Sea Information Center (SCSIC)
      e) Shenzhen Oceanic Administration Office of SOA (SOAO)
      f) Zhuhai Oceanic Administration Office of SOA (ZOAO)
      g) Zhuhai Central Marine Station of SOA (ZCMS)
      h) Marine Inspection Nanhai Integrated Corps (MINIC)
   (3) Pearl River Basin Water Resources Protection Bureau of Pearl River Water Resources Commission (PRWRC)
   (4) Guangdong Environment Protection Bureau (GEPB)
   (5) Guangdong Provincial Bureau of Ocean and Fishery (GPBOF)

2) Research Institutes of the Government
   (1) South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Science
   (2) Scientific Research Institute in Water Resources Protection Bureau of Pearl River Water Resources Commission (SRI-WRPB, PRWRC)
   (3) South China Sea Fisheries Research Institute (SCSFI), Chinese Academy of Fishery Science
   (4) Guangzhou Institute of Geography (GIG), Guangdong Academy of Science
   (5) South China National Center of Metrology (SCM), and Guangdong Institute of Metrology (GIM)

3) Universities
   (1) Coastal Ocean Research Center (CORC), Zhongshan University
      a) Institute of Coastal and Estuarine Studies
      b) Institute of Coastal Marine Remote Sensing Application Studies
   (2) South China Teachers University (SCTU)
   (3) Jinan University

4) Association

(1) Guangdong Marine Association and Guangdong Marine and Lake Research Association (GMA, GMLRA)

The study on regulations and institutions for marine environmental monitoring was based on the national and provincial laws, regulations, rules, standards and documentation available in Guangzhou.

Table 4.1.1 introduces the organizations involved in marine environmental monitoring in Guandong, their level and nature of staffing and their major duties and accomplishments to date. Below are the objectives of the above entities as well as the interrelations of each organization. Information on present, planned and desired equipment at each organization is presented in tables, as noted.

State Oceanic Administration (SOA)

The State Oceanic Administration (SOA) was established as the State Council responsible for the management of national marine affairs. It was originally under the National Scientific and Technical Committee. In March 1998 it was shifted so as to be under the Division of Land Resources, which is one of the 29 National Committees.

SOA is charged with the responsibilities and tasks in the four fields of 'rights and interests, resources, environment and disaster mitigation' so as to achieve the goal of the unity of the marine economic, social and environmental benefits.

The present organization framework of SOA is shown in Figure 4.1.1. The number of officials at all of these levels totals about 10,000. The number of government officials in SOA headquarters has been decreased to about 100 by the recent restructuring.

South China Sea Branch of SOA (SCSB)

South China Sea Branch of SOA (SCSB) is the SOA's agency station in Guangzhou, and is responsible for the marine administration of the South China Sea. SCSB guides, coordinates and supervises marine management in Guangdong, Guangxi and Hainan. It carries out marine monitoring, surveys, disaster prevention measures, and more as state-assigned missions, and also provides services and supports to various public and private sectors for the development of the local economy.

The organization of SCSB is shown in Figure 4.1.2. It has four subordinate units, namely the South China Sea Environmental Monitoring Center, Guangzhou Marine Observatory, South China Sea Exploitation Engineering Center and South China Sea Information Center. Most of the scientists work in the fields of marine hydrology, chemistry, geology, meteorology, biology, equipment maintenance, communication, etc.

Since 1975, the SCSB has been surveying the marine hydrology in South China Sea. For eight years, coastal areas were surveyed, and for five years surveys were done around the islands in South China Sea. Notable surveys are the three surveys on the seawater quality of the Pearl River Estuary, with cooperation from the Hong Kong Government (since 1995). The data from the

survey comprise the base data showing the present environmental situation in the Pearl River Estuary.

South China Sea Environmental Monitoring Center (SCSEMC)

South China Sea Environmental Monitoring Center (SCSEMC) was originally one of the divisions in SCSB of SOA. In 1976 it started regular marine environmental monitoring and analysis of the presence of oil, heavy metal, radioactivity and other items in seawater, sediment and marine organisms. After SCSEMC separated from SCSB as the executive unit responsible for monitoring the marine environment, it was entrusted with routine monitoring works and surveying works, not only by the government but also by private enterprises.

With regard to the regional scope of work, the environmental monitoring works for the three sea areas of China are performed by three marine monitoring centers as follows.

1) North China Sea Environmental Monitoring Center in Qingdao, that works in the northern sea areas of Chang Jiang (Yangzhu Jiang).
2) East China Sea Environmental Monitoring Center in Shanghai, that works in the sea areas from Chang Jiang to Taiwan.
3) South China Sea Environmental Monitoring Center in Guangzhou, that works in the southern sea areas of Taiwan.

At the national level, the competent departments and monitoring centers sharing marine environmental monitoring work are as follows.

1) The Department of Agriculture is responsible for the sea areas where fishing and aquaculture is carried out.
2) The Monitoring Center of Navy is responsible for the sea area of naval ports.
3) The Department of Port Administration is responsible for the sea area of general ports.
4) The three Environmental Monitoring Centers of SOA are responsible for the other sea areas as noted above.

Existing equipment possessed by SCSEMC is listed in Table 4.1.2. Recently, the Chinese Government invested RMB one million to the center for new equipment for oil analysis, and an electron microscope for research on red tides and other subjects in conjunction with the revision of National Marine Environmental Protection Law (see Table 4.1.3). The center desires to acquire the additional equipment, listed in Table 4.1.4, in the future in order to enhance its capacity for monitoring and survey work, and to expand its provision of services.

Guangzhou Marine Observatory (GMO)

SOA has three marine observatories, one each in Qingdao, Shanghai and Guangzhou. The Guangzhou Marine Observatory (GMO) was established as one of the institutes of the SOA. GMO aims to prevent and reduce marine disasters and to serve to the economic development of the South China coastal area. Its scope of service includes marine environment forecasts, natural environment conditions assessment, marine disaster assessment, etc.

GMO has 56 employees at present, working in the fields of marine hydrology, marine meteorology, fluid mechanics, computers and communication, etc.

The existing main equipment and current investment plan for new equipment of GMO are listed in Tables 4.1.5 and 4.1.6. There is a problem in that the NOAA image receiver has been damaged, but it should to be repaired this year. GMO wants to have a software program for processing NOAA remote sensing data and GIS data, in order to improve the services for its clients (see Table 4.1.7).

South China Sea Exploitation Engineering Center (SCSEEC)

The South China Sea Exploitation Engineering Center (SCSEEC) was recently set up by merging the South China Sea Marine Survey Technical Center and South China Sea Buoy Data Center. The South China Sea Marine Survey Technical Center was established in 1973 by merging the South China Sea Survey Team, the South China Sea Geological Laboratory, and the technical unit in the survey division of the marine surveying ship, 'Xiangyanghong No.5',. The center thus has 27 years experience in marine surveying engineering.

The specialties of the professional staff members are in the field of marine dynamics, marine meteorology, geological monitoring, chemistry, biology, and buoy data collecting technology.

The existing equipment, the current investment plan for new equipment and the equipment that the SCSEEC wants to acquire in the future, are listed in Tables 4.1.8, 4.1.9, and 4.1.10, respectively.

South China Sea Information Center (SCSIC)

The South China Sea Information Center (SCSIC) was established as the Document Center of SOA. In 1991 its name was changed to South China Sea Marine Information Center. In 1997 the name was changed again to its present name.

Existing equipment, the current investment plan for new equipment and the equipment that the SCSIC wants to acquire in the future are listed in Tables 4.1.11, 4.1.12, and 4.1.13, respectively.

Shenzhen Oceanic Administration Office of SOA (SOAO)

The Shenzhen Oceanic Administration Office is a political executing agency unit under the South China Sea Branch of SOA. It has a business unit, the Chiwan Monitoring Station, which is administered by SOAO, and the routine jobs are led by the Zhuhai Central Marine Station.

Its main duty is marine pollution control. In a case of oil leakage from a ship, SOAO officials go to the site of the accident, and report the situation to SCSB of SOA. The work of collecting, restraining and removal of leaked oil, etc. is normally carried out by Marine Affairs Bureau of Transportation Department in such cases.

The challenge that SOAO is now concentrating on is illegal waste dumping in sea areas. For surveillance of waste dumping, SOAO carries out sea patrols on an irregular basis, jointly with Fishery Administration and Ocean Supervision

Sub-brigade of Shenzhen city government. Zhuhai Oceanic Administration Office also patrols a certain sea area in the Pearl River Estuary. There are 20 industrial plants in Chiwan, and these plants discharge 3,000,000 m^3/year of industrial waste. Administrative work, such as issuing permits to the plants for waste dumping, is also included in the duties of SOAO.

SOAO faces the problem that their monitoring equipment in Chiwan Monitoring Station is aging and becoming out of date. The need has arisen to replace the equipment with new and automatic equipment. The equipment that is desired for future acquisition is listed in Table 4.1.14.

Zhuhai Oceanic Administration Office of SOA (ZOAO)

The function of the Zhuhai Oceanic Administration Office (ZOAO) is almost same as that of the Shenzhen Oceanic Administration Office.

There is no big problem of environmental pollution and waste dumping here because the city government is very strict in its control of the construction of manufacturing plants. This Office also patrols certain areas of the sea together with the Fishery Administration and Ocean Supervision Sub-brigade of the Zhuhai city government. If there has been illegal waste dumping, they investigate the operation of the suspected vessel by checking its voyage data recorder (black box). The office is particularly concerned with illegal dumping by small vessels, because the quantities involved are small.

Zhuhai Central Marine Station of SOA (ZCMS)

Zhuhai Central Marine Station (ZCMS) controls four local monitoring stations, Chiwan (in Shenzhen), Wanshan, Kaipo and Naozhou

The local environmental monitoring stations monitor the general hydrological and meteorological items three times a day, and report the data to ZCMS every day. They take a seawater sample once a month and analyze COD, DO, pH, and salinity at the local environmental monitoring stations. They also take samples of dredge mud, which is sent to SCSEMC of SOA for analysis of heavy metal, oil and organic carbon.

They collect all the data from each monitoring station, and report the data to GMO of SOA by the Internet. The data are sent to Beijing, and are used for marine forecasts and broadcasts on radio and TV. All the data are compiled in a list every month and the original list is sent to the SCSIC of SOA.

The monitoring equipment of the ZCMS, which are listed in Table 4.1.15, are rather new compared to what is available at the Chiwan Station. They have an automatic sea-surface level gauge and the data are automatically transmitted to the computer in the office. This enables the officials to observe the data in real time. They are going to acquire test equipment for an automatic hydro-meteorological observation system, as shown in Table 4.1.16. They wish to acquire some new equipment for better marine monitoring, as shown in Table 4.1.17.

Marine Inspection Nanhai Integrated Corps (MINIC)

Marine Inspection Nanhai Integrated Corps (MINIC) is under the control of the Marine Inspection Integrated Corps of SOA and the SCSB of SOA. The

present staffing level is 14. Its duties are administration and inspection in all areas of the South China Sea. Law enforcement and administration of activities on sea areas are included in its administrative tasks. Littoral areas and air spaces are included in the scope of control. In littoral areas, the corps controls illegal waste dumping, illegal exploration of mineral resources, illegal activities by foreigners, etc.

Under the control of MINIC, the Coastal Air Corps for Law Execution and Inspection is patrolling its territory for 100 hours a year using two planes. They are going to purchase one helicopter next year.

Pearl River Basin Water Resources Protection Bureau of Pearl River Water Resources Commission (PRWRC)

The Pearl River Water Resources Commission (PRWRC) was set up as an agency under the Ministry of Water Resources. The commission is responsible for water administration in the six provinces (450,000 km^2) of Yunnan, Guizhou, Hunan, Jiangxi, Guangxi and Guangzhou, where the Pearl River traverses, Hujiang, where the Hanjiang River runs, and Hainan. It covers 796,300 km^2 in total.

PRWRC has conducted many projects with the cooperation of such foreign countries as France, Holland, Portugal, Thailand, and Bangladesh.

The Pearl River Basin Water Resources Protection Bureau (PRWRPB) of PRWRC plans water resources development and management, monitors water resources, performs quality control of water resources. It also undertakes administrative activities, primarily related to water utilization. All of these activities are under the guidance of the Ministry of Water Resources and the National Environment Protection Bureau.

The planning of city water supply for Guangzhou is now underway, and others have been completed. The most important study theme of the Ministry is the causes of environmental pollution in four eastern estuaries of the Pearl River.

The Water Resources Monitoring Center of PRWRPB collects a great quantity of water quality data and provides them to the Ministry of Water Resources. The Water Resources Protection Scientific and Technological Institute of PRWRPB has a numerical simulation model for 18 quality items, such as COD, BOD, T-N, T-P, etc. in the area of the Pearl River Estuary.

According to the Commission, the areas of Guangdong have enough quantitative water resources, except for the areas of Zhanjiang Peninsula and Hainan Island, where rainfall is low. The practical control of the city water supply is by a private company. The sewerage control is done by each regional city and the water discharge control from the plant to rivers is basically the concern of the Department of Water Resources. These systems are different in each city and district.

The Commission is in continuous, close contact with SCSB and has carried out its activities with good relations with SCSB for a long time.

Guangdong Environment Protection Bureau (GEPB)

Guangdong Environment Protection Bureau (GEPB) is one of the organizations of the Guangdong Provincial Government responsible for environmental protection, and for controlling and leading the executive departments of the province's municipalities.

In Guangzhou, environment protection measures are implemented by GEPB as well as the Planning Bureau, the Natural Resources Bureau, the Marine Administration Bureau, SOA, the Department of Fishery, the Water Resources Commission, and the Department of Land Resources.

GEPB and SCSB do not utilize the marine hydrological and environmental data that each other generates unless a major problem arises. GEPB provides its own data to National Environment Protection Bureau (NEPB) as the marine environmental data, and SCSB provides its data to SOA as marine water quality data. The river water data (including water flow speed and total pollutant quantities) and the pollution sources data collected by GEPB are provided to the other when so decided by the NEPB. If SCSB want to use GEPB's data, SCSB has to request it to GEPB by submitting a data item list and information on the objectives of data utilization. GEPB reports the request to NEPB, and NEPB replies with its decision. GEPB bought land use information data, analyzed using remote sensing technology, from the Land Resources Bureau. According to GEPB, the price was very expensive. It is very common here that even if both the user and supplier of data are government institutes, the user is charged for the data except in the case of cooperative projects organized by the government.

GEPB has the Guangdong Environment Protection Monitoring Center (GEPMC) as a subordinate unit, the same as SCSB of SOA. GEPMC is equipped with latest models of AAS, GC, ion chromatograph, Poralo-graph, water purifier, etc.

Guangdong is a sister province with Hyogo Prefecture in Japan. The water purifier has been supplied by Hyogo Prefecture in connection with a technical cooperation scheme. One official at the GEPMC has studied in a JICA training course and can speak Japanese well.

In the Guangdong Government office building, where the headquarters of GEBP and GEPMC are, there is the head office of Environment Industries Association. The Association is a private business unit led by GEPB.

Guangdong Provincial Bureau of Ocean and Fishery (GPBOF)

a. Function and Administration Activities

Guangdong Provincial Bureau of Ocean and Fishery (GPBOF) is an administration organization of the Guangdong provincial government, responsible for the comprehensive administration of marine areas, control of fishery industries, and sustainable development of ocean fisheries. They are carrying out the work of marine administration, putting emphasis on the harmonization of environmental protection and economic development.

There are in GPBOF the Resources and Environment Administration Office and the Environmental Monitoring Center. Local coastal city governments also have environmental-monitoring stations for water quality observation

and resources-monitoring stations for marine resources observation. Among the monitoring stations, the Guangzhou Central Station is the biggest and the second is the Shenzhen Station.

The National Fishery Law was revised on December 1, 2000 by the addition of 15 articles. For instance, in Articles 19 and 20 of the revised Law, it is prohibited for fisheries to use feed containing toxic and hazardous materials or to cause the environmental deterioration in sea areas, and scientifically sound cultivation density, feeding, fertilizing, and chemical-feeding are obligatory in aquacultural areas. Other changes included adding some items, such as the issuance of certificates for fisheries (in Chapter 3 of the law) and the prohibition of using electricity for fishing (in Chapter 4 of the law). These changes have been added to the original law for conservation of marine resources. GPBOF has the responsibility of enforcement of this law in its territory of jurisdiction.

b. Fishery Industry in Pearl River Estuary and Development Project

The Fishery Division of GPBOF administers aquatic industries and manages projects for the development of the fishery industry in the Pearl River Estuary.

The Pearl River Estuary is richly endowed with biological resources, and there are some natural conservation areas, such as for mangroves and bird life conservation (Nailingding Dao) and white dolphins (mouth of the Pearl River Estuary), etc. Preservation of ecosystems is one of the important duties of GPBOF. The mariculture area under its jurisdiction is 50,000 hectares, and the output of cultivated sea fish is 400,000 tons in the Pearl River Estuary alone, which is one quarter of the total output in Guangdong. The output of cultivated freshwater and marine fish is half of the total for Guangdong. The estuary has a twenty-year history of net-fish cultivation. Its output was a third of the province's total at its peak, but is currently dropped to one quarter. Oysters are mainly cultivated in Shenzhen, Zhuhai and Dapeng Wan, and are the object of active development efforts in Yangjiang, Taishan, Zhanjiang, and elsewhere. The oyster cultivation area in the Pearl River Estuary is 30 % of the total for Guangdong, but the output is only 10 %. The cultivated area and output of prawns are 10 % of those of Guangdong.

The government specifies the sea area for aquatic industries. Within the specified area anyone can do any business by applying for and getting permission from the government.

The Daya Wan Aquatic Products Fry Breeding Center, which belongs to the GPBOF, researches yellowfish fry breeding. GPBOF funded RMB 20 million for this project, and provided the land and constructed the building and access road, etc. This project is being implemented with cooperation by the Fishery Cooperation Association in Japan. The Japanese association supplied special equipment and supported the center in fry breeding technology. The project was commenced in 1996, the center was opened officially on August 13, 1997, and the project was completed at the end of March 2001. After the termination of the Japanese Association's assistance, the center will continue the research and contribute to the development of the fisheries industry.

c. Assistance to Private Enterprise Activities

There are many private associations related to aquatic products industries in Guangdong, including the Fishery Research Association, Turtle Research Association, Eel Research Association, Prawn Research Association. These associations seem to be set up separately for each kind of aquatic product. These associations are not cooperative associations but research associations. They do not have a close relation with any governmental administration organization, and are carrying out their activities independently from the governmental administrative activities. The government sometimes utilizes these associations for the dissemination of information on its policies to the individual fishermen and private fisheries enterprises, but basically communicates directly with them through special governmental administration lines.

Governmental assistance to individual fisheries and private fishery enterprises is not strong. Marine environmental protection activities are not considered as assistance to the private sector, but as routine control works to achieve the objectives provided by Law. The government does not financially assist private projects directly, but indirectly assists the private sector by funding such practical projects organized by government as construction of fisheries ports, research and technical development of aquaculture industries, environmental countermeasures, and so on.

d. Red Tides in Pearl River Estuary

Red tides occur frequently in the Pearl River Estuary; they have been recorded 20 times in the past. Before 1995, they were rarely observed in the Pearl River Estuary, but were mainly observed in Dapeng Bay. In early 1998, the biggest red tide known spread over the entire estuary and the Hong Kong sea-area. The economic loss caused by the red tide was calculated as RMB 40 million (RMB 200 million including Hong Kong). The major genus of algae in the red tide was Dinophyta. The investigation of the cause of red tide is one of the important tasks of the GPBOF.

In January 2000, a red tide was observed around Wanshan Dao. No blue tide has been observed so far, but a water mass with low DO was observed once near Wanshan Dao.

South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Science

South China Sea Institute of Oceanology (SCSIO) was established in Guangzhou as one of the institutes of the Chinese Academy of Science. The other institute is in Qingdao.

SCSIO has accomplished numerous projects in the field of marine environment, biology, ecology, biological resources, and oil and gas resources during its 40 years of operation. It has accomplished many research studies regarding the Pearl River Estuary.

The existing equipment of SCSIO is listed in Table 4.1.18. There is no topographical miniature model of the sea and land area, but Qingdao Institute has one. At present, they do not feel it is necessary for their basic research.

Most of the research expenses are met by a governmental budget allocation. In the case of big project, a research fund is set up for the purpose.

In the south China area, there are two research associations named the Guangzhou Marine Association and Marine and Lake Research Association. The head of SCSIO is the chairman of these associations, and the heads of SCSB of SOA and SCSEMC are the vice-chairmen. The Guangzhou Marine Association is one of the branch associations of the China Marine Academy. In the case of the technical meeting with the Taiwanese counterpart association, SCSIO represents Mainland China.

Joint research projects with other institutes are sometime organized on special themes; this is done especially with the institutes and monitoring center in Qingdao, Huizhou and Dalian. Contact with other institutes is not frequent. Regarding co-research with oversea institutions, Qingdao Institute has contacts with Korea and Japan, and Guangzhou Institute has a relationship with Taiwan.
SCSIO desires to have joint research projects with Japan from now on. The themes, which are now under study by the institute and relate closely to Japan, are research on the Black Current, and research on the sea waves under typhoon conditions and the course of the typhoon by use of satellite images. In future, the Institute wants to have co-research projects with Japan on such subjects as marine botanical pharmaceuticals and marine biology. SCSIO has a history of thirty years of work in the field of biological research and technological development, and has its own pharmaceutical laboratory.

Scientific Research Institute in Water Resources Protection Bureau of Pearl River Water Resources Commission (SRI-WRPB, PRWRC)

The Scientific Research Institute in WRPE of PRWRC undertakes studies in the exploration and exploitation of water, hydropower, water transport and estuary beach land, providing a scientific basis and practical foundation for the planning and designing of construction projects. The institute also works for foreign and domestic economic sectors by carrying out scientific research, technical cooperation, technological development, technical consultation and technical services.

The Hydraulic Research Divisions have an experimental field of 60,000 m^2. Notable in the experiment field is the Grate-size Tidal Estuary Modeling in the Lishui experimental bases in Nanhai. It is quite wide, with a scale of 1/700 in horizontal section and 1/70 in vertical section of the actual area, and covers from Humen in Dongguan to Hong Kong and Macao. This model is used for collecting the data for design and environmental impact assessment requirements, as requested by the central and/or provincial government, when they have a big project in the Pearl River Estuary. It was constructed in 1996, and since completion five tests have been carried out on it. One more test was planned for 2000, but was postponed by the client. The Institute has another test plan for water flow control of eight big rivers in the Pearl River Delta, aiming to prevent flooding. To conduct the test, it is necessary to have topographical data for the land area.

The Institute has developed a numerical hydrodynamics simulation model for the Pearl River Estuary. The model covers the Estuary but not the rivers in the land area; expansion of the model to include the rivers is to be done in the future. The Institute also intends to develop an analysis method integrated with a numerical and physical simulation model.

South China Sea Fisheries Research Institute (SCSFI), Chinese Academy of Fishery Science

The South China Sea Fisheries Research Institute (SCSFI) was set up as an integrated scientific and technical institute, with the objectives of applying modern science and technology to sustainable fisheries production, and developing aquatic resources in the South China Sea areas. It is now under the jurisdiction of the Chinese Academy of Fishery Sciences of the Agriculture Ministry, and undertakes major scientific research projects of the State and Ministry, resolves critical technical problems, provides its research results to interested parties, promotes academic exchanges, and serves for the modernization of fisheries.

The institute studies environmental protection for aquaculture, as well as studies protection measures for environmental pollution caused by aquacultural activity.

The head of SCSFI, who is a specialist on the environment, is one of the committee members on the Red Tide Research Center in Guangdong. The head of SCSFI is a representative of the Guangdong in the National Fisheries Association in Beijing, and the Guangdong Fisheries Association in Guangdong.

Individuals and private companies, representing a variety of marine and freshwater products, have organized many business associations to protect their interests. Some of the associations, such as the Fish Feed Association, have commissioned research work to the institute.

Guangzhou Institute of Geography (GIG), Guangdong Academy of Science

Guangzhou Institute of Geography (GIG) was established under the provincial government, and belongs to the China Academy. The head of GIG is the chairman of the Guangdong Geology Association. As the national level, there is the China Geology Association.

The remote sensing technology developed by the Guangdong Remote Sensing & GIS Center (GDRGC), in the GIG, has been highly evaluated and is used in many fields. GDRGC has already completed a digital map of the Guangdong area, but it is still only for internal use. The land use plan in their GIS was obtained from the National Environment Protection Bureau.

South China National Center of Metrology (SCM), and Guangdong Institute of Metrology (GIM)

South China National Center of Metrology (SCM) belongs to the China State Bureau of Quality and Technical Supervision, and Guangdong Provincial Bureau of Technical Supervision. SCM is a second-class metrology center and one of the seven administrative large regional metrological organizations of China. SCM always takes part in the preparation of national primary standards and standard measurement methods, because SCM is recognized as having high technological capability. These standards are equivalent to the National Institute for Metrology in Beijing (NIM) and the International Bureau of Weights and Measure in Paris (BIPM), and conforms to international standards.

SCM has been awarded the Certificate of Laboratory Accreditation (equivalent to ISO/IEC Guide 25) by the China National Accreditation Committee for Laboratory (CNACL) and the Hong Kong Laboratory Accreditation Scheme (HOKLAS). Shenzhen Institute of Metrology (a third class institute) has also been awarded the certificate by CNACL. In the south China area, only two institutes, in Guangdong and Shenzhen, have the certificate at present. Foshan and Shantou Institute of Metrology (third class) are currently preparing to apply.

SCM has nine laboratories and one administrative office. The number of staff is 150; two-thirds are assigned to measuring work and one third are in personnel and administration section.

Center for Coastal Ocean Sciences and Technology (CCOST), Zhongshan University

In Zhongshan University (originally named Ling-nan University), there is a Department of Global and Environmental Science, which has the Center for Coastal Ocean Sciences and Technology (CCOST). The center consists of six institutes; among the institutes are the Institute of Coastal and Estuarine Studies and the Institute of Coastal Marine Remote Sensing Application Studies.

a. Institute of Coastal and Estuarine Studies

The Institute of Coastal and Estuarine Studies set up the Pearl River Estuary Integrated Observation System (PEIOS) project, in January 1999, which was scheduled to be completed by the end of 2000. In the project, many samples were collected and analyzed from the mouth of eight rivers, coastal areas and the whole area of the Pearl River Estuary. Based on the data, a simulation model, for investigating such environmental parameters as SS, DO, and COD, and a displaying system for demonstration, are under being developed. The base data that were collected by the Hong Kong government were not included, because it was very difficult to obtain that data from the government or the private consultant who did the work under contract. In the simulation model, the point source data of polluters and biological analysis are excluded.

CCOST thinks that their model is rather academic, and that a model for practical use should be studied by organizations such as SCSEMC, GMO and others, and that the latter model should be developed by the close communication and cooperation of each body.

b. Institute of Coastal Marine Remote Sensing Application Studies

The Institute of Coastal Marine Remote Sensing Application Studies (ICMRSAS) was set up in 1989 for research in the fields of marine geology and topography. The institute uses remote sensing technology.

The institute has been in contact with Dr. Murai, of Tokyo University in Japan, since early in its history. Recently, the institute was selected by the government as one of ten institutes to do a commemorative project of 'China 21 Century's Marine Year' program. ICMRSAS was the only institute selected from the south China area.

ICMRSAS has studied a wide area in the northern part of China, regarding subjects such as desertification, and a narrow area in the southern part of

China regarding subjects such as aquaculture. The institute has studied many subjects about the coastal area of Guangdong, because the area is close to the institute and special in topography. They applied special technology in the study around the coastal sea area of Guangdong. For example, the institute studied a seaweed in Daya Bay that flourishes at the water induction point of the nuclear power station and interferes with smooth operation of the power station. The institute improved the accuracy of analyzing the seaweed by deleting the green wavelength caused by chlorophyll-a from the data of the satellite image.
Another notable study by the institute was on the effect of gases, such as SO_2 and NO_X, in the land area. The results of the sudy were scheduled to be reported in an academic journal at the end of 2000.

South China Teachers University (SCTU)

The South China Teachers University was set up in 1936. The University was selected as one of the one hundred universities of China in the '2.1.1. Project' conducted in 1996. There were four universities selected from Guangdong: Zhongshan, Jinnan, Huanan Technology and SCTU.

There are no special environmental science and marine science courses, but the Institute of Environmental Science was established in 1988, and started the research, development and education of environmental technology. It has nine teachers, including a specialist on water pollution, and has an exchange program with universities in Hong Kong.

In Guangdong, SCTU is charged with environmental science, Zhongshan University is charged with environmental geography, Jinan University is charged with environmental biology and Huanan Technology University is in charge environmental technology and engineering. Zhanjiang Oceanology University is charged with the marine environment. Besides the normal research and education activities at the Institute of Environmental Science, it sponsors public lectures and edits textbooks regarding the environment.

In addition, there is a college related to environmental biology, where 500 students (200 of these students are studying environmental science, environmental protection, environmental control, etc.) are enrolled. Graduates of the college do not become teachers; about 70 % of them find a job in pollution control and monitoring in enterprises, and 30 % go to governmental institutes. Two graduates are working in Guangzhou Environmental Monitoring Center.

Institute of Hydrobiology (IHB-JU), Jinan University

Jinan University has six departments, including the Life Science and Technology Department, which consists of six courses or institutes, Biology, Chemistry, Institute of Hydrobiology, Biomedical Engineering, Bio-botanical Immunity, and Bioengineering. The institute provides post-graduate courses only; there are no undergraduate students. Only about 20 % of the graduates from the institute go to work for private enterprises, as most of the graduates remain in the university or find their jobs in the governmental institutes.

The research subjects of the Institute include red tides, fish species in rivers and lakes, bio-plankton and bio-production simulation. Professor Qi Yu-Zao in the institute is recognized as the No. 1 researcher in China in red tide research.

As for research associations relating to bioscience, there are the Guangdong Marine Association, Guangdong Marine and Lake Research Association, Guangdong Botanic Association, Guangdong Zoo Association, Guangdong Fishery Association, Guangdong Ecological Research Association and others. The former Algae Research Association has been absorbed by the Marine and Lake Research Association. The Guangdong Botanic Research Association publishes *The Journal of Tropical and Subtropical Botany*. Professor Qi Yu-Zao is one of the managing editors of the journal.

The Institute has a technical exchange program with Tokyo, Kitazato, Nagasaki, Hiroshima, and Mie universities (all in Japan), and Professor Qi is a member of the Bacillariophtceae Research Association and the Algae Research Association in Japan.

Guangdong Marine Association and Guangdong Marine and Lake Research Association (GMA, GMLRA)

There are two associations related to the marine environment in Guangdong; the Guangdong Marine Association and the Guangdong Marine and Lake Research Association. These two associations are independent. They registered separately to appropriate organizations of the central government, the former to SOA about 20 years ago, and the latter to the China Academy of Science about 40 years ago. These associations are voluntary, general public and academic organizations, and differ from political organizations, such as the Labor Union and Ladies Association, which are under the control of government.

The associations were set up for the purpose of mutual connection and close communication of the members. Its roles are unity of researchers, provision of technical information services to members, and education of marine affairs to the leaders of private enterprises and government officers. Through their activities, the associations contribute to the development and progress of marine projects and the enhancement of human resources.

Operating funds are obtained mainly from other organizations, donations from enterprises, income from consultation and commissioned work, and membership fees.

The Associations have two divisions; a specialist subcommittee and an executive subcommittee. They are going to set up an environmental protection subcommittee that will cover the entire area of the South China Sea. They also want to have a technical interchange with the Setonaikai Environmental Protection Association.

Table 4.1.1 Details of the Organizations Relating Marine Environmental Monitoring in Guangdong (1/6)

No.	Name	Establishment	Number of staff	Organization	Major duties	Recent notable researches, investigations, and activities (year)	Remarks
4.1.1	State Oceanic Administration (SOA)	1964	10,000 (Head office; 100)	See Figure 4.1.1	1) Safeguard of marine rights and interests. 2) Management of the sea area use. 3) Coordination of the development of resources. 4) Protection of the marine environment.	1) The Black Current and its source (1986-1993). 2) An ecological preservation study with the cooperation of the Japan Environmental Agency (1997). 3) Revision of The National Marine Environmental Protection 4) Staff training, study of shipping lanes, and research on mareculture as projects of the 20th anniversary of China-Japan Technical Cooperation (2000). 5) Review of the National Marine Environment Protection	
4.1.2	South China Sea Branch of SOA (SCSB)	1965	700 (Head office; 70)	See Figure 4.1.2	1) Marine administration of the South China Sea. 2) Guidance, coordination and supervision of marine management in Guangdong, Guangxi and Hainan. 3) Marine monitoring, surveys, disaster prevention measures, and more as state-assigned missions. 4) Services and supports to various public and private sectors for the development of the local economy.	1) Survey of volcanic ash dispersed by eruption of a volcano in the Philippines, together with Hamburg University (1991). 2) Investigation of the source of the Black Current, with the cooperation of Hiroshima University and the three SOA oceanographic institutes, in Qingdao, Hangzhou, and Xiamen (1994 3) Three surveys on the sea water quality of the Pearl River Estuary, with cooperation from the Hong Kong Government (since 1995). 4) Hydrological and meteorological study related to the formation of typhoons, with cooperation from a university in Taiwan and Hiroshima University (1999). 5) Review of the National Marine Environment Protection Law.	
4.1.3	South China Sea Environmental Monitoring Center (SCSEMC)	1976	86 Senior engineer; 19 Engineer; 41 Assistant engineer; 13	See Figure 4.1.2	1) Routine environmental monitoring for the area of South China Sea including the Pearl River Estuary. a) Coastal area: three times a year. b) Ocean area : two times a year. 2) Special researches and surveys. a) Tidal currents. b) Seawater quality around waste dumping places. c) Seawater quality in the case of accidents. 3) Environmental impact assessment for the construction of waste dumping places and other general construction in sea areas. 4) Publication of environmental pollution levels by using mass-communication. 5) Staff training for regional monitoring centers in different provinces and cities.	1) Research and survey on red tides, for the Red Tide Fund. 2) Survey on environmental pollution in the Pearl River Estuary, with cooperation by Hong Kong. 3) Validation of the simulation model, prepared by Hong Kong. 4) Study on the Longgu Channel. 5) Study on heavy metal in seawater, living organisms, and sediment.	1) Awarded certification a) The Certificate of Metrology in the Field of Marine Environmental b) The Certificate of Metrological Authorization (Third grade) c) the Certificate of Environmental Impact Assessment (First Grade) d) Under preparation of ISO 9002 application
4.1.4	Guangzhou Marine Observatory (GMO)	1977	56 Professor; 1 Senior engineer; 10 Engineer; 29 Assistant engineer; 8 Accountant; 1	See Figure 4.1.2	1) Marine weather and hydrological forecasts, regarding sea waves, tides and tidal currents, storm surges, water temperature, and marine currents, in the South China Sea. 2) Forecasting services for TV and radio broadcasting and marine project sites. 3) Special observation and investigation of the marine environment. 4) Marine environment impact assessment for construction work in sea areas. 5) Marine information service including multiple-year statistical analysis of observational data such as hydrologic information (waves, tides, sea surface temperature, salinity, density and storm surges), and meteorological information (wind, atmospheric pressure and temperature, visibility, cloud and weather phenomena).		1) Awarded certification a) The Certificate of Marine Environment Forecast (First Grade).
4.1.5	South China Sea Exploitation Engineering Center (SCSEEC)	1973	129 Senior engineer; 8 Engineer; 35 Senior technician;60 Senior driver; 4 Process supervisor; 2 Internal assessor for quality system; 6 Accountant; 1	See Figure 4.1.2	1) Geological marine exploitation. 2) Topographical marine survey. 3) Arrangement of ship routes. 4) Arrangement of marine development. 5) Marine environment impact assessment.	1) The research and survey on the interrelation of marine meteorology in west tropical Pacific Ocean, by cooperation by the USA. 2) Survey on marine meteorology in the middle of the South China 3) Survey on marine meteorology and marine resources, entrusted by the government of Guangdong. 4) Research and survey on the source of the Black Current, with cooperation from Japan. 5) Survey on seawater quality in the Pearl River Estuary, entrusted by the government of Hong Kong.	1) Awarded certification a) The Certificate of Special Marine Metrology b) The Certificate of Marine Utilization

Table 4.1.1 Details of the Organizations Relating Marine Environmental Monitoring in Guangdong (2/6)

No.	Name	Establishment	Number of staff	Organization	Major duties	Recent notable researches, investigations, and activities (year)	Remarks
4.1.6	South China Sea Information Center (SCSIC)	1974	18 Senior engineer; 5 Engineer; 10	See Figure 4.1.2	1) Collecting, processing, controlling and consulting regarding marine data. 2) Purchasing, arranging, controlling, consulting and searching of specialty books. 3) Documentation services for projects.		
4.1.7	Shenzhen Oceanic Administration Office of SOA		15 (21) Officer; 13 Office worker; 2 (Chiwan Station; 6)	1) Environmental Testing Control Section. 2) Marine Environmental Protection & Resources Section. 3) Monitoring Section. 4) Chiwan Monitoring Station (business unit).	1) Marine pollution control (red tides, pollution sources, etc.) in the Pearl River Estuary, Shenzhen Bay, Dapeng Bay, Dayan Bay (jointly with Huizhou), and the oil exploration platform of Pearl River Basin. 2) Administrative work for waste dumping in sea areas.	1) Observation and investigation of oil leakage from a Norwegian ship, after a collision with another ship (November 2000).	
4.1.8	Zhuhai Oceanic Administration Office of SOA (ZOAO)		10-20	Same as SOAO	Same as SOAO	1) Protection of the oyster beds from oil contamination caused by a vessel from Fujian Province (March 1999).	
4.1.9	Zhuhai Central Marine Station of SOA (ZCMS)		about 40	1) Chiwan station. 2) Wanshan station. 3) Kaipo station. 4) Naozhou station.	1) Monitoring of the general hydrological and meteorological items a) Monitoring: three times a day, at 08:00, 14:00, and 21:00. b) Sampling: seawater and dredge mud, once a month, on the 20th. c) Analysis: COD, DO, pH and salinity at the local environmental monitoring stations. d) Analysis: heavy metal, oil and organic-carbon at the SCSEMC of SOA. 2) Reporting the data. a) Daily report to the ZCMS by telephone. b) Monthly report to the SCSIC of SOA.		
4.1.10	Marine Inspection Nanhai Integrated Corps (MINIC)		14		1) Administration and inspection in all areas of the South China Sea. 2) Law enforcement and judgment of various applications for activities in sea area 3) Illegal waste dumping, illegal exploration of mineral resources, illegal activities by foreigners in littoral areas.		
4.1.11a	Pearl River Water Resources Commission (PRWRC)	1979	1,030 Senior engineer; 201 Engineer; 310	1) Water Administration and Water Resources Division. 2) Planning Division. 3) Water Conservancy Management Division. 4) Soil and Water Conservancy Division. 5) Planning and Technology Division. 6) Investigation, Design & Research Institute. 7) Water Resources Protection Bureau. 8) West River Bureau. 9) Hydrology Bureau. 10) Scientific Research Institute.	1) Hydrological and environmental monitoring at the mouth of the eight Pearl Rivers. 2) Water flow control at the Sixianxue Dam (crossing of the Beijiang and the Xijiang). 3) Feasibility studies on water supply projects for Shenzhen, Macao and Guangzhou. 4) Feasibility studies on flood control plans at the mouth of the Pearl River. 5) Monitoring of environmental impact caused by the hydroelectric power station, which is under construction in the upper basin of the Xijiang and is expected to be able to hold 20 billion m^3 and to increase its discharge by 1,000 m^3/sec. in the dry season after completion of the construction.	1) Feasibility study on the Feilaixia Dam construction with the assistance of the Japan International Cooperation Agency (1985-1986). 2) Water resource development project for Hainan province with the assistance of the Asian Development Bank (1990-1992).	1) Award certification a) The Certificate of Water Resources Survey and Design (First Grade). b) The Certificate of Bridge Design (Second Grade).
4.1.11b	Pearl River Basin Water Resources Protection Bureau		45 University graduates; 90% Post-graduate degree; 20-30% Senior engineer; 50%	1) Water Resources Administration Station. 2) Water Resources Protection Scientific and Technological Institute. 3) Water Resources Monitoring Center.	1) Planning of water resources development and management. 2) Monitoring of the water quality of the river in each province and the international river. 3) Provision of guidance regarding water resources protection. 4) Settlement of water disputes between the provinces. 5) Environmental impact assessment.	1) Research projects commissioned by the Ministry relating to the Pearl River. 2) Water quality study and monitoring in the west coast sea areas for the Word Bank. 3) Environmental assessment for the hydropower station in Shaguan city, located to north of Guangzhou city. 4) Planning of city water supply to Guangzhou and study on the water quality. 5) Comparative study on the water resources in all the areas.	1) Award certification a) The Certificate of Water Resources Survey (First Grade). b) The Certificate of Environmental Impact Assessment (First Grade for Construction Works).

Table 4.1.1 Details of the Organizations Relating Marine Environmental Monitoring in Guangdong (3/6)

No.	Name	Establishment	Number of staff	Organization	Major duties	Recent notable researches, investigations, and activities (year)	Remarks
4.1.12	Guangdong Environment Protection Bureau (GEPB)		60	Nine sections.	1) Enforcement of the National Environment Protection Law and supervision of environment protection activities. 2) Study, review and issuance of environmental regulations and rules. 3) Environment control related to air, water, noise, waste and hazardous materials, including the marine environment. 4) Environmental impact assessment for big projects and supervising the practice of the law called 'Three Same Times'. 5) Supervising and advising regarding illegal practices of ecological degradation. 6) Promoting scientific and technical study related to environmental protection. 7) Supporting the nuclear power station in an emergency measure. 8) Surveying the environmental situation in the Pearl River Estuary. 9) Monitoring of coastal sea areas since 1986. a) Vicinity of Shenzhen Number of stations: ten stations Number of items: 23 items Monitoring time: three times a year, March, July and October. b) Vicinity of Zhuhai Number of stations: eight stations Number of items: 17 items Monitoring time: same as in Shenzhen 10 Survey on river water pollution since 1980. a) Survey points: at upper basins of four rivers. b) Monitoring times: six times a year (twice each in January, June and October). 11 Monitoring of pollution sources located at coastal areas since 1996 (base data as of 1995). a) Total pollution discharge quantities in coastal areas. b) Oil discharge quantity at wharves. c) Oil, COD, nitrogen and heavy metals discharged from industrial and domestic pollution sources.	1) Studies on pollution sources. 2) Review of the National Marine Environment Protection Law. 3) Supervision of marine projects and control of waste dumping. 4) Establishment of an environmental functional zone in coastal sea 5) Environmental supervision of the rivers in the Pearl River Delta. 6) Environmental and ecological conservation (12 marine natural conservation zones had been established by the end of 1999). 7) Special studies since 1998. a) Pollution sources which discharge effluent directly to the sea. b) Water flow speed and quality at vertical sections of the river. c) Marine environmental monitoring.	
4.1.13	Guangdong Provincial Bureau of Ocean and Fishery (GPBOF)		2,000 Monitoring Center; 10% Shenzhen Station; 15	1) Resources and Environment Administration Division a) Environmental Monitoring Center b) Environmental Monitoring Stations c) Resources Monitoring Stations 2) Fishery Division Guangdong Fishery Administration and Ocean Supervision General Brigade, Sub-brigade, Team and Section in provincial, municipal, country and township 3) Daya Wan Aquatic Products Fry Breeding Center (subordinate unit)	1) Marine environmental monitoring. Fishery areas, cultivated areas, sea-swimming areas and wastewater discharge points. 2) Law enforcement. 3) Management work related to the ocean and fisheries. 4) Patrol. 5) Administrative responsibilities for aquatic industries. 6) Management of the projects for development of the fisheries industry. 7) Preservation of ecosystems.	1) Enforcement of environmental control, oceanic survey and experimentation, improvement of the marine environment, recovery of ecosystem. 2) Research on red tide 3) Revision of the National Fishery Law. 4) Future development plans of aquatic industries. Research on sea-sand in the Pearl River Estuary. 5) Research on yellow fish fry breeding in the Daya Wan with cooperation by the Fishery Cooperation Association in Japan.	
4.1.14	South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Science	1959	500 Researcher; 389 (Professor; 35) Assistant Professor and Senior engineer ; 114	1) Academic Committee.	(Organizations) 1) Research Department. a) Physical Oceanography Department. b) Applied Marine Biology Department. c) Marine Environment and Ecology Department. d) Marine Tectonophysics Department. e) Marine Geological Environment Department.	1) Research on the Black Current 2) Research on the sea waves under typhoon conditions and the course of the typhoon by use of satellite images. 3) Planned co-research projects a) Marine botanical pharmaceuticals. b) Marine biology.	1) Publications a) *Tropical Marine.* b) *Tropical Marine Research Institute.*

Table 4.1.1 Details of the Organizations Relating Marine Environmental Monitoring in Guangdong (4/6)

No.	Name	Establishment	Number of staff	Organization	Major duties	Recent notable researches, investigations, and activities (year)	Remarks
					2) Open laboratories. a) Open Laboratory of Tropical Marine Environmental Dynamics. b) Open Laboratory of Marginal Sea Geology and Paleoenvironment. 3) Seashore marine biological stations. a) Marine Biological Research Station at Daya Bay. b) Tropical Marine Biological Research Station in Hainan. c) Marine Economic Animal Research Station in Zhanjiang. d) Marine Plant Research Station in Shantou.		
				2) Institute's Affairs Committee.			
4.1.15	Scientific Research Institute in Water Resources Protection Bureau of Pearl River Water Resources Commission (SRI-WRPB, PRWRC)			1) Hydraulic Research Division-No.1. 2) Hydraulic Research Division-No.2. 3) Remote-sensing Application Research Division. 4) Instrument & Automation Research Division. 5) The Instrument & Automation Research Division.	(Experimental facilities) 1) Experimental field of 60.000 m^2. a) Grate-size Tidal Estuary Modeling in Lishui experimental bases in Nanhai. b) Two river engineering experimental chambers. c) Three hydraulic engineering experimental chambers. d) Two flumes with fixed slopes. e) One flume with a variable slope. f) One wave flume.	1) Construction Project of Lingding Bridge. 2) Construction Project of Zhuhai Sea Port. 3) Research and Development of a high performance water level gauge.	
4.1.16	South China Sea Fisheries Research Institute (SCSFI), Chinese Academy of Fishery	1953	300 Professional researcher; 198 (Senior scientist; 42) (Mid-level Professional; 72) (Researcher charged in environment; 50)	1) Marine Resources Div. 2) Mareculture and Enhancement Div. 3) Marine Fishery Environment Protection Div. 4) Fishery Organisms Disease Div. 5) Marine Fishing Technique and Aquatic Product Processing Div. 6) Fleet for scientific survey. Two mareculture experimental bases in Shengzhen and Shanwei 7) Two tropical fishery research and development centers in Shanya and Hainan. 8) South China Sea Fisheries Institute Scientific and Technical Service Company (subordinate unit).	1) Prospecting biological resources in South China Sea areas. 2) Monitoring fishery resources in developed marine areas. 3) Research on the life cycle of valuable fish and biological study on fish tribes. 4) Study of the trend of the number of valuable fish species, evaluating fishery resources, and estimating the potential fishery catch. 5) Study of the interrelation between various kinds of fishes, the fish tribe shift and the change of the number of fishes. 6) Research on the possible scale of fishery catches and control of the limitation of catches. 7) Research on fishery technique. 8) Construction of fish reefs and increasing fishery resources. 9) Study of the application of new techniques for prospecting fishery resources.	1) Hatchery fry of yellowtail fish in Dapeng Bay. 2) Surveying the number of the China dolphin (white dolphin) in the Pearl River Estuary. 3) Studies on environmental protection for aquaculture. 4) Marine environmental pollution protection from the viewpoint of aquacultural activity.	1) Publications. a) *South China Sea Fisheries Research* b) *Fisheries Abstracts.* 2) Contributions to the journals. a) *Fisheries Academy Report.* b) *China Fisheries.* c) *Marine Industries.* d) *Fisheries Science and Technology.* e) *Fresh Water Fisheries.* 3) Awarded certifications. a) Certificate of Laboratory Accreditation (ISO/IEC Guide 25)
4.1.17a	Guangzhou Institute of Geography (GIG), Guangdong Academy of Science	1958	106 Senior engineer; 36 Engineer; 33	1) Resources and Environment Center. 2) Information center. 3) Urban and Rural Planning Center. 4) Environmental Geographical Research Center. 5) Landscape, Tourism and Sightseeing Planning Center.	1) Research themes a) Sustainable development of resources and environment. b) Application of geographical information by using remote sensing 2) Research projects a) Study on the water shortage situation in the Pearl River and Hainan areas. b) Study on the development of tourist resorts in Guangzhou. c) Study on the sustainable development in urban areas (especially in Shenzhen).	1) Number of research projects completed is 380. 2) Number of treaties contributed to technical journals is 120. 3) Numerous prizes awarded.	1) Publication. *Tropical Geology*
4.1.17b	Guangdong Remote Sensing & GIS Center (GDRGC)	1994	29 Senior researcher (professor); 9 Researcher; 13 Ph.D. degree; 2 Master's degree; 5				

Table 4.1.1 Details of the Organizations Relating Marine Environmental Monitoring in Guangdong (5/6)

No.	Name	Establishment	Number of staff	Organization	Major duties	Recent notable researches, investigations, and activities (year)	Remarks
4.1.18	South China National Center of Metrology (SCM), and Guangdong Institute of		150 Senior engineer; 19 Engineer; 56	1) Length Measurement Lab. 2) First Mechanics Measurement Lab. 3) Second Mechanics Measurement Lab. 4) Temperature Measurement Lab. 5) Electric and Magnetic Measurement Lab. 6) Electronics Measurement Lab. 7) Physics-Chemistry and Optics Measurement Lab. 8) Acoustics Measurement Lab. 9) International Technical Service Section 10) Guangzhou Measurement and Testing Business Center.	1) Contribution to the establishment and maintenance of the system of national primary standards of measurement. 2) Services for verification and testing to disseminate the accuracy of value of quantities . 3) Research on metrology. 4) Pattern evaluation of new measuring instruments authorized by the China State Bureau of Quality and Technical Supervision and prototype testing of new measuring instruments designated by Guangdong Provincial Bureau of Quality and Technical Supervision. 5) Dispatching technical specialists for testing and verification. 6) Training technical personnel of enterprises and other metrology laboratories. 7) Certification and reexamination of the measuring standards for enterprises and other testing laboratories. 8) Technical advice about the establishment of measuring standards and metrological verification activities for enterprises and other testing laboratories. 9) Testing and provision of advisories about the accreditation of products inspection services and quality assurance systems for enterprises and other testing laboratories.		
4.1.19	Center for Coastal Ocean Sciences and Technology (CCOST), Zhongshan University	1978 (1924)	70 scientists (The University) (16,000 students) (300 professors) (500 assistant professors)	1) Institute of Coastal and Estuarine Studies. 2) Research Institute of Marine Natural Products. 3) Institute of Marine Biological Studies. 4) Institute of Coastal Ocean Dynamics Studies. 5) Institute of Coastal Marine Remote Sensing Application Studies. 6) Research Institute of Marine Instrument Technology.		1) More than 120 research projects in the national, provincial and ministry levels and hundreds of application projects were completed since 1985. 2) Study on the Pearl River Estuary Integrated Observation System (PEIOS) 3) Study on seaweed flourishes in Daya Bay, applying remote sensing technology. 4) Study on gases such as SO_2 and NO_X on the surface of the land area.	
4.1.20	South China Teachers University (SCTU)	1936	(Number of officers and teachers) Officer; 2,600 Teacher; 1,100 (Senior teacher; 700) (Teachers for master's and doctorate course ; 300)	(Number of students) 1) Undergraduate level; 11,000 2) Postgraduate; 3,000 3) Research courses; 1,000 4) Adult education courses; 6,000 5) Foreign students; 200	(Organization) 1) Academies; 10 2) Departments; 21 3) Bachelor degree specializations; 30 4) Master's degree specializations; 43 5) Doctoral courses; Five 6) Post-doctoral course; One 7) Research institutions and/or research centers; 28 8) Provincial level important courses; Eight 9) Provincial level important experimental laboratories; Three 10) Education training base; One 11) Zhengcheng branch campus for education of engineers. 12) Nanhai branch campus for research on new technology.		
4.1.21	Jinan University		(Number of teachers) 22 (Professor; 4)	(Number of students) 30	(Organization) 1) Departments of Literature, 2) Scientific Engineering, 3) Life Science and Technology, 4) Economics, 5) Medicine, 6) and Education 7) Society Peoples school	1) Red tides, 2) Fish species in rivers and lakes, 3) Plankton, 4) Bioproduction simulation	

Table 4.1.1 Details of the Organizations Relating Marine Environmental Monitoring in Guangdong (6/6)

No.	Name	Establishment	Number of staff	Organization	Major duties	Recent notable researches, investigations, and activities (year)	Remarks
4.1.22	Guangdong Marine Association and Guangdong Marine and Lake Research Association (GMA, GMLRA)			1) Ten Specialist Subcommittees such as the Biological Subcommittee, Environmental Impact Assessment Subcommittee, etc. 2) Executive Subcommittee	1) Organization of academic relationships between the members engaged in marine affairs. 2) Propaganda and dissemination of knowledge. 3) To urge the members to submit their opinions, to give members opportunities to voice their concerns, and to support the government in formulation of policy. 4) Contribution to economic development in the province. 5) Enhancement of communication between various associations and between groups related to marine affairs. 6) Identifying, educating and recommending human resources to the government. 7) Creation of marine science and technology, and introduction of overseas developed technology. 8) Publication of the academic journal *South China Sea Research and Development* (four times a year) and literature such as *China Oceanic Illustrated* , etc. 9) Organizing technical forums.	1) Forums; 20 times since 1995 (the participants have totaled 1,386, and 1,056 reports have been published. Summaries of treaties were published on ten occasions.) 2) General education and dissemination activities a) Publication of bulletins and illustrated books b) Propaganda by using mass-media like radio and TV. c) Visiting and lecture to school by specialists. d) Camping at coastal area with school children. e) Competition of speech and composition.	

Table 4.1.2 Existing equipment of SCSEMC

No.	Name	Number of equipment	Purchase year	Maker	Type	Condition (Good or NG)
1.	Total organic carbon analyzer	1	1998	Shimazu	TOC-5000A	Good
2.	721-spectrophotometer	2	1998	Shanghai	724-1	-ditto-
3.	Fluorescence spectrophotometer	1	1998	Shanghai	930	-ditto-
4.	Kjeldatherm	1	1998	Gerhardt	KB40S	-ditto-
5.	Liquid chromatograph	1	1999	Shimazu	LC-10A	-ditto-
6.	GC/MS analyzer	1	1993	VG, UK	MD-800	-ditto-
7.	Ultraviolet spectrophotometer	1	1986	Shanghai	7520	-ditto-
8.	Polarograph	1	1992	Jiangsu	AD-3	-ditto-
9.	Gas chromatograph	1	1983	Shimazu	GC-7AG	-ditto-
10.	Induction salinometer	1	1980	Shanghai	WUS	-ditto-
11.	Analytical balance	1	1990	Shanghai	TG31	-ditto-
12.	Sonometer	2	1993		ND10	-ditto-
13.	Purified laboratory	1	1988	Shimazu	EXT	-ditto-
14.	DO detector	3	1990	YSI Co. Ltd	YSI58	-ditto-
15.	Biochemical incubator	3	1992	Guangdong	LRH-15013	-ditto-
16.	Atomic absorption spectrophotometer	1	1997	Beijing	BFS2100	-ditto-
17.	Atomic absorption spectrophotometer	1	1987	PE Co. Ltd	Zenman 1303	-ditto-
18.	Nutrients auto-analyzer	1	1989	ALPREM Co. Ltd	RFA 12	-ditto-
19.	Fluorimeter	1	1985	TURNE Co. Ltd	10-005R	-ditto-
20.	Chromatograph	1	1995	Qingdao		-ditto-

Table 4.1.3 Present Investment Plan for New Equipment of SCSEMC

No.	Name	Number of equipment	Purchase year	Maker	Type	Price (yuan)
1.	Fluorescence spectrophotometer	1		Hitachi	4500	190,000
2.	Ultraviolet atomic absorption spectrophotometer	1			UV-241PC	90,000
3.	Multi-channel analytical card	1			PCA3-PIUS	
4.	Salinometer	2			WUS	10,000
5.	Portable air compressor (non-noise, non-oil)	1				15,000
6.	DO meter	2		YSI	YSI 5750	15,000

Table 4.1.4 Equipment to be Introduced in the Future in SCSEMC

No.	Name	Number of equipment	Purchase year	Maker	Type	Price (yuan)
1.	Fluorescence spectrophotometer	1			Jenway 6200	60,000
2.	Fluorescence inverted microscope (with camera)	1			IX 70-142	120,000
3.	Fluorescence detector	1			KF-10AXa	90,000
4.	Biological microscope	2			CH 30-313E	70,000
5.	EMT stereomicroscope	2			EMT-1	20,000
6.	Focal variation stereomicroscope	2			EMT-2	50,000
7.	Biological γ spectrum standard	1				10,000
8.	Visible light spectrophotometer (with microprocessor)	1			724-1	10,000
9.	Functional logger	1			L230-104	10,000
10.	High pressure sealed soluble substance tanker	4			4mPa, 60 ml	5,000
11.	Self-contained current meter	2				100,000
12.	High accuracy thermometer	2			SLC9-3A	50,000
13.	Water level recorder	2			AANDERAA	110,000
14.	Portable micro-computer	1			IBM	15,000
15.	Graininess analyzer	1				800,000
16.	Sieving detector	1				500,000
17.	Multi-function chemical analyzer	1				500,000
18.	Software					
(1)	Are Info 8.0 + Grid + Tin	1		ESRI Co.		
(2)	Are View 3.2 + spatial analyst + 3D analyst	1		ESRI Co.		
(3)	DAK	1		ESRI Co.		
(4)	Map objects	1		ESRI Co.		
(5)	Imagine 8.4	1		ESRI Co.		
(6)	ENVI	1				
19.	Hardware					
(1)	A0 size color plotter	1				
	Total					2,520,000

Table 4.1.5 Existing Equipment of GMO

No.	Name	Number of equipment	Purchase year	Maker & Type	Condition (Good or NG)
1.	Vsat	1	1999		Good
2.	Personal computer	5	1995		Good
3.	NOAA image receiver	1	1995	made in China	NG (out of work)
4.	GMS image receiver	1	1995	made in China	Good
5.	Vsat	1	1997	made in China	Good
6.	Computer operation station	1	1996	made in USA	Good

Table 4.1.6 Present Investment Plan for New Equipment of GMO

No.	Name	Number of equipment	Purchase year	Maker & Type	Objective	Price (yuan)
1.	Vsat	1	2000	Japan	Receiving data	200,000
2.	Marine buoy data network for oil exploration platform	1	2000	China	Receiving data	150,000
3.	NOAA image receiver	1	2000	repair	Receiving remote sensing information	100,000

Table 4.1.7 Equipment to Be Introduced in the Future in GMO

No.	Name	Number of equipment	Purchase year	Maker & Type	Objective	Price (yuan)
1.	Data processing program software for NOAA remote sensing information	1	2001	USA	Remote sensing information for forecast	300,000
2.	GIS and its data processing program software	1	2001	USA	Marine environmental management	500,000
	Total					800,000

Table 4.1.8 Existing Equipment of SCSEEC

No.	Name	Number of equipment	Purchase year	Maker	Type	Condition (Good or NG)
1.	ADCP (Acoustic Doppler current profiler)	1	1985	RD Co. (USA)	RD-VM	Good
2.	CTD (Conductivity temperature depth)	1	1985	N-B Co. (USA)	MARKIIIB	-ditto-
3.	CTD	2	1985	Co. (USA)	SBE Sea -logger	-ditto-
4.	ADCP	1	1998	Norek As	Nortek as 500Hz	-ditto-
5.	WLR5 (Water level recorder)	5	1997	Aanderaa	WLR5	-ditto-
6.	WLR7	3	1997	Aanderaa	WLR7	-ditto-
7.	RCM (Recording current meter)	6	1987	Aanderaa	RCM4S	-ditto-
8.	Directional wave, tide and current gauge	1	1998	Inder Ocean	S4ADW	-ditto-
9.	Direct recording current meter	10	1995	Qingdao	SLC9-2	-ditto-
10.	Temperature meter for surface sea	3	1990	Tianjing	SWM1-1	-ditto-
11.	Reverse temperature meter	25	1984	made in China	SWC	-ditto-
12.	Aneroid barometer	1	1984	Tianjing	DYM13	-ditto-
13.	Ventilated humidometer	5	1984	Tianjing	DHM2	-ditto-
14.	Hydraulic engineering drilling rig	1	1982	Beijing	XY1	NG
15.	Light drilling rig	1	1982	made in China	a-50	Good
16.	Leveler	2	1985	made in China	DS2	-ditto-
17.	Theodolite	2	1986	made in China	J2	-ditto-
18.	Flat-bed plotter	2	1988	made in	DS3	-ditto-
19.	DGPS(Differetial global position system)	2	1997	made in	3011R	-ditto-
20.	Sub-bottom profiler	1	1998	Shanghai	GPY	-ditto-
21.	Edgetech sonar	1	2000	made in USA	DF-100	-ditto-
22.	Echo sounder	1	1987	Shanghai	st-500	-ditto-
23.	Echo sounder	1	1985	made in China	SDH-13	-ditto-
24.	Spectrophotometer	2	1997	Shanghai	53W13	-ditto-
25.	Automatic DO meter	5	1996	made in USA	YS758	-ditto-
26.	Electronic balance	2	1989	Shanghai	MA110	-ditto-
27.	Marex information buoy system	1	1986	made in USA	DS14	-ditto-
28.	Sub-buoy mooring system	12	1988	Tianjing	FSS1	-ditto-
29.	Acoustic releasing system	6	1988	made in USA	Datasonic	level

Table 4.1.9 Present Investment Plan for New Equipment of SCSEEC

No.	Name	Number of equipment	Purchase year	Maker	Type	Objective
1.	Water Level Recorder	5	2000	Norway AANDERAA	WLR7	
2.	Acoustic Doppler current profiler	4	2000	Norway AANDERAA	ADP	
3.	Recording Current Meter	10	2000	Norway AANDERAA	RCM9	
4.	Directional wave, tide and current gauge	2	2001	USA	S4ADW	
5.	CTD	2	2001	USA	Mark IIIC or SBE25	
6.	Weather station	1	2001	Norway AANDERAA	AWS 2700	

Table 4.1.10 Equipment to Be Introduced in Future in SCSEEC

No.	Name	Number of equipment	Purchase year	Maker	Type	Price (RMB)
1.	Multi beam sonar	1	2005			4,500,000
2.	Deep multi beam sonar	1	2005			15,000,000
3.	Low and high frecuency echo-sounder	1	2005			400,000
4.	Total station	1	2005			200,000
5.	Shallow strati-graphic section instrument	1	2005			500,000
6.	Buoy (ADP, S4, CTD)	1	2010			1,000,000
7.	Sub-buoy mooring system	1	2010			3,000,000
8.	Single (multi) channel seismometer	1	2010			8,000,000
	Total					32,600,000

Table 4.1.11 Existing Equipment of SCSIC

No.	Name	Number of equipment	Purchase year	Maker	Type	Condition (Good or NG)
1.	Computer	4	1995	Compaq	586	Good
2.	Computer Printer	2	1997		LQ1600K	Good
3.	Copy M/C	1	1996	Canon	NP-3020	Good
4.	Copy M/C	1	1995	Ricoh	FT-4495	Good
5.	High Speed Copy M/C	1	1994	Ricoh	RC-4500	Good

Table 4.1.12 Present Investment Plan for New Equipment of SCSIC

No.	Name	Number of equipment	Purchase year	Objective	Price (RMB)
1.	Network service system	2	2000	Data communication	200,000
2.	Computer	5	2000	Data processing and storage	100,000
3.	Relay station	1	2000	Data communication	150,000

Table 4.1.13 Equipment to Be Introduced in Future in SCSIC

No.	Name	Number of equipment	Purchase year	Objective	Price (RMB)
1.	Computer	6		Data processing	90,000
2.	CD-ROM	1		Data storage	3000
3.	Scanner	1		Reading figures	50,000
	Total				143,000

Table 4.1.14 Equipment to Be Introduced in the Future in SOAO

No.	Name	Number of equipment	Purchase year	Maker	Type	Price (yuan)
1.	Atomic absorption spectrophotometer	1			USA	
2.	Gas chromatograph / mass spectrometer	1			USA	
3.	Infrared spectrophotometer	1			Japan	
4.	Ultraviolet spectrophotometer	1			Japan	
5.	Injector	1			Import	
6.	Multi-purpose water quality analyzer	2			USA	
7.	COD meter	1			China	
8.	DO meter	2			USA	
9.	Electronic balance	1			Swiss	
10.	Electronic balance	1			J/V Co.	
11.	Visible light spectrophotometer	3			China	
12.	Moisture analyzer	1			inport	
13.	Salinometer	2			China	
14.	pH meter	1			China	
15.	Centrifuge	1			China	
16.	High speed centrifuge	1			China	
17.	Digital control drying oven	1			China	
18.	Electron bio-microscope	1			Japan	
19.	Microscope with camera	1			import	
20.	Stereoscopic microscope	1			import	
21.	Stereoscopic microscope with camera	1			import	
22.	Bio-safety shelf	1			Japan	
23.	Disinfections pan	1			Japan	
24.	Incubator	1			China	
25.	Bottom sampler	2			China	
26.	Centrifugal separator	1			China	
27.	Sieve	2			China	
28.	Shallow sanpling apparatus	2			China	
29.	Consumables for biological monitoring	1 set			China	
30.	Consumables for plankton monitoring	1 set				
	Total					2,500,000

Table 4.1.15 Existing Equipment of ZCMS

No.	Name	Number of equipment	Purchase year	Maker	Type	Condition (Good or NG)
1.	Mercury barometer	1		Changchun		Good
2.	DYJ1 barometer	1		Shanghai		Good
3.	DWJ1 temperature gauge	1		-ditto-		Good
4.	DHJ1 humidometer	1		-ditto-		Good
5.	EF-type anemometer	1		-ditto-		Good
6.	Parallel processor	1		Beijing		Good
7.	SBA-2 type coastal digital wave gauge	1		Jinnan		Good
8.	SCA1-1 type water level meter	1		Shanghai		Good
9.	SYC1-2 type sensing salinometer	1		Risoh		Good
10.	Dry and wet bulb temperature gauge	1		-ditto-		Good
11.	Maxmum temperture gauge	1		-ditto-		Good
12.	Minimum temperature gauge	1		-ditto-		Good
13.	Surface layer water temperature gauge	1		Tianjin		Good
14.	Rain gauge	1		Shanghai		Good

Table 4.1.16 Present Investment Plan for New Equipment of ZCMS

No.	Name	Number of equipment	Purchase year	Objective	Price (RMB)
1.	Automatic hydrometeolorogical observation system	1		For testing	

Table 4.1.17 Equipment to Be Introduced in the Future in ZCMS

No.	Name	Number of equipment	Purchase year	Objective	Price (J¥)*
1.	Automatic hydrometeolorogical observation system	1		Monitoring	20,000,000
2.	Water quality monitoring equipment	1		Monitoring	10,000,000
3.	Portable water quality monitoring equipment	1		Monitoring	2,000,000
4.	Salinometer	1		Monitoring	200,000
5.	Simplified portable GPS	1		Monitoring	50,000
	Total				32,250,000

Note:* is based on estimation value in Japan

Table 4.1.18 Existing equipment of SCSIO

No.	Name	Type	Usage
1.	Acoustic doppler current meter	SC-ADCP VM-ADCP	Physical oceanographic observations
2.	Directional wave current	S4ADW	-ditto-
3.	Directional track wave buoy	WaveTrack-1156	-ditto-
4.	Auto-weather station	2700	-ditto-
5.	Anderaa current meter	RCM-7	-ditto-
6.	48 channel seismic system	DFS-V	Marine geophysical investigations
7.	Marine gravimeter	KSS-30	-ditto-
8.	Sea-air protm magnetometer	MAPM-92	-ditto-
9.	Sea beam	SeaBat 8111	-ditto-
10.	Sub-bottom profiler	GeoPuls GeoChirp	-ditto-
11.	Dual-frequency side-scan/echo sonar	SS491, 320M	-ditto-
12.	Digital spinning magnetometer	DSM-1	Paleomagnetics
13.	Electronic probe	EPM-810Q	Micro-analysis
14.	Ionic chromatograph	DX-1000Dionex	Marine chemical and biological analysis
15.	Gas chromatograph	HP5899	-ditto-
16.	Liquid chromatograph	ALC/GPC-244	-ditto-
17.	Element analyzer	PE24000II	-ditto-
18.	ICP spectrometer	ARL-3580	-ditto-
19.	Ultraviolet spectrometer	SRPP10-Pc	-ditto-
20.	Research vessel (SHIYAN 2)	1100 tons	Investigation
21.	Research vessel (SHIYAN 3)	3300 tons	-ditto-

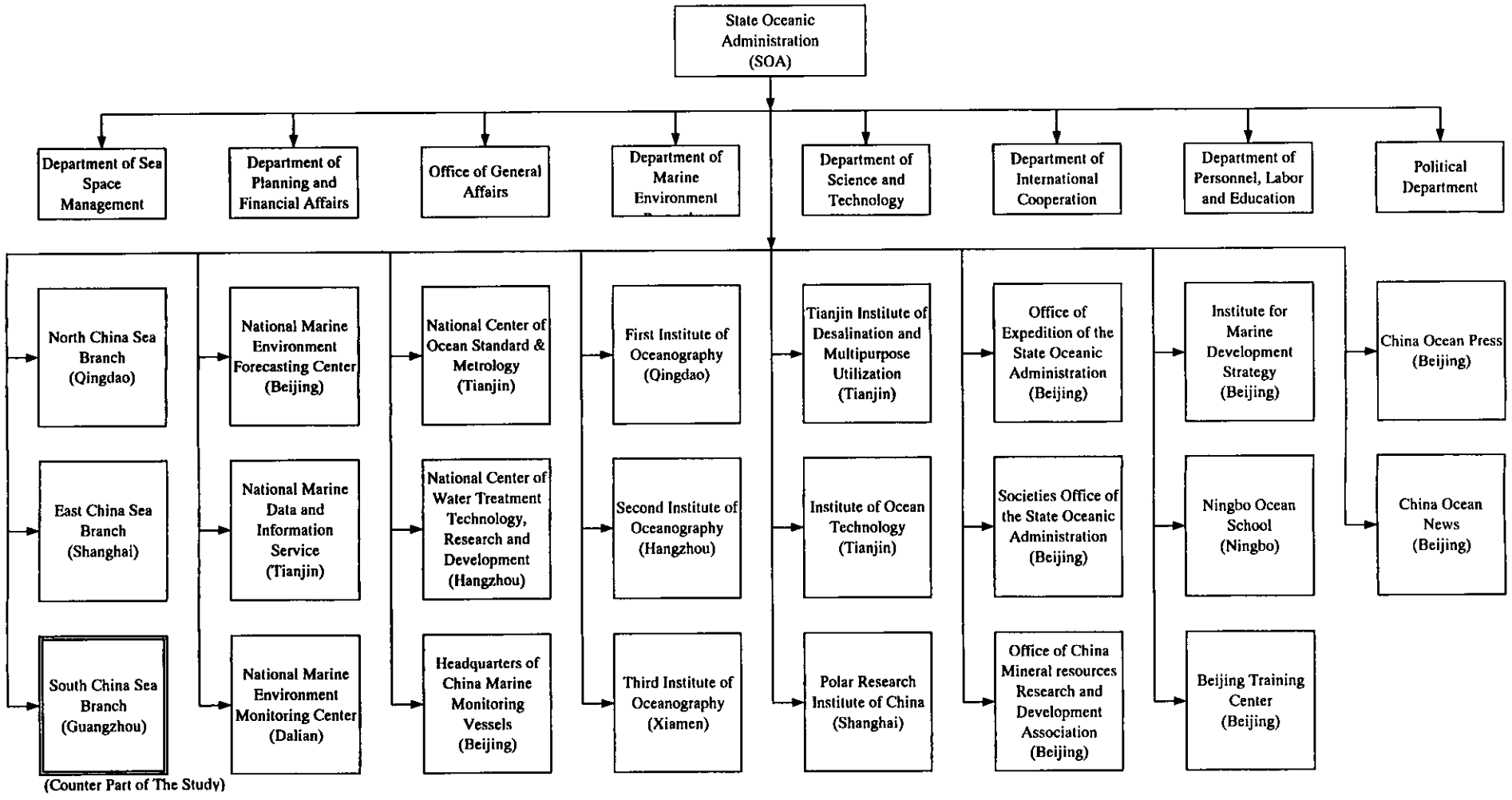


Figure 4.1.1 Institutional Framework of State Oceanic Administration

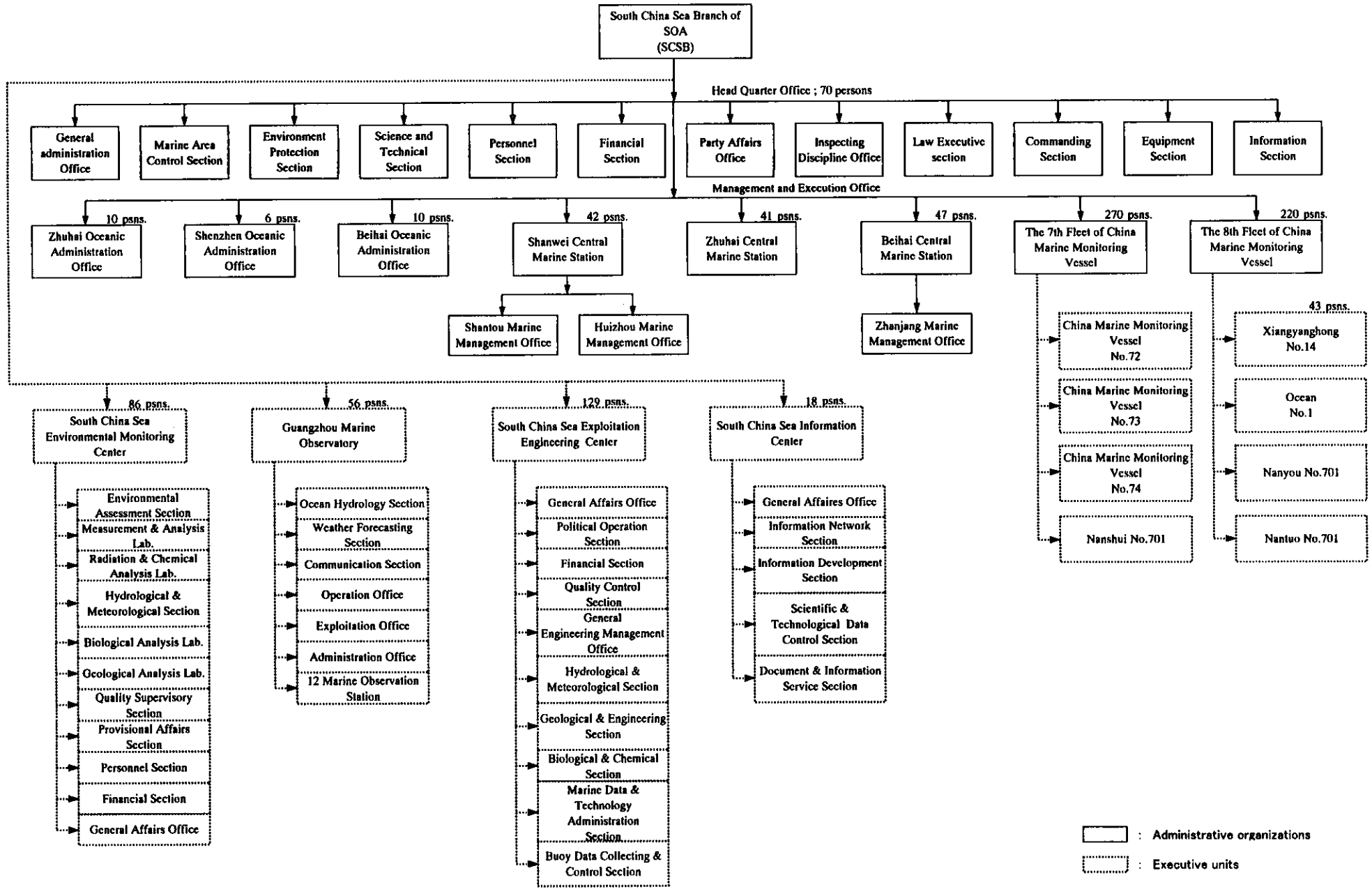


Figure 4.1.2 Institutional Framework of South China Sea Branch of SOA

4.2 Laws and Regulations on Marine Environmental Monitoring

The laws, regulations, rules and standards regarding marine environment management are summarized in Table 4.2.1. Marine environmental protection is prescribed in Article 2 of the National Environment Protection Law. In Article 7 of the law, the National Oceanic Administration is prescribed to take part in the management of marine environmental improvement work, together with the Departments of Port Administration, the Department of Fishery and Fishery Port Administration, and the Environmental Protection Department of the Navy.

Details of marine environment administration are prescribed in the National Marine Environmental Protection Law, which was revised in April 2000. In the revised edition, two new chapters, Marine Environment Administration (Chapter 2) and Marine Ecological Protection (Chapter 3) were added. The original Chapter 3, Protection and Remediation of the Environmental Damage Caused by Oil Exploitation and Exploration in Marine Areas, was revised to include all construction works in marine areas. The contents of other articles were also detailed more precisely.

The ordinances regarding environmental pollution source control are issued for each pollution source, including ships, oil exploitation and exploration plants, construction work sites, and waste dumping areas.

Regarding scientific research on marine areas, the Regulation Of The Control For International Marine Scientific Co-Research has been issued. The regulation is applied to this JICA Study when a survey is carried out in sea areas. The JICA study team had to submit a sea survey plan and ship sailing plan to SOA six months before starting the survey and two months before starting the ship sailing.

SOA established the Rule of Organization for National Marine Environmental Monitoring Network in 1987. The rule prescribes the basic duties and processes of the network, and the role of the organizations concerned with marine monitoring.

The Guangdong provincial government has issued the Guangdong Regulation for Marine Use Control. Based on the regulation, the government awarded 44 Certificates of Marine Use and 886 Certificates of Marine Use for Aquatic Culture to the official organizations and private enterprises in 1998 (*Guangdong Yearbook*, 1999). SCSEEC of SOA has been given this certificate. The government has also issued the Guangdong Integrated Plan for Marine Use and Development, the Guangdong Standard for Collecting the Marine Use Tax and others.

As for the national standards for marine monitoring, there are two specifications; one is the Specification for Marine Monitoring and other is the Specification for Oceanographic Survey. In Part 1 (General rules) of the Specification for Marine Monitoring, it is prescribed that the personnel charged in sampling work are required to have passed an examination after taking a special training course. Fifty-one members of the SCSEMC have passed and obtained the certificate. Also, the laboratory conducting marine monitoring is required to have the Certificate of Metrology. SCSEMC has been given a second-grade certificate by Guangdong Provincial Bureau of Technical Supervision.

The members who are assigned to the work of marine environmental monitoring are required to have a Certificate of Technical Specialist, such as for a marine geologist, hydrologist, biologist, meteorologist or physicist. The certificates are given to the personnel who have passed the examination by SOA.

Table 4.2.1 The Law, Ordinance and Regulation of Marine Environmental Administration (1/6)

Name of the law, ordinance and regulation	Date of proclamation	No.
1. Laws relating to marine environmental administration		
(1) National marine environmental protection law	04/01/00	Law No. 9 (Revised in 2000)
(2) Ordinance of marine pollution protection control for ship sailing	12/29/83	Issued by State Council
(3) Ordinance of marine environment protection control for oil exploitation and exploration	12/29/83	Issued by State Council
(4) Ordinance of marine control for waste damping	03/06/85	Issued by State Council
(5) Regulations of the Republic of China on the Management of Foreign-related Marine Scientific Research	06/18/96	State Council Order No.199
(6) Ordinance of environment control for pollution prevention in ship destruction	05/18/88	Issued by State Council
(7) Ordinance of marine environment control for pollution prevention and improvement of environmental damage caused by pollution sources in land	06/22/90	State Council Order No.61
(8) Ordinance of marine environment control for pollution prevention and improvement of environmental damage caused by construction work in coastal areas	06/25/90	State Council Order No.62
(9) Implementation methods of environment control for oil exploitation and exploration in marine areas	09/20/90	Issued by SOA
(10) Organization method of national marine environmental pollution monitoring network	09/24/87	Issued by the Steering Committee of the Network
(11) Provisional national regulation of control for marine use		
(12) Control method of environmental functional area of coastal ocean	12/10/99	NEPB[*1)] Order No.8
(13) Control method of marine use certificate		
(14) Control method of marine use application and examination		
(15) Control method of certification examination of marine use		
(17) Standards and requirement for model procedure to control marine use		
(18) Control method of marine natural conservation area		
(19) Principle for type and classification of marine nature conservation area	10/12/98	GB/T 17504-1998

Table 4.2.1 The Law, Ordinance and Regulation of Marine Environmental Administration (2/6)

Name of the law, ordinance and regulation	Date of proclamation	No.
2. The marine environmental administration law under preparation by SOA (internal use at present)		
(1) Ordinance for marine environmental pollution monitoring		
(2) Ordinance for marine environmental pollution control		
(3) Regulation for quality control of marine environmental pollution monitoring		
(4) Rule for examination of technician of marine environmental pollution monitoring and analysis		
(5) Rule for examination of excellent laboratory of marine environmental pollution monitoring		
(6) Rule for reporting of marine environmental pollution monitoring results		
(7) Rule for control of marine environmental monitoring data and information of materials and equipment		
(8) Rule for evaluation of judgment and decision of marine environmental pollution monitoring results		
3. General environmental laws relating to marine environmental administration		
(1) National environmental protection law	12/26/89	President Order No.22
(2) National water pollution protection and improvement law	05/15/96	
(3) National water pollution protection and improvement detailed regulation	07/12/89	NEPB Order No.1
(4) Control method for environmental quality standard	01/05/99	NEPB Order No.3
(5) National ordinance for nature conservation areas	12/01/99	State Council Order No.167
(6) Control method for certificate of environmental protection facility operation (provisional)		
(7) National ordinance for environmental monitoring network control	07/21/83	Issued by NEPB
(8) Rule for examination of technician of environmental pollution monitoring (provisional)	01/11/91	Issued by NEPB
(9) National rule for examination of excellent laboratory of environmental pollution monitoring (provisional)	01/11/91	Issued by NEPB
(10) National rule for reporting of environmental pollution monitoring results (provisional)	02/21/91	NEMC No.089
(11) National regulation for control of environmental pollution monitoring equipment and facility (provisional)	02/21/91	Issued by NEPB
(12) National regulation for control of environmental pollution monitoring equipment and facility (provisional)	01/11/91	Issued by NEPB

Table 4.2.1 The Law, Ordinance and Regulation of Marine Environmental Administration (3/6)

Name of the law, ordinance and regulation	Date of proclamation	No.
(13) Rule for control of environmental protection archives	07/28/94	HJ/T 8.1～8.5-94
(14) Control method for environmental protection archives	09/27/94	NEPB Order No.13
(15) Control method for environmental protection plan	08/16/94	Issued by NEPB No.1241
(16) Provisional statistical control method for environmental data	06/15/95	NEPB Order No.17
(17) Method of environmental protection control for construction projects	03/26/86	Issued by NEPB No.003
(18) Procedure of environmental protection control for construction projects	06/90	Issued by NEPB
(19) Method of environmental impact assessment certificate control for construction projects	09/02/89	NEMC No.281
(20) Technical guidelines for environmental impact assessment	09/18/93	HJ/T 2.1～2.3-93
(21) Technical guidelines for environmental impact assessment - Ecological environment for resource development	11/18/97	HJ/T 19-1997
(22) Sampling requirements for water quality monitoring in nuclear facilities	01/08/98	HJ/T 21-1998
4. Laws relating environmental management system		
(1) Guideline for environmental auditing - Auditing procedures - Auditing of environmental management system	12/20/96	GB/T 24001-1996 (1dt ISO 14001: 1996)
(2) Guideline for environmental auditing - Qualification criteria for environmental auditors	12/20/96	GB/T 24012-1996
(3) Provisional regulation for control of issue and utilization of environmental control system certificate		
(4) Provisional regulation for control of environmental control system certification		
(5) Control method of registration mark and certificate of environmental management system assessor		
(6) Basic requirement for certification of accreditation body of environmental management system		
(7) Basic procedure for certification of accreditation body of environmental management system		
(8) Provisional national regulation for preparation of environmental management system consultant		

Table 4.2.1 The Law, Ordinance and Regulation of Marine Environmental Administration (4/6)

Name of the law, ordinance and regulation	Date of proclamation	No.
5. National standards		
(1) Sea water quality standard	12/03/97	GB 3097-1997
(2) Oil pollutants discharge standard for marine oil exploration industries	01/05/85	GB 4914-85
(3) Pollutants discharge standard for ship sailing	04/09/83	GB 3552-83
(4) Surface water quality standard	04/05/88	GB 3838-88
(5) Integrated wastewater discharge standard	10/01/96	GB 8978-96, 1996 revised
(6) Water quality standard for fisheries	08/12/89	GB 11607-89
(7) Water quality standard for scenery and recreation areas	03/18/91	GB 12941-91
(8) Standard for archives of the national multipurpose investigation of the coastal zone and tidal wetland resources	09/20/88	GB 9852-1～3-88
(9) The specification for marine monitoring		
Part 1: General rules	06/22/98	GB 1738.1-1998
Part 2: Data processing and quality control of analysis	06/22/98	GB 1738.2-1998
Part 3: Sample collection, storage and transportation	06/22/98	GB 1738.3-1998
Part 4: Seawater analysis	06/22/98	GB 1738.4-1998
Part 5: Sediment analysis	06/22/98	GB 1738.5-1998
Part 6: Organism analysis	06/22/98	GB 1738.6-1998
Part 7: Ecological survey of offshore pollution and biological monitoring	06/22/98	GB 1738.7-1998
(10) The specifications for oceanographic surveys		
General rules	03/26/91	GB 12763.1-91
Marine hydrographic observations	19913/22	GB 12763.2-91
Marine meteorological observations	19913/22	GB 12763.3-91
Observation of chemical parameters in seawater	19913/22	GB 12763.4-91
Survey of acoustical and optical parameter in the sea	19913/22	GB 12763.5-91

Table 4.2.1 The Law, Ordinance and Regulation of Marine Environmental Administration (5/6)

Name of the law, ordinance and regulation	Date of proclamation	No.
Marine biological survey	19913/22	GB 12763.6-91
Oceanographic survey data processing	19913/22	GB 12763.7-91
Marine geology and geophysics investigation	12/10/92	GB 13909-92
(11) The Standard of State Oceanic Administration		
Organization cords for China marine survey	02/10/90	ZB A24 001-90
Station cords for China marine observation	02/10/90	ZB A24 002-90
Sectional cords for China coastal marine survey	02/10/90	ZB A24 003-90
(12) Water quality - vocabulary (part 1, 2)	10/10/86	GB 6816-86
(13) Water quality - vocabulary (parts 3-7) and analytical method	12/25/89	GB 11889-11915-89
(14) Water quality - technical regulation on the design of sampling	01/25/91	GB 12997-91
(15) Water quality - guidance on sampling techniques	01/25/91	GB 12998-91
(16) Water quality - sampling - technical regulation of the preservation and handling of samples	01/25/91	GB 12999-91
(17) Water quality - analytical methods 1991	08/31/91	GB 13192-91
(18) General specification of analytical instruments	11/06/90	GB 12519-90
(19) The regulations for monitoring effluents at nuclear facilities	03/16/89	GB 11217-89
(20) Specification for marine engineering topographic survey	10/12/98	GB 17501-1998
(21) Specification for hydrographic survey	11/10/98	GB 12327-1998
(22) Specifications for offshore platform engineering geology investigation	10/12/98	GB 17503-1998
(23) Application formats for oceanographic data records	08/27/90	GB 12460-90

Table 4.2.1 The Law, Ordinance and Regulation of Marine Environmental Administration (6/6)

Name of the law, ordinance and regulation	Date of proclamation	No.
6. Ordinance issued by Guangdong province and Guangzhou city governments		
(1) Guangdong Regulation for Control of Marine Use		
(2) Guangdong Standard for Collecting of Marine Use Tax		
(3) Guangdong Ordinance for Water Quality Protection of Dongjiang Basin	01/10/91	Issued by GPPCSC*2)
(4) Guangdong Ordinance of Environmental Protection Control in Construction Project	07/06/94	Issued by GPPCSC*2)
(5) Guangdong Regulation of Examination Control by District Level for Environmental Protection in Construction Pr	10/13/94	Issued by GPPG*3)
(6) Guangdong Ordinance for Water Quality Protection in Pearl River Delta	12/28/98	Issued by GPPCSC*2)
(7) Guangzhou Environmental Protection Ordinance	05/31/97	Established by GPPCSC*2)
(8) Zhuhai Environmental Protection Ordinance	05/21/98	Established by GPPCSC*2)
(9) Shenzhen Environmental Protection Ordinance	09/16/94	Established by GPPCSC*2)

Note: *1) NEPB; National Environmental Protection Bureau (National Environmental Protection Department)

*2) GPPCSC; Guangdong Provincial People's Congress Standing Committee

*3) GPPG; Guangdong Provincial People's Government

4.3 Technology on Marine Environmental Monitoring

As described in this Section 4.1 of this chapter, several organizations and institutes, such as SCSEMC, the collaborating units of SCSEMC, Guangdong administrative organizations, national research centers, and institutes of universities, participate in the marine environmental monitoring in the Pearl River Estuary. These organizations have enough engineers with sufficient experience and ability. Therefore, human resources are adequate to conduct the monitoring plan.

However, at present, the engineers' abilities are not fully utilized because of the shortage and deterioration of facilities and equipment, the limited budget, and a deficiency of communication with organizations concerned. In addition, although individual engineers make efforts to research their own subjects, there is a tendency for them not to participate in the other subjects even if the subject is closely related to their own subject. Therefore, it should be recognized that communication and cooperation between the engineers brings further quality analysis on the marine environment.

For example, an engineer who conducts a marine environment observation tends not to notice the condition of terrestrial pollutant load sources; a water quality analyst does not take part in the evaluation process of the results; and the survey results are not compared with the other survey results.

Technical problems on the existing environment monitoring system in the Pearl River Estuary are shown below.

1) Personnel abilities in their own subjects are enough to conduct the monitoring plan. However, to improve effective monitoring, their potential and motivation should be raised by seminars and cooperation with engineers in other subjects.

2) Equipment and facilities, as stated in Chapter II Section 2.4, should be managed to minimize their short supply and deterioration. As some equipment is very expensive, such as the dioxin analysis equipment or GC/MS, plans should be made for such equipment to be used cooperatively with the other organizations.

3) Techniques on observation and analysis are plentiful. However, more attention should be paid to quality control of the data. In particular, significant numbers and S/N ratios should be noticed to maintain the reliability of survey results.

4) The most important thing is to promote information exchange and technical cooperation. Even in this study, it was also difficult to obtain the data on pollutant load from the inland area, which was possessed by other organizations, such as Guangdong Environment Protection Bureau, and coastal water quality data. These data are indispensable to monitor the marine environment comprehensively in the Pearl River Estuary, and to utilize the results for the management of the marine area. Therefore, it is essential that the monitoring take place under close cooperation with related organizations.