

Table 2.21 Change of mangrove areas and mangrove-related species

Region	Existing total areas (Km2)	Lost areas (Km2/a)		Number of mangrove species	Number of related species (bird, fish and invertebrate)	
		1950-1990	Last 5-10 years			
uangdong	38.13	4.37	0.03-0.44	18	Bird	121
					Fish	11
					<i>Coelenterata</i>	11
					<i>Cladocera</i>	2
					<i>Ostracoda</i>	1
					<i>Copepoda</i>	6
					<i>Euphausiacea</i>	1
					<i>Sergestinae</i>	2
					<i>Tunicata</i>	3
					Shellfish	49
					<i>crustacea</i>	44
					<i>Insecta</i>	133
Hainan	48.36	1.29	0.10-0.40	35	Bird	118
					Fish	8
					Beast	4
					Shrimp	5
					Crab	2
					Annelida	2
					Other species	76
Guangxi	56.54	1.09	0.28-2.5	14	Bird	Some
					Fish	4
					<i>Mollusca</i>	Dozens
					Shellfish	Some
H.K.	0.85	N/D	N/D	11	<i>Reptilia</i>	4
					<i>Maniralia</i>	7
Macau	0.01	N/D	N/D	5	N/D	
Fujian	3.6	9.0	N/D	9	N/D	
Taiwan	1.2	N/D	N/D	17	N/D	
Total	148.69	6.78	1.26	37	N/D	

● **Damage caused by human activities**

- (1) Reclamation and construction of salt pan;
- (2) Marine aquaculture practice; and
- (3) Land demand expansion for coastal cities, roads, ports and industrial installations.

In Dongzai Port of Hainan Province the forest areas destroyed by reclamation were 53 ha in 1957, while in 1972 and 1976 it were 80 ha and 533 ha respectively; 133 ha of mangrove trees were destroyed for construction of salt pan in 1957 and 67 ha in 1973. As a result, total areas of 866 ha of mangroves were destroyed. Besides, 40 ha of mangroves and mudflats were occupied by construction of ponds from 1994 to 1995.

The total areas of Futian Mangrove & Bird Preserve, Shenzhen City used to be 304.4 hectares, but from 1989 to 1993, 148.4 hectares of mangrove trees (48.76% of total areas of the Preserve) were changed for other purpose.

● **Causes of change**

The hydrology condition of mangrove ecosystem has been changed by human activities. For example, project of reclamation blocks the waters around part of mangroves of Futian Mangrove & Bird Preserve, then the original tidal movement has been changed and the shoal ecological environment has been turned into an inland pond one. As a result, 6.1 ha of original mangroves distributed in the central district and the experiment mangroves introduced from whole country have been destroyed.

● **Impacts of global change**

As has been discussed in section 2.3.1.6, it is possible that global climate becoming warm has reverse impact on the mangrove ecosystem.

● **Countermeasures**

At present three national-level mangrove preserves, five county-level ones and eight provincial-level ones, in which three in Taiwan and one in Hong Kong, have already been set up in China. They cover 6,965 ha areas of mangroves, which composes 47% of total areas of existing mangrove. Meanwhile, as the effective measures to recover and to develop mangroves and afforestation are in progress. In Dongzai Port Mangrove Preserve, Hainan Province, 122.6 ha of mangroves have been planted from 1981 to 1987. And the surviving rate is 61.5%. At the same time, series of scientific studies on mangrove has been conducted.

2.4.2.4 Seagrass Bed

● **Change in area and species composition**

The seagrass distributes along all the seaside of SCS (Fig. 2.10). The larger areas of seagrass beds distribute in Pearl River Mouth and Hepu County, Guangxi Region. During past 40 years the areas of seagrass beds along seaside of the SCS have reduced sharply due to reclaim land from sea and reclaim mudflats.

The dominant species of seagrass growing in Pearl Estuary are *Zostera mana* and marine *Zosstera marina*; the dominant species of benthon living in seagrass bed are *Neritina variegata*, others are *crustacea* and *Mollusca*.

In Guangxi Region the seagrass beds, with total area of 4,200 ha, mainly distribute in coastal waters from Hepu County to Dafeng River mouth. The beds consist of *Haloduie uminervis* and *Halophila ovalis* while organisms dwelling in the beds include 24 species of *Mollusca*, 9 species of *Arthropoda*, 4 species of *Echinodermata*, 3 species of *Annelida*, 2 species of *Coelenterata*, 8 species of *Pisces* and, 1 species of *Maniralia* — *Dugong*, the marine endangered animal. The areas of coastal seegrass bed and the related species are seen also in Table 2.22.

Table 2.22 Areas of coastal seegrass bed and related species

Subregion	Current areas (Km2)	Area lost or will lose/ year	Number of seagrass species	Number of related species (fish, Mollusca, other invertebrate)	
Guangdong	Small	N/D	2	<i>Neritina variegata</i>	1
Guangxi	4.2	N/D	2	<i>Mollusca</i>	24
				<i>Coelenterata</i>	9
				<i>Echinodermata</i>	4
				<i>Annelida</i>	3
				<i>Arthropoda</i>	2
				<i>Pisces</i>	8
				<i>Maniralia</i>	1
Hainan	N/D	N/D	N/D	N/D	
Total	4.2	N/D	4	<i>Mollusca</i>	25
				<i>Coelenterata</i>	9
				<i>Echinodermata</i>	4
				<i>Annelida</i>	3
				<i>Arthropoda</i>	2
				<i>Pisces</i>	8
				<i>Maniralia</i>	1

- **Damage caused by human activities**

Reclamation has caused decrease of seagrass bed areas.

- **Causes of change**

- (1) **Natural calamity**

Typhoon, especially windstorm wave caused by typhoon can violently destroy seagrass by rushing grass down, or burying them in soil or sand.

- (2) **Human activities**

- **Economic losses**

Habitats modification can result in tracts of seagrass beds vanish or make *Dugong* migration or death due to shortage of food.

- **Major impacted areas**

Pearl Estuary and Dafeng River Mouth.

- **Countermeasures**

- (1) **Setting up nature preserves**

Nowadays *Dugong* Nature Preserve of Shatian-Dafeng River Mouth and *Dugong* Nature Preserve of Yingpang Port-Yingluo Port have been set up.

- (2) **Enforcement of laws and regulations**

2.4.3 Critical Habitats, Ecosystems and Species with Transboundary Implication

The biodiversity of coastal areas and coastal waters is seen in Tab. 2.23.

Table 2.23 Biodiversity of coastal areas and coastal waters

Distribution Areas	Number of species	Number of local species	Number of harmed species	Number of migration species
Guandong Province	321 species of freshwater fish	4	4	6
Hainan Province	200 species of freshwater fish	29	>1	>1
Guanxi Autono. Region	Freshwater N / D	N/D	N/D	N/D
SCS	104-260 species of phytoplankton	N/D	N/D	N/D
North SCS	1064 species of marine fish	N/D	5-10	Over 30
	Over 200 species of shrimp	N/D	N/D	N/D
	130 species of zooplankton	N/D	N/D	N/D
South SCS	535 species of marine fish	N/D	5-10	Over 30
	58 species of <i>Polychaeta</i>	N/D	> 2	N/D
	250 species of zooplakton	N/D	N/D	N/D
Esturaies waters of Guangdong	319 species of benthos	N/D	N/D	N/D

Distribution Areas	Number of species	Number of local species	Number of harmed species	Number of migration species
Coastal waters of middle and west Guangdong	820 species of benthos	N/D	N/D	N/D
Coastal areas of Hainan	755 species of benthos	N/D	N/D	N/D
Coastal areas of Guangxi	832 species of benthos	N/D	N/D	N/D
Xisha Island	135 species of benthos	N/D	N/D	N/D
Guangdong	18 species of mangrove	N/D	N/D	N/D
Hainan	35 species of mangrove	14	> 1	N/D
Guangxi	14 species of mangrove	N/D	N/D	N/D
Fujian	9 species of mangrove	N/D	N/D	N/D
Hong Kong	11 species of mangrove	N/D	N/D	N/D
Macao	5 species of mangrove	N/D	N/D	N/D
Taiwan Province	17 species of mangrove	1	N/D	N/D
Guangdong	120 species of bird in mangrove	Over 30	Over 21	About 36
	250 species of invertebrate in mangrove	N/D	N/D	N/D
Hainan	100 species of bird in mangrove	N/D	N/D	N/D
	100 species of invertebrate in mangrove	N/D	N/D	N/D
Guangxi	Over 3 species of bird in mangrove	N/D	N/D	N/D
	Dozens of species of invertebrate in mangroves	N/D	N/D	N/D
Donsha Island (Guangdong Province)	70 species of reef-building coral	N/D	N/D	N/D
	Hundreds of other organisms	N/D	N/D	N/D
Hainan	110 species of reef-building coral	N/D	N/D	N/D
	186 species of Mollusca in reef-building coral	N/D	N/D	N/D
	104 species of Arthropoda in reef-building coral	N/D	N/D	N/D
	81 species of algae in reef-building coral	N/D	N/D	N/D
	27 species of fish in reef-building coral	N/D	N/D	N/D
	42 species of Coelenterata	N/D	N/D	N/D
	34 species of Echinodermata	N/D	N/D	N/D
Guangxi	45 species of reef-building coral	N/D	N/D	N/D
	Dozens of other marine organisms in reef-building coral	N/D	N/D	N/D
Nansha Island	94 species of reef-building coral	N/D	N/D	N/D
	195 species of fish in reef-building coral	N/D	N/D	N/D
	180 species of Mollusca in reef-building coral	N/D	1	N/D
	73 species of crab	N/D	N/D	N/D
Xisha Island	127 species of reef-building coral	N/D	N/D	N/D
	Over 300 species of fish in reef-building coral	N/D	N/D	N/D
Zenmuansha	6 species of soft coral	N/D	N/D	N/D
	61 species of drift fish roes & fries in reef-building coral	N/D	N/D	N/D
	47 species of Mollusca, 40 species of <i>Crustacea</i>	N/D	N/D	N/D
Huanya Island	46 species of reef-building coral	N/D	N/D	N/D
Taiwan	230 species of reef-building coral	N/D	N/D	N/D

Distribution Areas	Number of species	Number of local species	Number of harmed species	Number of migration species
Hong Kong	50 species of reef-building coral	N/D	N/D	N/D
Fujian	Over 10 species of reef-building coral	N/D	N/D	N/D
Pearl River Estuary of Guangdong Province	2 species of seagrass	2	N/D	N/D
Guangxi	2 species of seagrass	2	N/D	N/D
	24 species of Mollusca in seagrass	N/D	N/D	N/D
	8 species of fish in seagrass	N/D	N/D	N/D
	9 species of Coelenterata in seagrass	N/D	N/D	N/D
	1 species of Manniralia in seagrass	1	1	1

There are over 30 of transboundary species, as discussed in Section 2.3.2.2.

Beilun River Mouth Mangrove Preserve in Guangxi Region, the national-level preserve, is one of key ecosystems with transboundary implication.

It covers 2,680 ha of total areas of Mangroves, including 213 ha of key zones, 1,260 ha of buffer zones, 1,193 ha of experiment zones and 14 ha of other lands. The protection objects are mangrove marine ecosystems. In the preserve the mangrove community, with the largest tract of woods in the nation, can be divided into Group of *Bruguiera*, Group of *Aegiceras*, Group of *Kandelia* and Group of *Rhizophora*. In the mangroves mudflats biomass is 650 g/m², shallow waters benthos biomass is 67—175 g / m² and shallow waters plankton biomass is 75 – 254 g / m². The preserve is also rich in marine product resources, such as hundreds species of fish, dozens species of shrimp, sea snake and *Mollusca*; also blue crab, nude crab, squid, inkfish, octopus, sea cucumber, pipefish and sea horse and various species of shellfish.

● Momentous significance for sustainable fishery production

Mangroves are a special woody plant community growing in the tidal zones of tropic water, also the major regulator of ecological balance of estuaries and embayments. The mangrove is the suitable place for fish, shrimp, crab, algae and other marine resources to grow, reproduce, migrate and stay. It is obvious that the rootage becomes a natural marine cultivation region. On other hand, the woods are also the perching places for bird and insect. Therefore, mangroves have abundant biological resources.

Seagrass is fodder for *Dugong* as well as the habitats for fish, shrimp, shellfish, etc.

Coral reefs are appropriate regions for reef-staying organisms to live, hide and reproduce.

Above-mentioned special ecosystems supply the phytoplankton and zooplankton with growing and reproducing environment. Meanwhile, these plankton become biats of fish, the higher level organism in the food chain. Therefor, these ecosystems have important significance to stabilize ecosystem structure and to promote cycling of mater.

In marine ecosystems located in boundary areas there exists an inter-dependent relationship between water body, living organism and habitat. To strengthen protection and management of boundary area preserves will play an important role to sustainable development of fishery resources in local and boundary zones.

For instance, before establishment of Beilun River Mouth Mangrove Preserve, because of mangroves destruction the habitats of marine resources have narrowed and the marine product yield decreased gradually. In Fangcheng County, Guangxi Autonomous Region the fish yield went down to 5071 tons in 1987 from 5,541 tons in 1980; and the shrimp yield decreased to 16 tons in 1985 from 109 tons in 1983.

● **Importance in regional / global biodiversity**

Protection of key habitats, ecosystems and species not only guarantees sustainable development of marine economy, but also enrich the regional / global biodiversity.

For example, in Beilun River Mouth Mangrove Preserve, in pace with increase of species of marine resources staying under mangroves trees. Fish, shrimp and other marine products resources also goes up while a number of birds are led to the preserve for perching and looking for food, so regional biodiversity rises. Moreover, every year thousands of migrant birds from Siberia or Australia perch in Shenzhen Futian mangrove preserve for spending winter.

Dugong, a species living in boundary area, is the first – grade protection animal in China. Only one species survive. Protection of *Dugong* habitats will be advantageous to the growth and reproduction of the endangered species.

● **The vulnerable habitats**

Because of over-fishing, environment pollution, human activities and external variety introduction, the marine biodiversity is threatened gravely. As for above-mentioned key habitats and ecosystems, due to long-term disturbance of human activities their stability has degraded and their structure is weakened, thus some imprudent actions maybe destroy the whole system or even extinguish species. Therefore, we must be very careful in conducting any development activities in the areas with existing key habitats, ecosystems and species of transboundary importance.

● **Losses associated with degradation of habitats**

Because mangroves have the function of withstanding storm and resisting tide, if it is destroyed or cut down, the anti-calamity capability of coastal areas is weakened. As a result, local industrial and agricultural production is impacted gravely. Excavation of coral reefs disturbs original ecological balance and lends to seashore erosion. These key habitats, ecosystems and species also contribute more to maintaining ecosystem diversity, inheritance diversity and gene diversity.

● **Countermeasures**

- (1) Set up nature preserves Nowadays, 15 nature preserves for mangrove ecosystems, 8 nature preserves for coral reefs ecosystems, 3 nature preserves for estuaries and embayments and 7 key nature preserves for other rare species and aquatic resources have been set up in China coastal areas of SCS.
- (2) License for fishery. All fishing activities, determination of major fishing grounds and in fishing seasons are all licensed or arranged by responsible government departments or their authorized organizations.
- (3) Designate fishery preserves, forbidding catching production of motor crafts with trawlnets in the preserves

The no fishing seasons in SCS are June to August for Guangdong Province and Hainan Province, June to July for Guangxi Autonomous Region.

3. NATIONAL ANALYSIS OF THE SOCIAL AND ECONOMIC COSTS OF THE IDENTIFIED WATER-RELATED PRINCIPAL ENVIRONMENTAL ISSUES

In China there is no quantitative analysis on the social and economic costs of the identified water-related principal environmental issues. Due to no quantitative data available, here qualitative analysis of major costs is discussed.

3.1 Costs Due to Pollution and Shortage of Fresh Water

In China the social and economic costs due to pollution and shortage of fresh water comes from following aspects:

- Additional investment and operational costs are needed for moving water plants due to water quality degradation by pollution. This happens in Guangzhou, Fuoshan, Zhuhai and Zhanjiang.
- Loss of riverine fishery resulted from pollution. Fish catch in the lower courses of Pearl River and Han River basin decreases year by year. In some seriously polluted river courses, living freshwater resources are hard to be found.
- Loss of fresh water aquaculture. The Pearl River Delta has a tradition of fresh water aquaculture. Fresh water aquaculture develops quickly in past years in the coastal areas. Pollution and degradation of fresh water quality has resulted in increased costs of fresh water aquaculture year by year, quality degradation of aquaculture products and therefore value reduction.
- Loss due to modification of biodiversity in the coastal areas.

The problem of shortage of fresh water in China is very serious. Estimated economic loss of shortage of fresh water in China is 120 billion Chinese Yuans per year. In many islands of outer Pearl Estuary, fresh water demand continues to increase, fresh water shortage is very serious, therefore, water price goes upper and upper. Precious water price is a heavy economic load on the inhabitants on the islands. For example, Water price on Guishan Island and Dachan Island is 28 Chinese Yuans and 17 Chinese Yuans a ton respectively.

3.2 Costs Due to Pollution and Degradation of Sea Water

- With rapid economic development, municipal and industrial wastewater discharge into the sea from coastal zone increased sharply, fertilizer used and maritime aquaculture area increases rapidly in recent years. Therefore, concentrations of organic pollutants and nutrients in the estuaries and bays increased, areas of eutrophication and red tide have extended, and frequency of occurrence has increased. The loss of fishery and maritime aquaculture in near shore waters increases surprisingly year after year. For instance, red tide occurred in the estuaries and bays at south Fujian Province and Guangdong province from October of 1997 to May of 1998, in the waters where red tide occurred all net cultured living maritime resources died. Estimated loss of the red tide in the period from March to April of 1998 is around 20 million Chinese Yuans.
- The costs caused by maritime pollution accidents are very big. For instance, in May 1995, an oil supplement ship collided with a fish boat in Fangcheng Port Bay. Oil spilled on the water and contaminated area covered over 25 km² of seawater and over 4.5 km² of inter-tide mudflat. A large part of cultured living maritime resources was killed. Estimated loss is 16 million Chinese Yuan.
- Entertainment and tourism value reduction of the related seawater sand beaches is caused by seawater quality degradation.

3.3 Loss Due to Over-catching

3.3.1 Living Freshwater Resources

Over-catching of living fresh water resources has resulted in sharp reduction of catch production of high-value fresh water fish. Particularly over-catching of spawning fish and young fish has resulted in some species becoming endangered species and rare species, such as *Acipenser sinensis* Gray, *Macrura reevesi* (Richardson) et al.

3.3.2 Living Maritime Resources

Please see sections of 2.3.2.3 and 2.3.2.4.

3.4 Costs Due to Modification of Aquatic Habitats

3.4.1 Freshwater

Modification of habitats affect spawning fields of fish and, therefore, make the populations of species declined.

3.4.2 Marine

Modification of habitats in estuaries and bays particularly inappropriately extensive reclamation results in huge loss. Cheng-Rao acclamation in Han River mouth, for example, is the biggest reclamation project in east of Guandong Province with an area of 48.6. The reclaimed land is lower than sea level. Arable land is only 58% of the total area. Only 41% of the total area were used till 1982. The reclaimed area used to be a shallow bay with an area of 135 hectares of oyster culture. The yield of oyster was over 100 tons per year. The yield of other living maritime resources was over 100 tons per year too.

Some species of mangrove cannot stand with the modified habitat, correspondingly became endangered species.

3.5 Loss Due to Biodiversity Declination

Serious loss arose from disruption of coral reef ecology balance. In Bangtang village, Wenchang City of Hainan Province, for example, disruption of coral habitat from human activities has caused serious coastline erosion, the coastline has been eroded away over 200 meters.

Due to destroy of mangrove, maritime living habitats and spawning habitats decreased. Therefore, living marine resources in some estuaries and bays decreases rapidly. Also due to destroy of mangrove, coastal dykes loses biological protection. The damage to coastal reclaimed land, aquatic culture practice and salt pans caused by typhoon has increased.

4. ANALYSIS OF THE ROOT CAUSES OF THE IDENTIFIED WATER-RELATED PRINCIPAL ENVIRONMENTAL ISSUES

The coastal zone is one of the rapidly developing areas in China also a dense-populated area. Wastewater discharge and pollution loads increases quickly in recent years. About twenty-percent industrial wastewater and eighty-percent municipal wastewater discharged into rivers and the sea is not treated. So, pollution discharge from coastal areas is the major cause of identified water-related principal environmental issues.

Urban area extension and industrial development in the coastal areas demand more land. Therefore, extensive reclamation for urban and industrial development decreased the area of wetlands.

Population boom and the improvement of living standards are stimulating the demand for food, vegetables, fruits and aquatic products. Therefore, the increasing use of fertilizer and pesticide for meeting the demand for aquaculture is also an important cause of pollution and degradation of fresh water and near shore waters.

Population boom and the improvement of living standards have also increased the demand for seafood. So, over-exploitation of living marine resources has resulted in the decrease of marine catching in the estuaries and bays year by year.

In brief, large population, lack of funds and poor management are major causes of water-related issues/problems. But, each specific environmental issue and its cause differ from one another. According to the data and information presented in chapter 2 and general circumstance of the South China Sea and its associated freshwater catchments, in Table 4.1 to Table 4.2, all specific identified water-related environmental issue/problem are listed. Table 4.1 to Table 4.4 involves issues of pollution, fresh water, exploitation of living aquatic resources and modification of aquatic habitats, the sources, main impact areas, particularly the analyses of the root social-economic causes, potential transboundary consequences and severity respectively. The severity is graded as 3 for severe effects, 2 for major effects, 1 for moderate effects, 0 for no effects.

According to analyses and evaluation in Table 4.1 to Table 4.4 and present status of the coastal areas, major environmental problems/issues, the causal chain analyses and proposed actions are listed in Table 4.5. Main environmental problems/issues include pollution of nutrients (N & P) and organic materials (COD & BOD), red tide, widespread modification of aquatic habitats, oil pollution and natural disasters.

Tables 4.1 to Table 4.5 are helpful for transboundary diagnostic analysis for the South China Sea and its associated freshwater catchments.

Table 4.1 Main pollution issues, impacts and causes

sources	Impact areas	impacts	Root/ social-economic causes	Trans-boundary aspect	Severity
1. Municipal wastewater: N/P, BOD/COD, bacteria, metals and chemicals loads to rivers and sea waters	Pearl Estuary Shantou Bay Guangzhou Bay Near shore water of Haikou City Near shore water of Beihai City	<ul style="list-style-type: none"> ● water quality degradation ● eutrophication ● anoxia/fish kills ● bioaccumulation ● human health 	<ul style="list-style-type: none"> ● lack of treatment facilities ● lack of investment 	biodiversity loss	3
2. industrial wastewater: chemicals, heavy metals, POPs, BOD, COD and SS loads	Pearl Estuary Shantou Bay Guangzhou Bay Near shore water of Haikou City Near shore water of Beihai City	<ul style="list-style-type: none"> ● acute/chronic toxicity ● anoxia/ marine animal asphyxiation 	<ul style="list-style-type: none"> ● lack of incentives for low-consumption/waste production ● lack of adequate treatment technology ● lack of resource for pollution control 	biodiversity loss	1
3. agricultural/rural/town pollution: <ul style="list-style-type: none"> ● Rice farms/domestic/ aquaculture wastewater ● N/P, BOD/COD, chemicals, POPs and pesticide/ herbicide loads ● Sediment/ silt 	Pearl Estuary Shantou Bay Guangzhou Bay Near shore water of Haikou City Near shore water of Beihai City	<ul style="list-style-type: none"> ● water quality degradation ● eutrophication ● anoxia/fish kills ● human health 	<ul style="list-style-type: none"> ● improper use of fertilizer /pesticide ● lack of integrated management ● poor enforcement of laws and regulations 	biodiversity loss	3
4. oil/hydrocarbons: <ul style="list-style-type: none"> ● ship-based operational discharge ● ports/ oil terminals spill ● exploration/exploitation ● municipal wastewater 	Pearl Estuary Shantou Bay Guangzhou Bay Near shore water of Haikou City Near shore water of Beihai City	<ul style="list-style-type: none"> ● anoxia/ marine animal asphyxiation 	<ul style="list-style-type: none"> ● lack of resource for pollution control ● lack of integrated management 	biodiversity loss	2

Table 4.1 continue

sources	Impact areas	impacts	Root/ social-economic causes	Trans-boundary aspect	Severity
5. solid waste: ● landfill fields ● solid waste/ litter/marine debris ● chemicals seepage ● waste dumping	Pearl River Delta	surface water degradation urban landscape public health	lack of regulation for recycle, reuse and disposal lack of resource	No	1
6. ship-based discharge: ● dumping(dredged materials) ● ballast waste ● exotic species bilge-water ● normal/accident waste discharge	Pearl Estuary Shantou Bay Guangzhou Bay Near shore water of Haikou City Near shore water of Beihai City	acute/chronic toxicity anoxia/ marine animal asphyxiation (e.g. accidental oil spill)	Lack of legal enforcement Lack of regulation to enforce Lack of capability of surveillance/ monitoring	Biodiversity loss Potential transboundary pollution (e.g. accidental oil spill)	2
7. sediment: ● pollutants accumulation ● benthos/coral asphyxiation caused by trawlnets ● soil erosion/sediment caused by water conservancy project construction	Pearl Estuary	anoxia/benthos asphyxiation sedimentation	lack of coordination between developing activities and environment protection	biodiversity loss	2
8. atmosphere inputs: ● carbon inputs from power station and fire ● acid inputs(smoke, NO _x , SO _x) from power station and plants ● heavy metals from industrial process and vehicles ● POPs formed in industry and burning	Pearl River Delta Coastal region in east Guangxi	long-term poisonous damage	improper energy composition lack of adequate technology to control air pollution lack of financial resource	possibility of long distance transportation	2

Table 4.2 Main fresh water issues, impacts and causes

Issue	impact areas	Impacts	direct causes	root/social-economic causes	tran-sboundary aspects	severity
Freshwater shortage	rural areas in the three counties in east Guangdong Province Leizhou Peninsula cities: Beihai, Guangzhou, Shantou, Shenzhen, Hong Kong, Macau	<ul style="list-style-type: none"> ● pause/closure of a part of plants ● economic loss 	insufficient precipitation /over extraction of ground water: Leizhou Peninsula, Zhanjiang City and Beihai City natural shortage: the three counties in east Guangdong Province and Shenzhen City quality degradation: Guangzhou City and Shantou City	lack of incentives for saving water lack of policy to encourage waste water treatment lack of investment	No	1
Quality degradation	Guangzhou City, Fuoshan City, Shantou City	<ul style="list-style-type: none"> ● Public health 	Untreated municipal/industrial wastewater to rivers Non-point sources	lack of funds for waste water treatment backward industrial techniques/high water consumption	no	2

Table 4.3 Over-exploitation of living aquatic resources, effects and causes

over-exploitation	effects	immediate causes	root/social-economic causes	transboundary consequence	severity
Fresh water	significant decrease of fish catch endangered species	over-fishing water pollution	population growth/demand increase failure in understanding importance of ecosystems lack of public awareness lack of sustainable development strategy	biodiversity loss productivity reduction	2
Marine	increase of production costs rise of price of marine products	growth of capability of marine catch	profit pursuance growth of demand	marine productivity reduction	1

Table 4.4 Modification of habitats, effects and causes

habitat	impact areas	effects	immediate causes	root/social-economic causes	transboundary asoects	priority
mangrove	Pearl Estuary Leizhou Bay Tieshan Bay Hainan Province	loss of amenity value aquatic productivity reduction coastal erosion weakening capability of seashore against natural disaster	improper coastal development/ reclamation	massive coastal population growth results in growing pressure for land reclamation lack of public awareness failure in evaluating the ecological/ economical values of mangrove	biodiversity loss	3
coral reefs	Hainan Province	marine productivity decrease	mining to make lime and roads extraction for handicraft articles	lack of public awareness failure in evaluating the ecological value of coral reefs profit incentive	biodiversity loss	3
seagrass	Pearl Estuary	marine productivity decrease	decrease caused by trawlnets covered by sediment over-exploiting by people	fail in understanding its ecological importance lack of legislation	biodiversity loss	3
wetlands	Pearl Estuary Beihai City	decrease of food/ spawning ground of living marine resources decrease of coastal buffer zone for land-based pollution	improper coastal development/ reclamation	massive coastal population growth and rapid development result in growing land demand failure in understanding environmental and ecological importance of wetland	biodiversity loss	2

Table 4.5 Main environmental problems/issues and causal chain analysis

problems/ issues	impact areas	sources	immediate causes	intermediate causes
nutrient(N&P)/ organic pollutants (COD)	Pearl Estuary Shantou Bay Guangzhou Bay Near shore water of Beihai City Near shore water of Haikou City	domestic wastewater industrial wastewater agriculture activity aquaculture activity	untreated domestic/ industrial discharge wash-away of excess N&P from fertilizer use improper agricultural technique poor management of agricultural waste	lack of treatment facilities for domestic/industrial wastewater high-consumption of water
harmful algae blooms	Pearl Estuary Han River mouth & adjacent waters	Industrial/domestic/agr icultural wastewater discharge Nutrients (N&P)from freshwater/ marine aquaculture practice	Eutrophication	excess nutrients discharged from domestic/industrial sources nutrient fluxes to water bodies from fertilizer application/ intensive animal husbandry/ aquacultural practice storm run-off
oil pollution	Pearl Estuary Shantou Bay Guangzhou Bay Near shore water of Beihai City Near shore water of Haikou City	ports/harbors riverine/marine transportation lad-based discharge ship accidents	oil spills discharge from ports/ harbors and ships oil-containing wastewater discharge	malpractice lack of sufficient facilities for collecting oily wastewater lack of treatment facilities
Modification of habitats(mangrove coral reefs, seagrass and wetland)	widespread: - the coastal areas - sea waters in the SCS - freshwater bodies	coastal development	coastal reclamation exploitation of coral reefs intensive aquaculture	demand growth for land trying to increase income
Natural disaster	widespread: - the coastal areas	natural element: El Rhino tropic storm	Typhoon storm surge tsunami	improper seashore protection improper coastal development improper alarm system

Tables 4.5 continue

problems	root causes	social/economic costs	needed actions
Nutrient (N&P)/organic pollutants(COD)	lack of funds to adopt adequate production/ treatment technology poor enforcement of environmental laws/ regulations improper water price	loss of freshwater/ marine fishery	capability building (e.g. planning, training, monitoring and information system) construction of treatment facilities legislation: revision of existing laws, making necessary new laws management improvement research on pollution mechanism and control technique
harmful algae blooms	lack of low-cost technology for nutrient removal from domestic and industrial sewage improper fertilizer application failure in understanding the mechanism of harmful algae bloom lack of forecast capability	loss of marine aquaculture	more efficient agriculture technology sustainable development strategy research works and information collection improvement of capability for forecast and of emergency measure
oil pollution	poor enforcement of regulations lack of public awareness on oil pollution lack of funds for management	loss of freshwater/ marine fishery loss of marine aquaculture negative effect on tourism cost growth of emergency measure for oil spill accident	improvement of management for treatment of oily containing wastewater and oil spill capability building of emergency measures for oil spill increase of investment to improve oil recovery facilities
Modification of habitats(mangrove coral reefs, seagrass and wetland)	too large population and poverty lack of public awareness failure in evaluate/value the ecological resources lack of legal enforcement public policy failures	loss of amenity value huge cost for restoration biodiversity loss loss of fishery	set-up of nature preserves habitat restoration projects environment education/ public awareness legal/regulation enforcement ecological resource evaluation capability building database/information
natural disaster	lack of forecast capability lack of coastal planning	casualties loss of property	capability building research work on potential effects of climate change and natural disaster improvement of coastal planning guideline for coastal planning and management

5. CONSTRAINTS TO ACTION

5.1 Information, Scientific Uncertainties and Public Awareness

The water environment systems and aquatic ecology systems are composed of multi-subsystem; i.e. they are intricate and complicated. Therefore, obtained information on the state of pollution may be inadequate. Information acquisition for the public is difficult. Particularly gained information on living aquatic resources and habitats is usually inadequate, incomprehensive, unsystematic and sometimes contradictory. Both the data provision and information acquisition needs a lot of time.

There exist scientific uncertainties in description and assessment of environment systems, living aquatic resources and habitats. This sometimes makes it difficult to convince public and decision-makers of social-economic profit of environmental improvement, and social-economic loss of environmental quality degradation and cost for restoration. Further more, since environment is an open system and there are interactions among its various parts, decision-makers may have difficulty in expecting direct reward of action.

China is a developing country. Up to now, its GNP per capita is only about 600 US dollars. Most people received just preliminary education. Therefore, lack of public awareness on the environment is an important constraint to action. Public and decision-makers usually give economic development high priority but environment protection low priority. More attention is paid to improvement of living standard than improvement of environment quality. Public particularly decision-makers without environmental consciousness are a much more severe constraint to action than information and scientific uncertainties.

5.2 Financial and Economic

To protect surface water from pollution, a huge funds for treatment of domestic and industrial wastewater is needed. In China coastal areas, financial and economic restraints to action are key points. Only in few big coastal cities are there domestic and mixed wastewater treatment plants. Treatment rate of domestic wastewater in the coastal areas is less than twenty percent.

5.3 Legal, Institutional and Managerial

The legislation on environment protection and natural resource protection in China started from early 1980s. Up to now, China has 6 laws which relate to identified principal environmental issues and 8 laws on natural resources protection. It is obvious that China should have more laws on environment protection and resources protection particularly for wetland and habitats. As a signatory state of many international conventions, China legally promises to fulfil its obligations for transboundary pollution control action.

Up to now, China has no national agency responsible for the management of aquatic resources, wetlands and habitats. For example, wetlands are managed by different agencies from different sectors. The mechanism of cooperation among sectors is unclear, which often causes overlaps and conflicts.

6. ON-GOING AND PLANNED ACTIVITIES TO THE IDENTIFIED WATER-RELATED PRINCIPAL ENVIRONMENTAL ISSUES

6.1 Legislation and Regulation

Laws promulgated, which are related to identified principal environmental issues, are as follows:

- Marine Environment Protection Law of People's Republic of China
- Fishery Law of People's Republic of China
- Marine Traffic Safety Law of People's Republic of China
- Mineral Resources Law of People's Republic of China
- Wildlife Protection Law of People's Republic of China
- Water Pollution Control Law of People's Republic of China

The relative regulations of China are as follows:

- Regulation on Preventing Seawater Pollution from Boats and Ships
- Regulation on Marine Environment Protection from Oil Exploration and Exploitation
- Regulation on Marine Dumping
- Regulation on Preventing Environmental Pollution from Ship Dismantling
- Regulation on Preventing and Controlling the Pollution and Damage of Marine Environment from Land-based pollutants
- Regulation on Preventing and Controlling the Pollution and Damage of Marine Environment from Coastal Construction Activity
- Regulation on Cooperative Exploitation of Marine Oil with Foreigner Partners
- Regulation on Nature Reserves
- Regulation on the Protection of Reproduction of Aquatic Resources
- Regulation on Abroad Boats and Ships
- Regulation on Drinking Water Source Protection
- Seawater Quality Standard

6.2 Chinese Trans-century Green Project Program

The program has been started from 1995 and will be finished by 2010. It covers China's seven major river (including Pearl River) catchments. Thirty-six projects including thirteen sewage treatment plants are planned in Pearl River basin in the ninth Five-year period (1995 to 2000). It is expected that the treatment plants will have a capacity of 1.54 million per day with 190,000 tons per year of COD removal (including 150,000 tons per year of COD from domestic wastewater and 40,000 tons per year of COD from industrial wastewater).

In the program are also planned ninety-nine projects for coastal cities and near shore waters. The planned capacity of sewage treatment is 1.04 million tons a day. Expected annual COD removal is 300,000 tons (including 110,000 tons from domestic wastewater and 190,000 tons from industrial wastewater).

It is expected that the planned projects will reduce significantly the pollution loads particular COD and oil to the South China Sea. Therefore, it can improve the marine environment.

6.3 Chinese Biodiversity Protection Action Plan

The Chinese Biodiversity protection Action Plan was completed by National Environment Protection Agency (NEPA, now it is called State Environment Protection Administration, SEPA) of China in 1993. Seven protection objectives and corresponding actions were planned. The action five is about the protection of coasts and seas. The objectives of action five are to protect marine ecosystems, to prevent the marine environment from pollution, to ban over-catching, to protect mudflats from pollution and reclamation, and to protect seawaters from marine aquaculture.

6.4 Determination of Water Quality Objectives for Coastal Waters

To coordinate the relationship of regional development and environment of coastal areas, to improve the ecological systems of near shore waters, and to protect marine environment from pollution, the SEPA of China started an action to determine water quality objectives of coastal waters in 1990. Water quality objectives were determined according to the utilization purpose of the near shore waters. The near shore waters of China were determined four type of utilization based upon current national marine water quality standard which includes three comprehensive sets of marine water quality standards. Correspondingly, water quality objectives were defined in four categories of utilization:

- Waters for marine nature reserves and waters where there exist rare marine creatures
- Waters serving for marine-related industrial production such as salt processing and food processing
- Waters for fishery, mariculture and swimming
- Waters for general amenity purpose

It is expected that the action will improve the management of marine environment and the coastal waters.

6.5 Pollution Reduction from Land-based Sources

To protect the coastal waters from land-based pollutant discharge eleven sewage treatment plants with a total capacity above 2 million tons a day have been in operation in the coastal cities up to now. The treatment rate of industrial wastewater in the coastal areas is eighty percent.

6.6 Total Load Control to the Seas from Land-based Sources

Total load control to the seas from land-based sources is a key measure to resolve marine pollution problems. China initiated recently the plan of total load control. The initial stage of the plan is to investigate pollution sources and pollutant loads to the seas. The total load to the sea is determined based upon the assessment of assimilative capacity.

6.7 Ship and Seaport Pollution Control

In view that severe pollution may result from oil spill from ship and marine installations, China has developed oil spill emergency program. In the mean time research and development of technologies for oil spill emergent reaction have be strengthened.

To control pollution of seaports, seaport pollution program has also been developed. Facilities have been installed to collect and treat oily wastewater and chemical or hazardous water from ship and harbors. Above-mentioned measures have suppressed pollution from sea-based sources.

7. SPECIFIC ACTION PROPOSED FOR EACH IDENTIFIED ISSUE/ PROBLEM

7.1 Habitat Modification

7.1.1 Marine Dumping

Environment protection law, marine environment protection law and the law of pollution protection from solid waste and relative regulations of China prohibit domestic and industrial waste to be dumped to any water body including sea.

China has set report requirement and license requirement for the management of marine dumping. This management requirement came into force in 1991. Any marine dumping activity must be reported to relative agencies and be licensed in advance. Most licensed marine dumping waste is dredging material. The dumping sites were located in the seas where the marine dumping has only slight effect or no effect on aquatic creatures.

Laws strictly ban dumping to any freshwater bodies in land.

7.1.2 Determination of Water Quality Objectives of Coastal Waters

The SEPA of China carried out an action to determine the water quality objectives coastal waters in 1990. Top level of water quality objectives were given to the coastal waters with important marine habitat value or endangered/ rare species. The action plays a very important role in the protection of marine ecosystems and endangered/rare species.

7.1.3 Chinese Biodiversity Protection Action Plan

The action 5 of Chinese Biodiversity protection Action Plan is about the protection of coasts and seas. Marine ecosystem protection, coastal mudflat protection and coastal pollution control are the essential contents.

7.1.4 Coastal Nature Preserves

Facing to great pressure of massive coastal population and coastal reclamation on marine habitats, China has set up coastal nature preserves to protect important habitats from being destroyed.

7.1.4.1 Mangrove Preserves

China has set up mangrove preserves in the coastal areas. They are:

- Futian, Guangdong
- Shenzhen River mouth to Baishizhou, Guangdong
- Beitan, Guangdong
- Haitian, Guangdong
- He'an and Xinchu, Guangdong
- Yinluo Bay, Guangdong
- Shankou, Guangxi
- Qingzhou Bay, Guangxi
- Beilun River mouth, Guangxi
- Dongzai Port, Hainan
- Qinglan, Hainan
- Caiqiao, Hainan
- Qingmei Port in Yalong Bay, Hainan
- Sanya River, Hainan
- Xialan, Hainan

7.1.4.2 Coral Reef and Seagrass Preserves

With respect to coral reefs preserves in China, please see section 2.4.2.2.

With respect to seagrass preserves in China, please see section 2.4.2.4.

7.2 Pollution

Pollution from human activities is major cause of identified environmental issues/ problems. So, pollution reduction and loads reduction to the sea is a key point of the actions to resolve water-pollution problems.

Several wastewater and waste treatment plants were constructed in the coastal cities (please see Tables 7.1). The existing treatment plants have alleviated the pressure of pollution discharge from the coastal cities on marine environment.

All levels of government in China in the coastal areas have paid much attention to waste/wastewater treatment in past years. All major coastal cities have made a comprehensive plan for pollution control and waste/wastewater treatment in a short term and a long term. The investments for waste/wastewater in the coastal cities started to increase greatly from 1997. A number of treatment plants are being constructed or will be constructed in recent years (please see Table 7.2) to reduce pollution to rivers and the sea. Here treatment plans in few typical coastal cities and Pearl River Delta are briefly introduced. The coastal cities and Pearl River Delta are major cities/ area of identified pollution hot spots.

Table 7.1 Existing waste treatment facilities

Subregion	Mixed wastewater treatment facilities		Domestic wastewater Treatment facilities		Industrial wastewater Treatment facilities	
	Number	Capacity (10 ³ ton/a)	Number	Capacity (10 ³ ton/a)	Number	Capacity (10 ³ ton/a)
Guangdong (1997)						
Chaozhou	0	0	0	0	72	3557.5
Shantou	1	3270	0	0	220	16873.6
Jieyang	0	0	0	0	43	4103.3
Shanwei	0	0	0	0	13	1296.0
Huizhou	0	0	0	0	150	7978.3
Shenzhen	7	152010	0	0	485	33760.9
Dongguan	2	3410	0	0	139	47176.8
Guangzhou	2	97040	0	0	1061	218532.7
Zhongshan	10	11260	0	0	247	50885.3
Zhuhai	3	28920	0	0	117	18755.3
Jiangmen	0	0	1	7300	270	73374.3
Yangjiang	0	0	0	0	43	16672.8
Maoming	0	0	0	0	159	49262.1
Zhanjiang	0	0	0	0	223	59145.6
Subtotal	28	295910	1	7300	3242	601374.5
Guangxi (1996)						
Beihai	0	0	0	0	N/D	15205.4
Qingzhou	0	0	0	0	N/D	18380.5
Fangcheng Port	0	0	0	0	N/D	2713.1
Subtotal	0	0	0	0	N/D	36119.0
Hainan (1997)						
Haikou	2	4030	0	0	12	4533.4
Wanning	0	0	1	840	4	171.5
Others	0	0	0	0	158	39772.3
Subtotal	2	4030	1	840	174	44477.2
Hong Kong	N/D	N/D	N/D	N/D	N/D	N/D
Macau	2	294410	0	0	N/D	N/D

Table 7.1 continue

Subregion	Solid waste treatment facilities			Volume of solid waste goes to landfills(ton/a)
	Number	Type	Capacity	
Guandong (1997)				
Shenzhen	1	Incinerator	139600 ton/a	826300
Dongguan	1	Incinerator	100 ton/d	N/D
Other cities	0			2883700
Subtotal	2			37100
Guangxi	0			N/D
Hainan	0			N/D
Hong Kong	N/D			N/D
Macau (1996)	2	Incinerator	198000 ton/a	480

Table 7.2 Waste treatment (in year 2003)

Subregion	Mixed wastewater treatment facilities		Domestic wastewater treatment facilities		Industrial wastewater Treatment facilities	
	Number	Capacity (10 ³ ton/a)	Number	Capacity (10 ³ ton/a)	Number	Capacity (10 ³ ton/a)
Guangdong (1997)						
Shantou	1	3270	2	69350	N/D	N/D
Jieyang	1	10950	N/D	N/D	N/D	N/D
Shanwei	0	0	0	0	13	1296.0
Huizhou	N/D	N/D	2	43800	N/D	N/D
Shenzhen	10	323400	N/D	N/D	N/D	N/D
Dongguan	2	3410	3	60220	N/D	N/D
Guangzhou	5	128700	N/D	N/D	N/D	N/D
Zhongshan	10	11260	1	36500	N/D	N/D
Zhuhai	3	73000	N/D	N/D	N/D	N/D
Jiangmen	1	32850	1	7300	N/D	N/D
Yangjiang	1	3650	N/D	N/D	N/D	N/D
Maoming	1	18250	N/D	N/D	N/D	N/D
Zhanjiang	1	36500	N/D	N/D	N/D	N/D
Guangxi (1996)						
Beihai	1	73000	N/D	N/D	N/D	N/D
Hainan (1997)						
Haikou	3	116800	N/D	N/D	N/D	N/D
Wanning	1	2190	N/D	N/D	N/D	N/D
Sanya	1	29200	1	1820	N/D	N/D
Ledong	1	3650	N/D	N/D	N/D	N/D

7.2.1 Water Pollution Control Plan of Shantou City

Present Status of Pollution Discharge

In the urban area of Shantou City, total amount of wastewater is 481.97 million tons a year. Among that, industrial wastewater directly to the sea is 45.98 million tons a year, domestic wastewater directly to the sea is 73.23 million tons, and wastewater through four channels to the sea is 362.75 million tons. The plan divides the urban area into eight drainage sub-areas. In Table 7.3 pollution loads of each sub-area are listed.

Table 7.3 Pollution loads of Shantou City (1995)

Sub-area	Wastewater (ton/a)	Load to the sea (t/a)					
		SS	CODcr	BOD ₅	Ammonia-N	Total-P	oil
New development	176723700	10523.06	20587.24	6235.21	1115.10	163.98	118.44
North old area	54438000	2639.85	7060.28	3744.58	950.5	150.64	89.94
West Port	111069000	10300.76	5752.42	2207.77	911.15	117.78	27.58
Meixi SE	(-1256000)	3286.60	5562.93	2829.78	692.74	105.16	79.40
Meixi NW	18471700	1062.93	2704.11	1175.48	207.27	38.66	19.05
Dagang River	49145700	2377.04	1512.48	825.26	156.62	60.43	20.30
Dahao	20871400	1122.97	3215.80	1017.39	201.87	49.94	27.55
Hepu Town	4416500	N/D	728.72	326.82	64.48	16.25	5.61

7.2.1.1 Wastewater Treatment Scheme

Four wastewater plants have been planned to be constructed in the urban area with total capacity of 422000 tons per day. The capacity of each plant is listed in Table 7.4.

Table 7.4 Planned wastewater treatment plants

Name of wastewater treatment plant	Capacity (ton/day)
East subregion	222000
Niutianyang	26000
Qishan	139000
Da'an	35000
Total	422000

7.2.1.2 Schedule of Implementation

Stage 1 (by year 2000)

The capacity of East subregion plant will be extended to 140000 tons a day. Niutianyang plant No. 1 with a capacity of 19700 tons a day will be constructed. Estimated total cost is 287.4 million Chinese Yuans.

Stage 2 (2001 to 2010)

Four treatment plants will be constructed. Total cost is estimated to be 579.7 million Chinese Yuans.

7.2.2 Water Pollution Control Plan of Zhanjiang City

7.2.2.1 Present Status of Pollution Discharge

The investigation result shows the major pollutants in the coast waters are COD, inorganic nitrogen and oil. Loads of effluents at four discharge points are listed in Table 7.5.

Table 7.5 Pollution discharge to the sea from Zhanjiang urban area

Locations	CODcr (ton/a)	Inorganic-N (ton/a)	Oil (ton/a)
Shawan	6435.0	454.8	77.71
Developing zone	2496.6	228.5	64.71
Huguang District	2752.1	155.9	47.89
Potou District	7.3	0.37	0.15

7.2.2.2 Wastewater Treatment Scheme

By year 2000 four planned wastewater treatment plants will be completed. Total capacity is 199,000 tons a day. The estimated cost is 239.2 million Chinese Yuans. The operational cost is estimated to be 199,000 Yuans a day.

Table 7.6 Wastewater treatment in Zhanjiang City

Name of plant	Capacity (ton/d)	COD removal rate (%)	Cost (million Yuan)	Operation cost (Yuan)
Shawan	94200	78.9	113.0	94200
Lutang	23200	61.8	27.8	23200
Bifeng	35400	83.8	42.5	35400
Chemical P.	46200	62.2	55.4	46200
Total	199000		23.9	199000

7.2.3 Water Pollution Control Plan for Pearl River Delta

Pollution discharge from city group in the Pearl River Delta is the major source of water pollution and quality degradation of Pearl River network and Pearl Estuary. To improve water quality, sixteen major industrial wastewater facilities (see Table 7.7) and seven comprehensive projects (see Table 7.8) in Pearl River Delta have been planned. The estimated cost for the sixteen facilities is 6904.8 million Yuans, and the estimated cost for the seven projects is 6523 million Yuans.

Table 7.7 Industrial wastewater treatment facilities in the Pearl River Delta

Name of facility	Cost estimation(million Yuan)
Guangzhou papermaking plant	40
Guangzhou monosodium glutamate plant	20
Guangzhou Huangpu ship-making plant	16.97
Guangzhou chemical plant	0.65
Panyu Meishan sugar refinery	20
Lianhuashan papermaking plant	6
Panyu fertilizer plant	12
Fuoshan Huanan decorative cloth plant	7.5
Fuoshan textile mill	4.5
Shanshui Qiangli brewery	3.5
Jiangmen papermaking plant	233.77
Huizhou brewery	2
Huidong sugar refinery	2.5
Doumen Baijiao sugar refinery	6.5
Zhuhai Pingsha sugar refinery	3.5
Zhuhai brewery	2.4
Total	381.79

Table 7.8 Water projects in the Pearl River Delta

Name of project	Cost estimation (million Yuan)
Sixianjiao dam	1100
Guangzhou-Humen regulation project	3900
Second stage of Fen River regulation project, Fuoshan	1260
Qi River regulation project, Zhongshan	1350
Yisha River regulation project, Jiangmen	113
Star Lake regulation project, Zhaoqing	100
Shenzhen River regulation project	1100
Total	6523

7.3 Freshwater Shortage

7.3.1 Coastal Cities Deficient of Freshwater

Coastal cities being deficient of freshwater are Hong Kong, Shenzhen, Macau, Zhanjiang, Beihai and Sanya. In the cities the demanded amount of freshwater is larger than maximum sustainable freshwater supply. Due to massive population growth, urban expansion and industry development in past years, surface water degradation is so serious that it cannot be used as drinking water source. The freshwater supply in these cities has to be dependent on surface water of other areas.

Hong Kong and Shenzhen City

Since 1987 a part of freshwater supply has come from Dongjiang River that is thirty kilometers north from Shenzhen City. At present, freshwater supply from Dongjiang River composes about eighty percent of total freshwater supply in the two cities.

Macau

All freshwater supply comes from Muodaomen outlet of Pearl River. The freshwater pipeline is about forty kilometers long.

Zhanjiang City, Beihai City and Sanya City

Water diversion works have been constructed for these cities. The distance from the cities to freshwater sources is between forty to eighty kilometers.

7.3.2 Coastal Cities with Surface Water Degradation

Guangzhou City, Fuoshan City and Jiangmen City in the Pearl River Delta are rich in surface water. Freshwater sources of these cities were local rivers before. Due to freshwater degradation caused by pollutant discharge from the cities, freshwater sources had to be moved to upper reaches of the rivers.

8. IMPLICATIONS OF THE PROPOSAL ACTIONS BY SECTOR

8.1 Finance

- Central government and provincial government will provide subsidies for key pollution control projects in the coastal zone.
- Municipal and/or county budget is for domestic wastewater treatment facilities.

8.2 Economic Development

- Chinese government will launch environment-friendly economic development policy. In the course of urbanization and industrialization sustainable development is the essential target of economic development. Cleaning production and material recycling are encouraged to reduce resource consumption and pollution.
- Environment-friendly master plans are promoted at provincial, regional and municipal levels.
- Favorable policy is made for foreign and domestic investment in environment projects (clean water, wastewater treatment, waste treatment and so on) and low pollution production.

8.3 Fisheries

- Set up fishery-banned zones in reservoirs, rivers, lakes and the sea to protect spawning fish and young fish. Setting up fishing forbidden season in the sea.
- Encourage freshwater and coastal aquaculture, technology transfer, breeding and supply of young fish.
- Put young fish into rivers to increase fish population.
- Encourage offshore fishing, technology transfer and assistance.
- Strengthen education, propaganda and public awareness on environment protection.

8.4 Agriculture

- Make sustainable agriculture policy to reduce pollution causing eutrophication and red tide.
- Encourage technology transfer and assistance of chemical fertilizer utilization.
- Use pesticide of low poison.
- Launch non-poisonous vegetable program and clean water project in rural areas.
- Strengthen propaganda and education to rural population on environment protection.

8.5 Forestry

In the coastal regions, decrease of area of forest stopped in 1980s and forest has increased significantly in 1990s in Guangdong subregion. It is still needed to

- Forbid cutting land and wetland forest and promote afforestation;
- Accomplish green-cover program for bare hills and mountains;
- Establish more nature reserves; and
- Construct green projects.

8.6 Manufacturing

- Conduct environment impact assessment for new project and expanding project
- Set deadline for all sectors to meet effluent standard by year 2000.
- Implement total load control scheme.

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press, Beijing, 1996



Figure 1.1 Geographical Position of South China Sea.

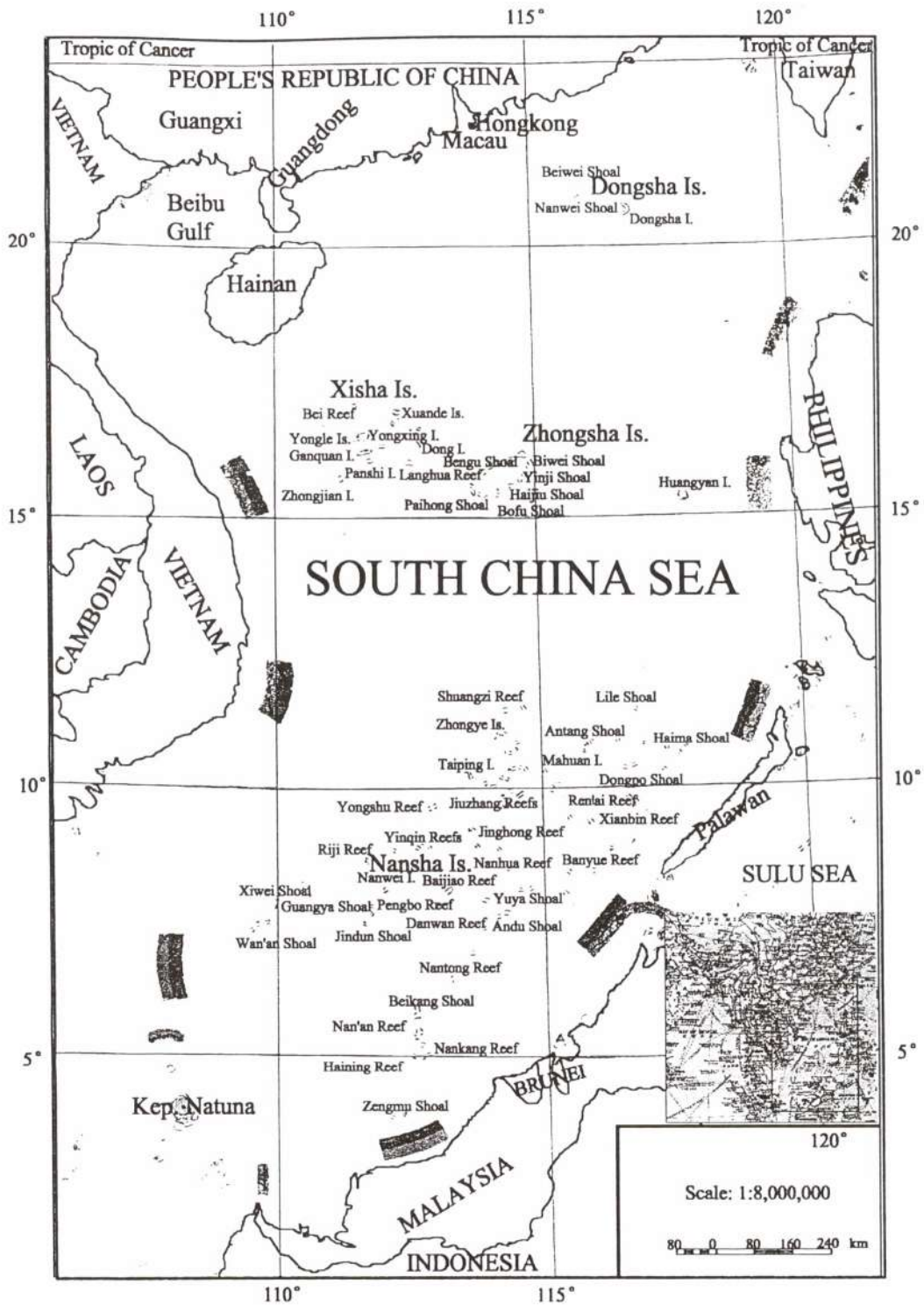


Figure 1.2 Boundaries of South China Sea in PRC.

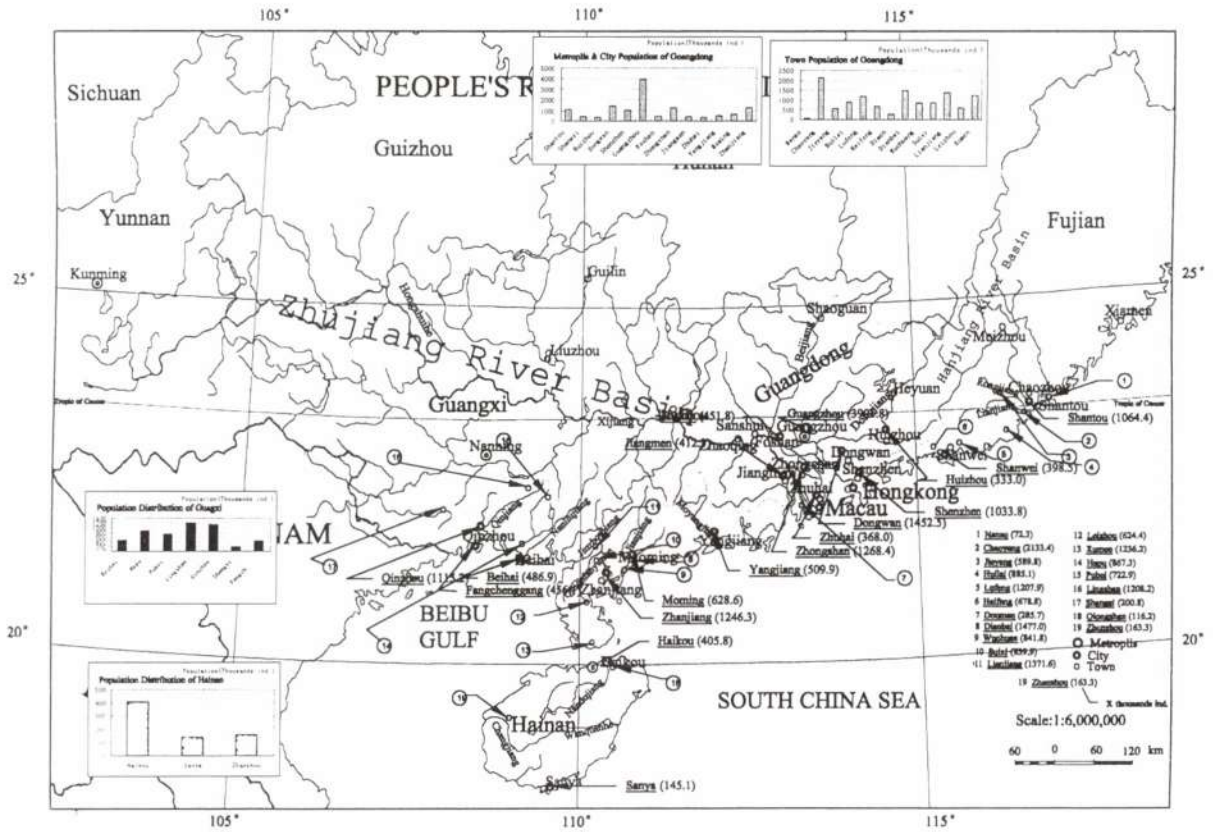


Figure 1.3 Population Distribution and Coastal Developing Centres (1996).

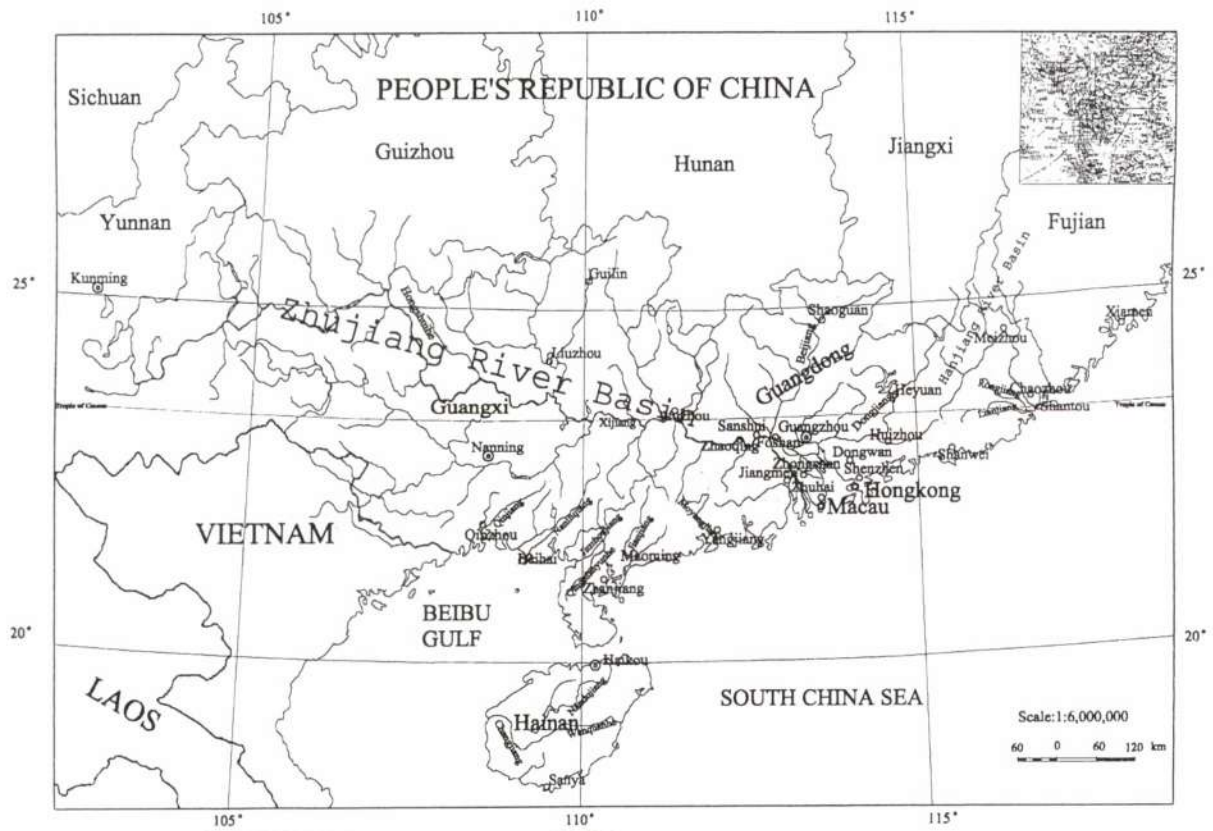
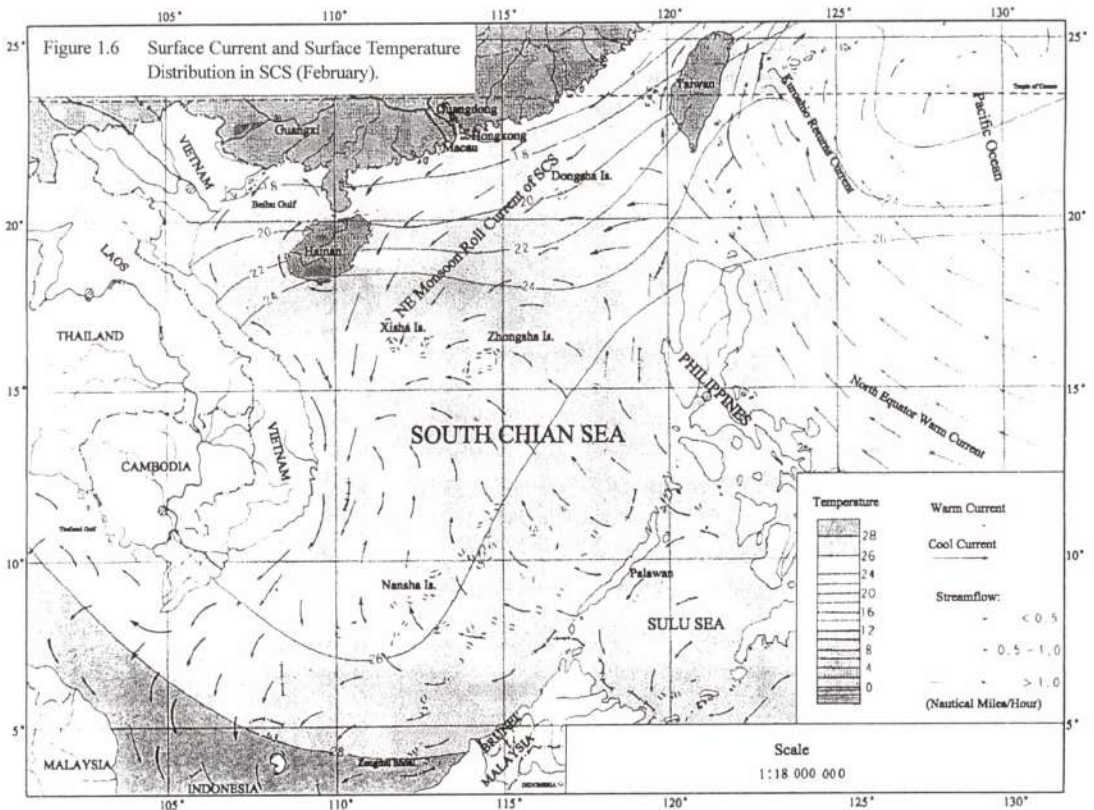
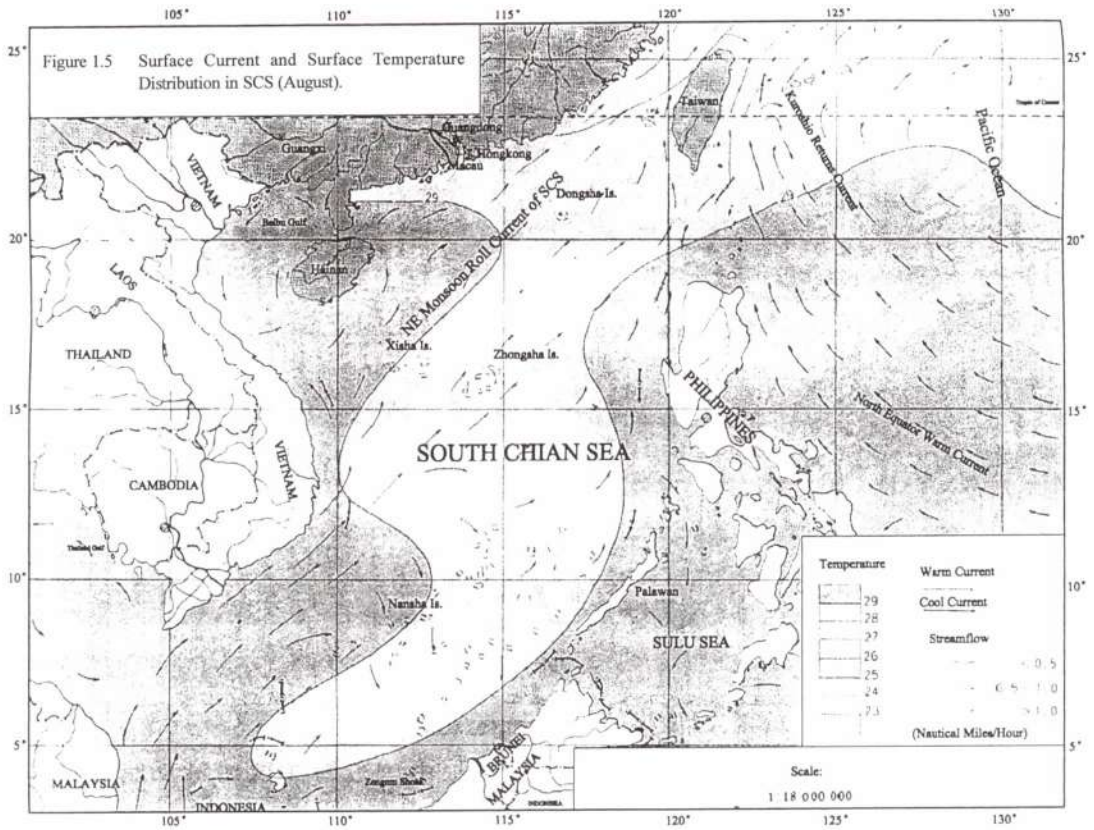


Figure 1.4 Boundaries of River Basins (Zhujiang, Hanjiang Basins etc.) in South China.



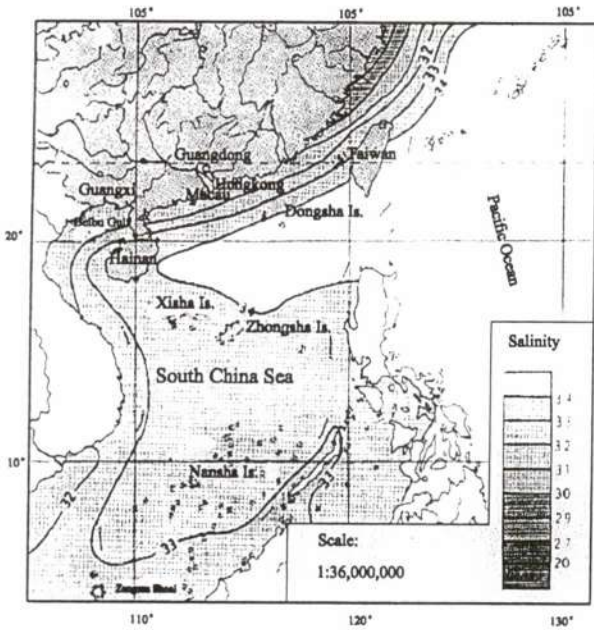


Figure 1.8 Distribution of Salinity in SCS (February).

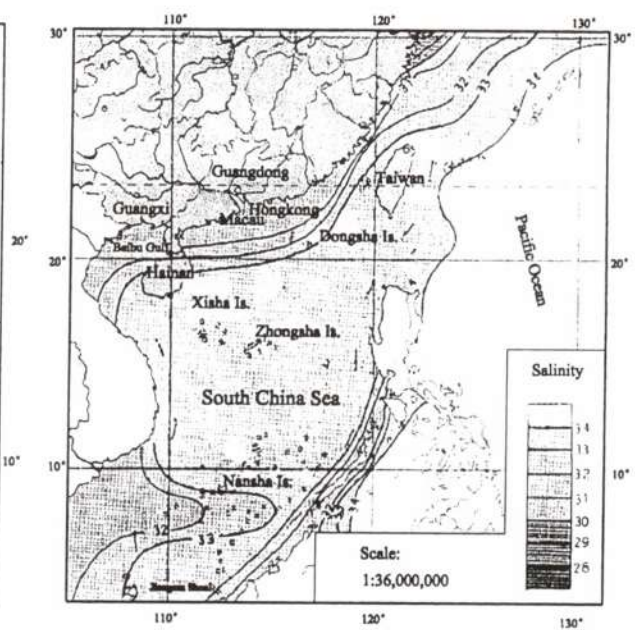


Figure 1.7 Distribution of Salinity in SCS (August).

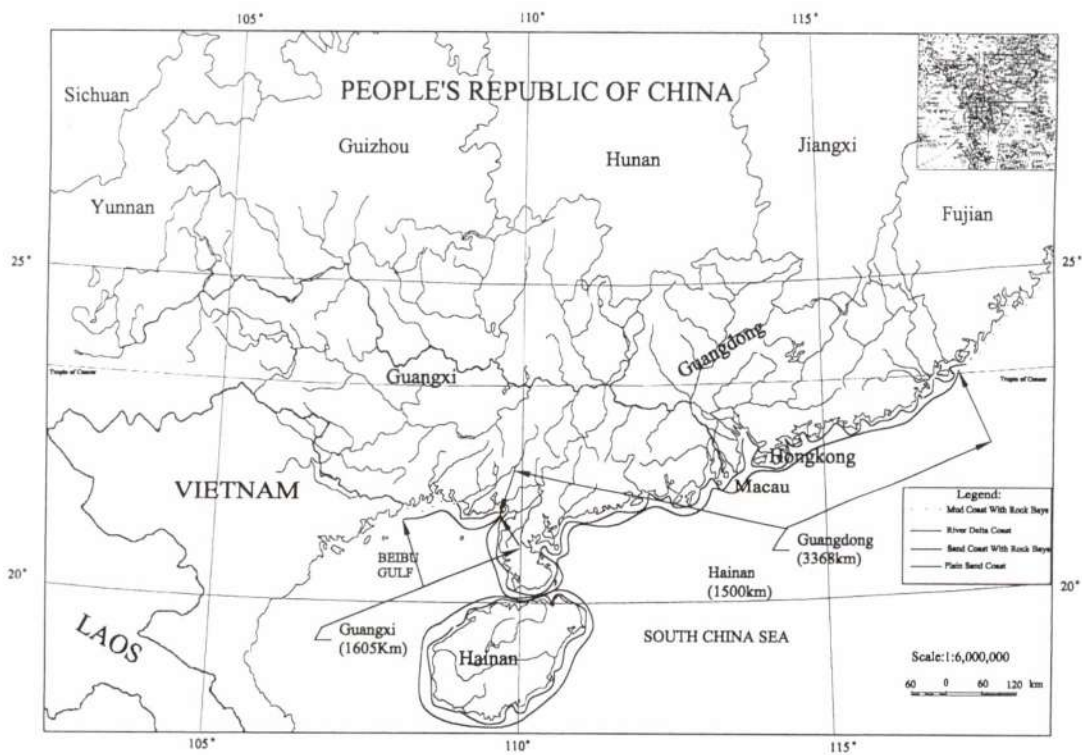


Figure 1.9 Geomorphological Characteristics of Continental Shelf and Length of SCS' Coastline in PRC.

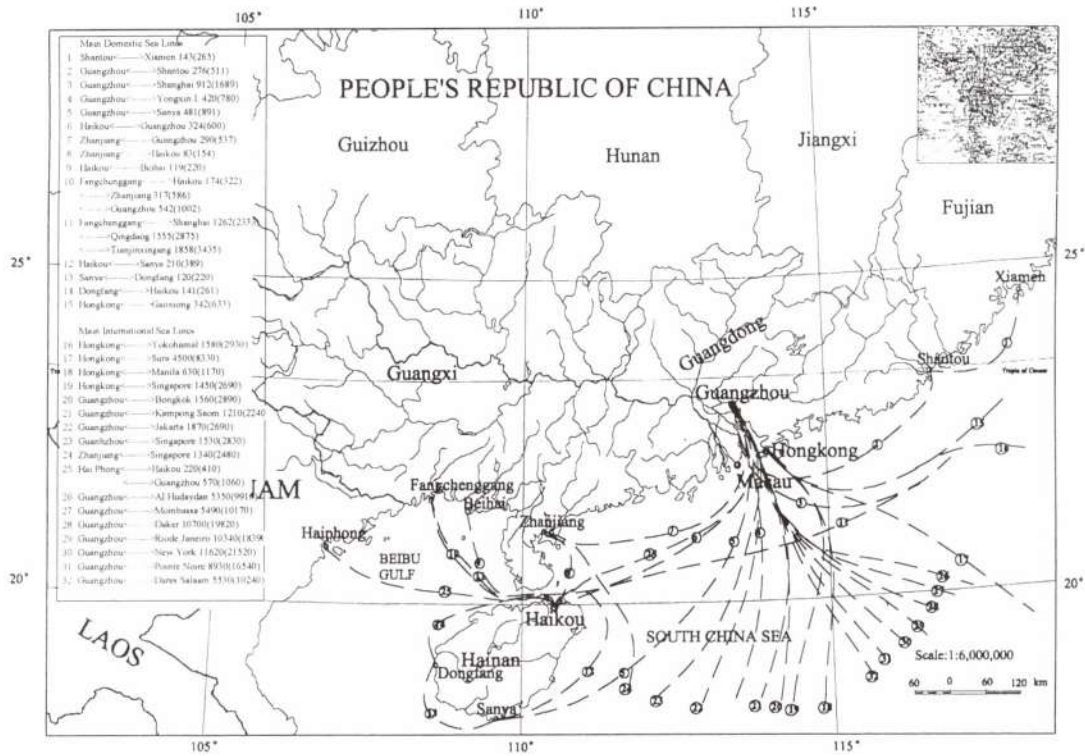


Figure 2.1 Main International and Domestic Sea Lanes.

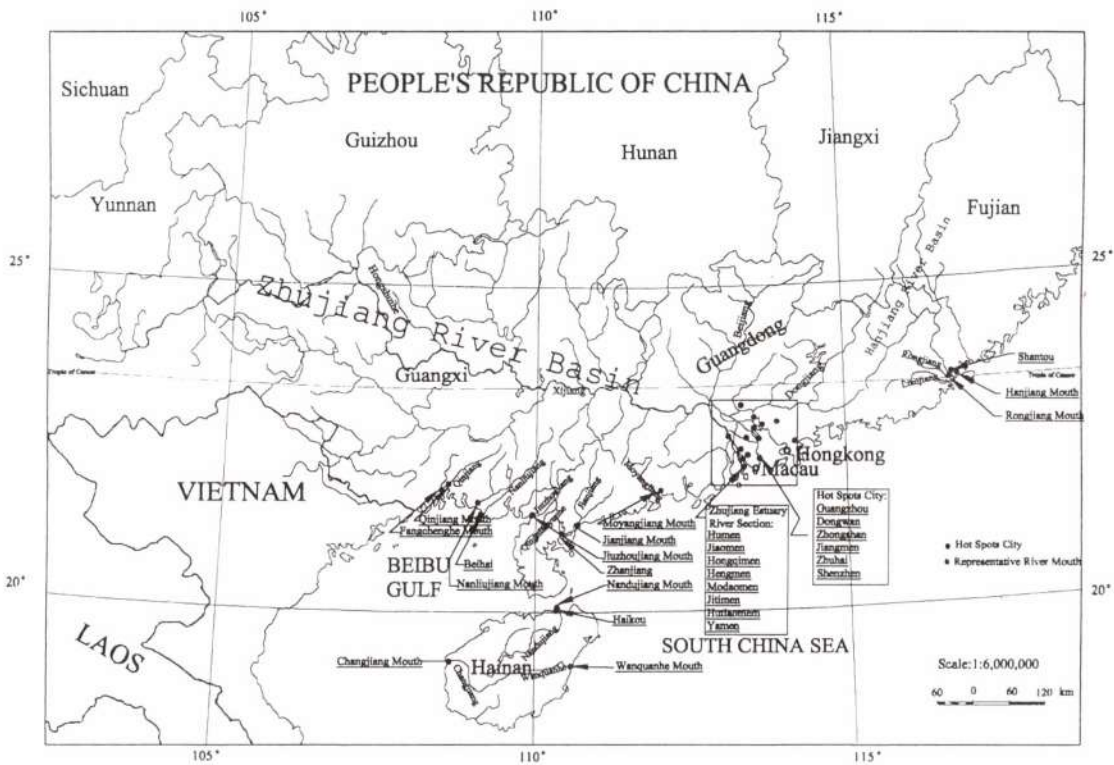


Figure 2.2 Hot Spots of Environmental Pollution in terms of Water Quality.

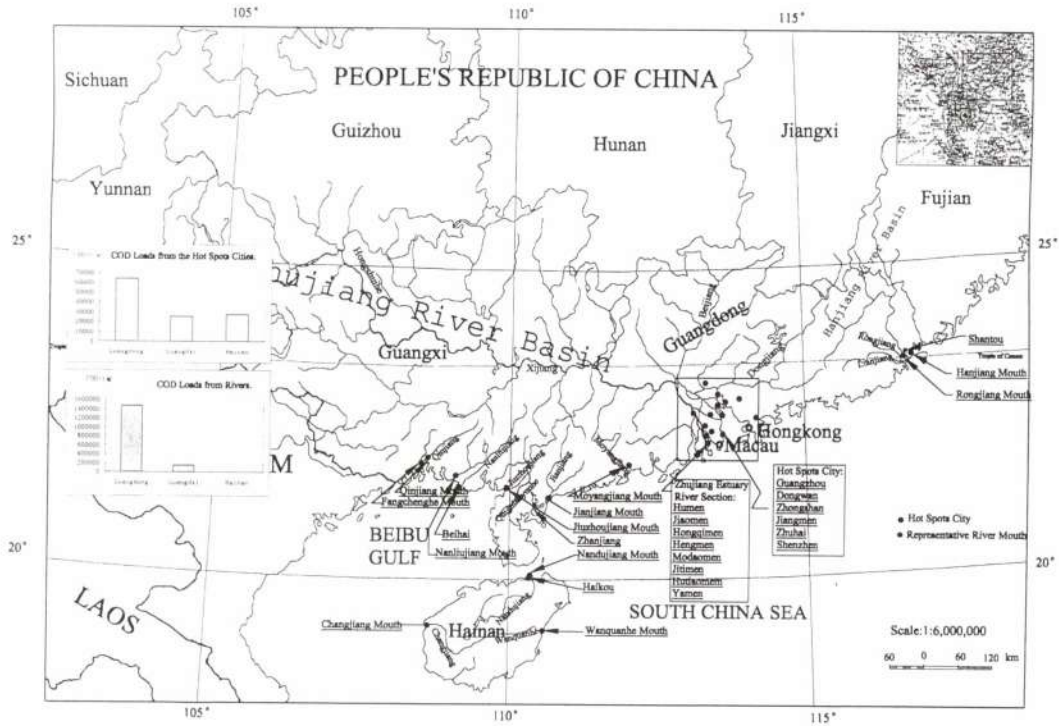


Figure 2.3 Distribution of COD Loads Directly Discharged to SCS.

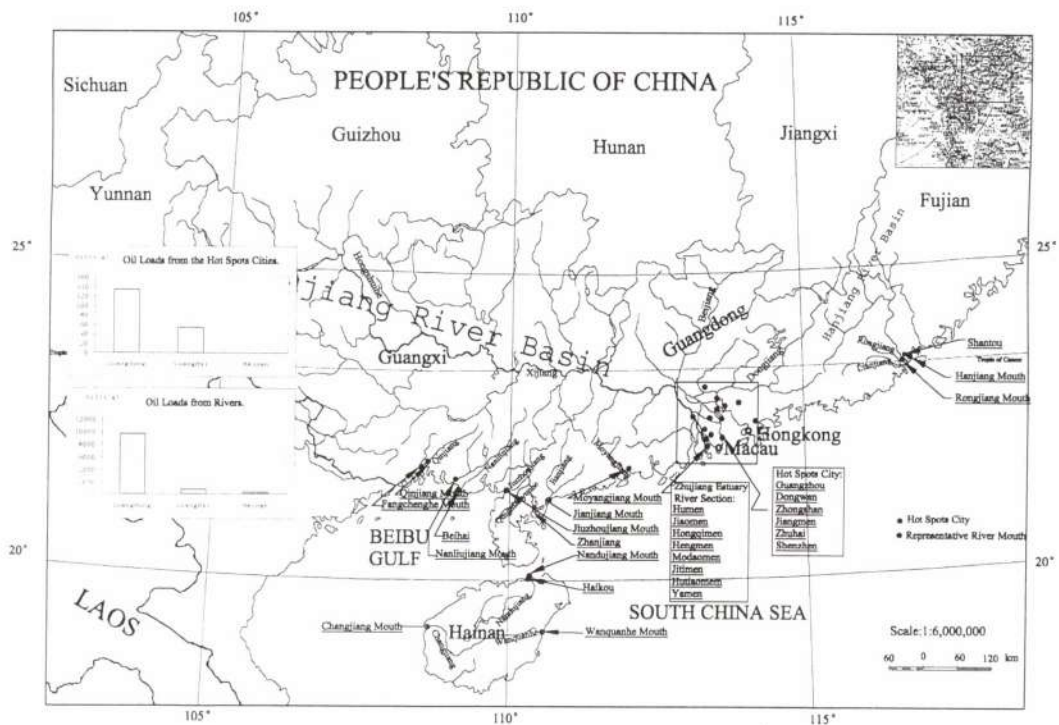


Figure 2.4 Distribution of Oil Loads Directly Discharged to SCS.

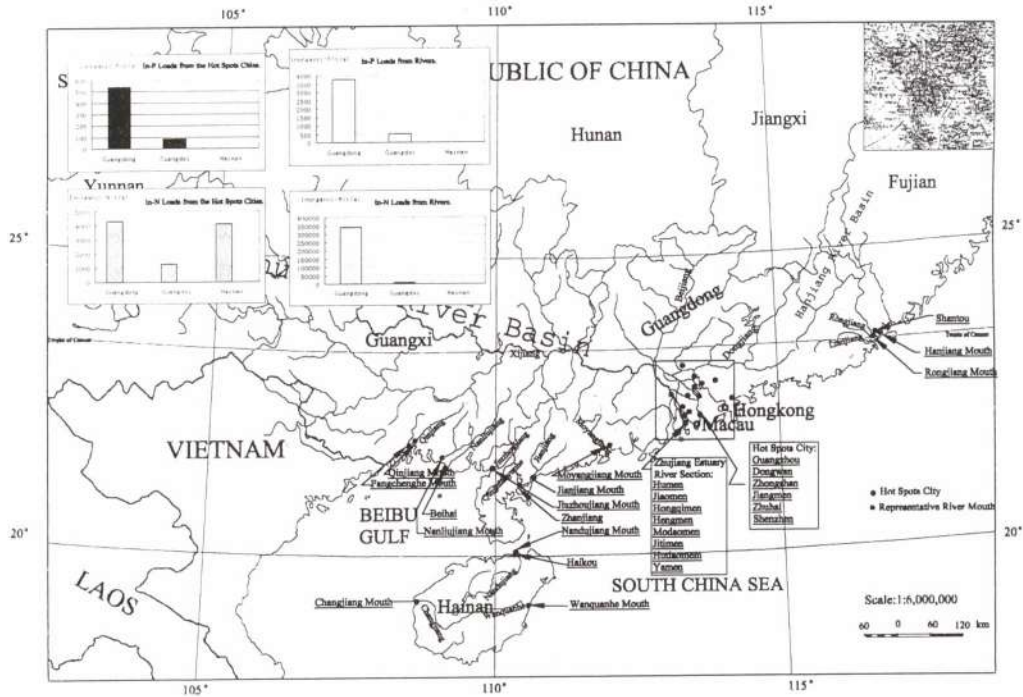


Figure 2.5 Distribution of Inorganic-N, P Loads Directly Discharged to SCS.

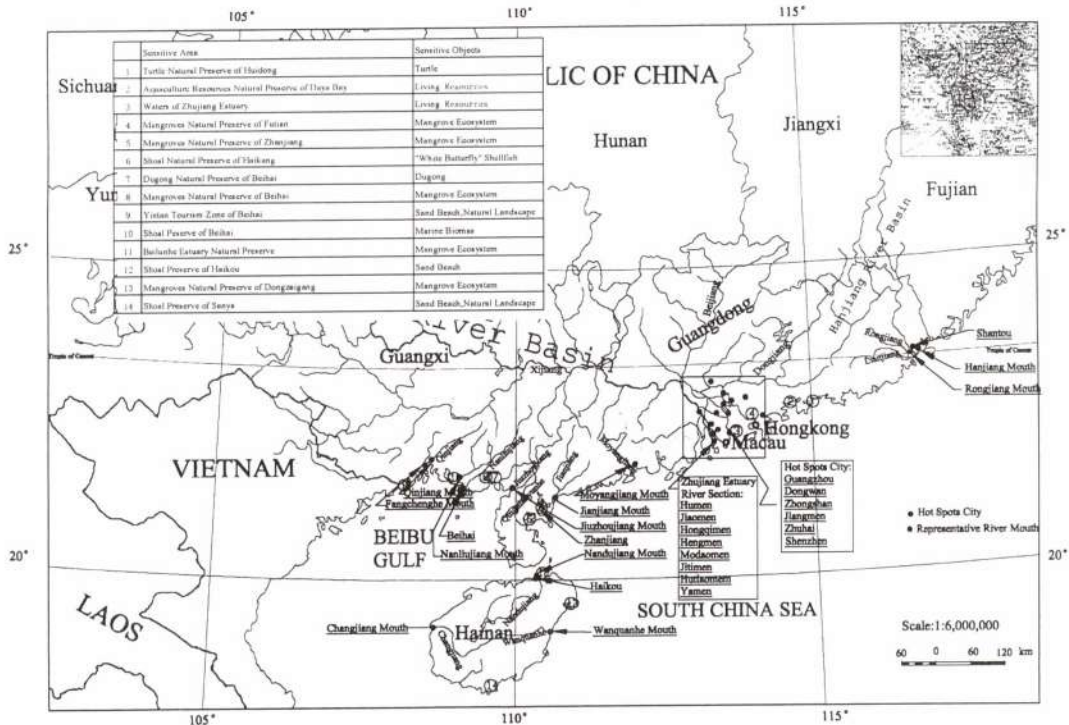


Figure 2.6 Pollution Sensitive Areas.

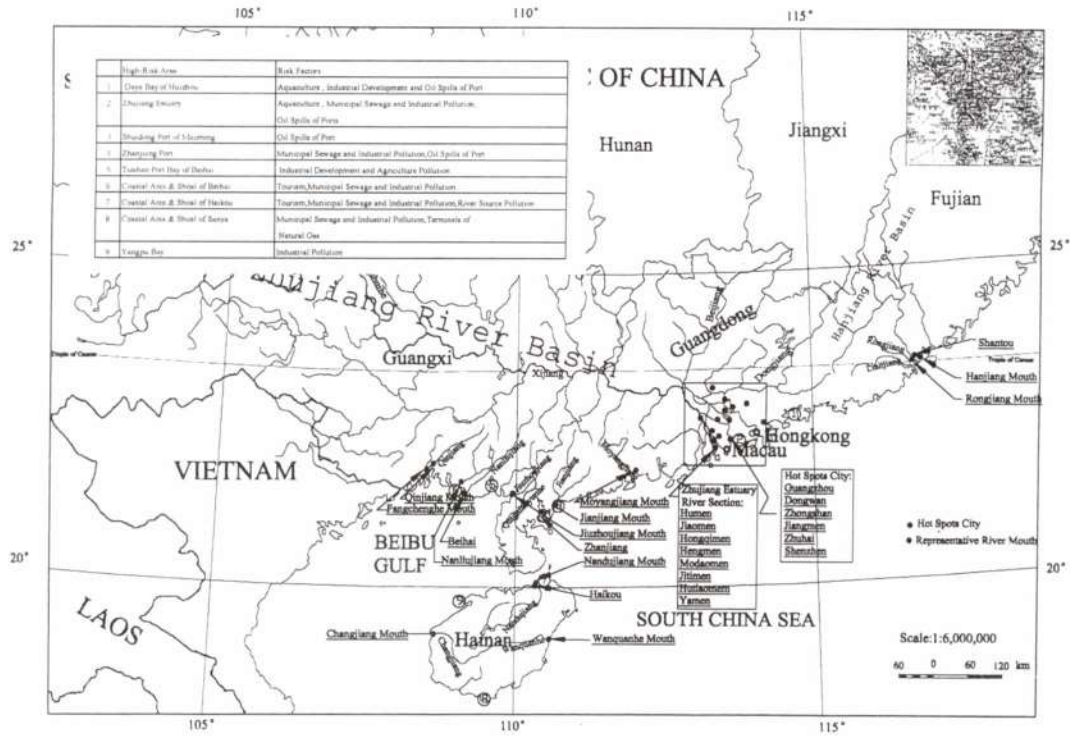


Figure 2.7 High-Risk Areas of Pollution.



Figure 2.8 Boundaries of Lancangjiang River Basin in People's Republic of China.

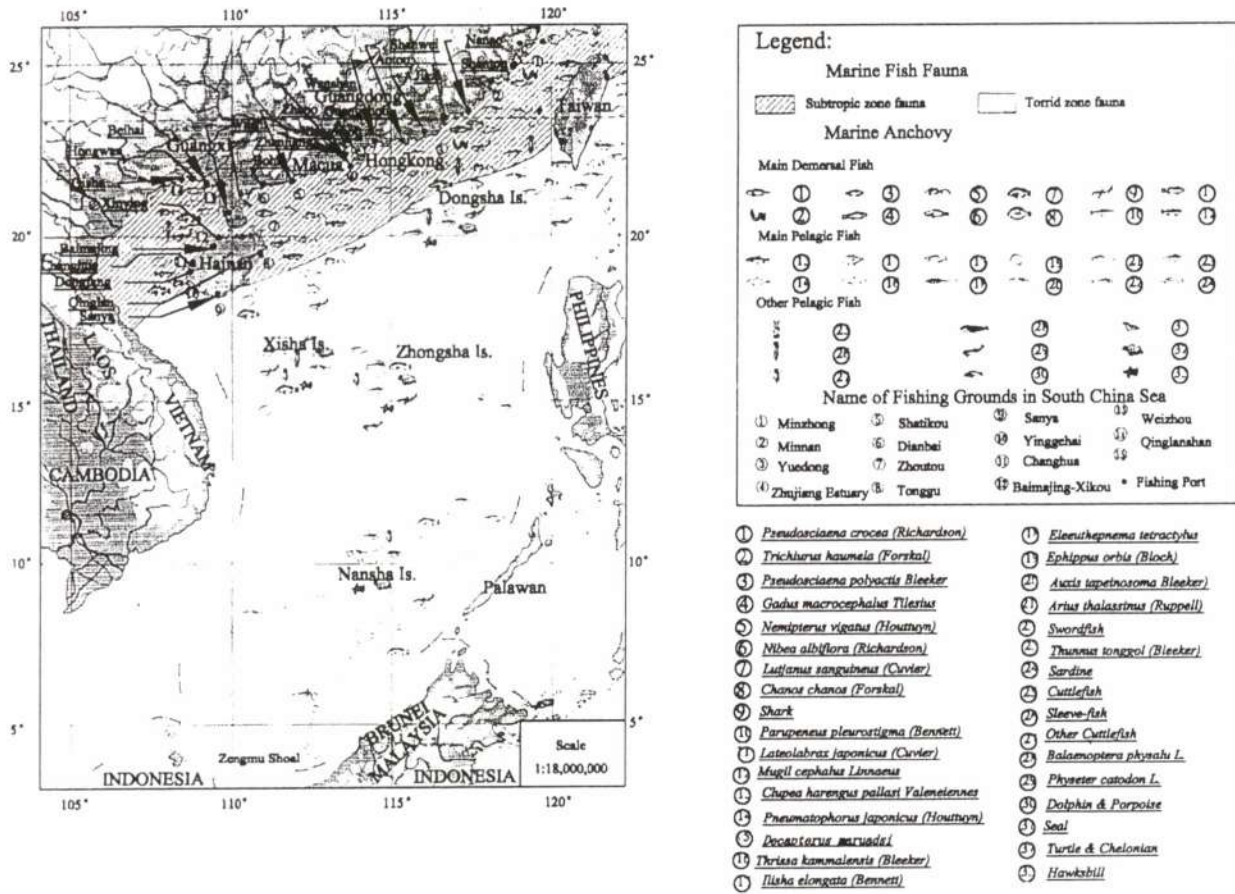


Figure 2.9 Marine Living Resources in SCS – Distribution of Marine Economy Anchovy.

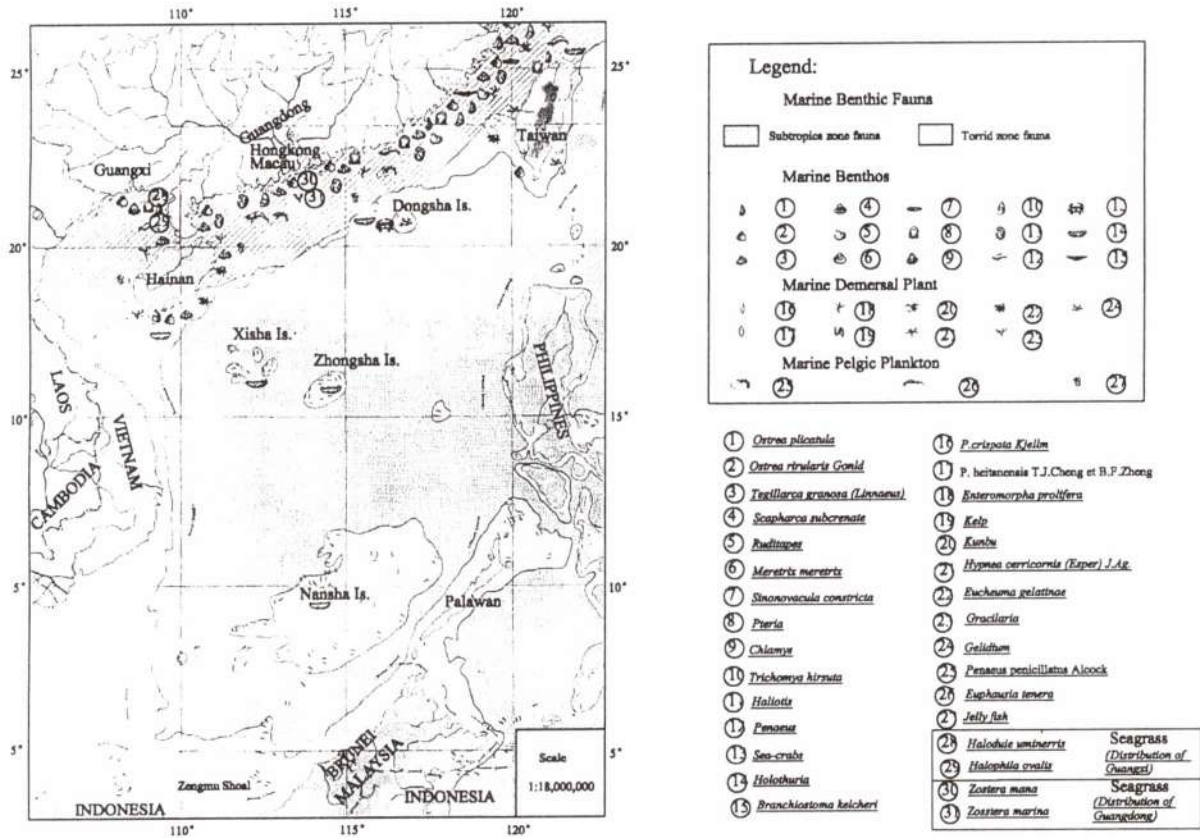


Figure 2.10 Marine Living Resources in SCS – Distribution of Marine Benthos and Seagrass.

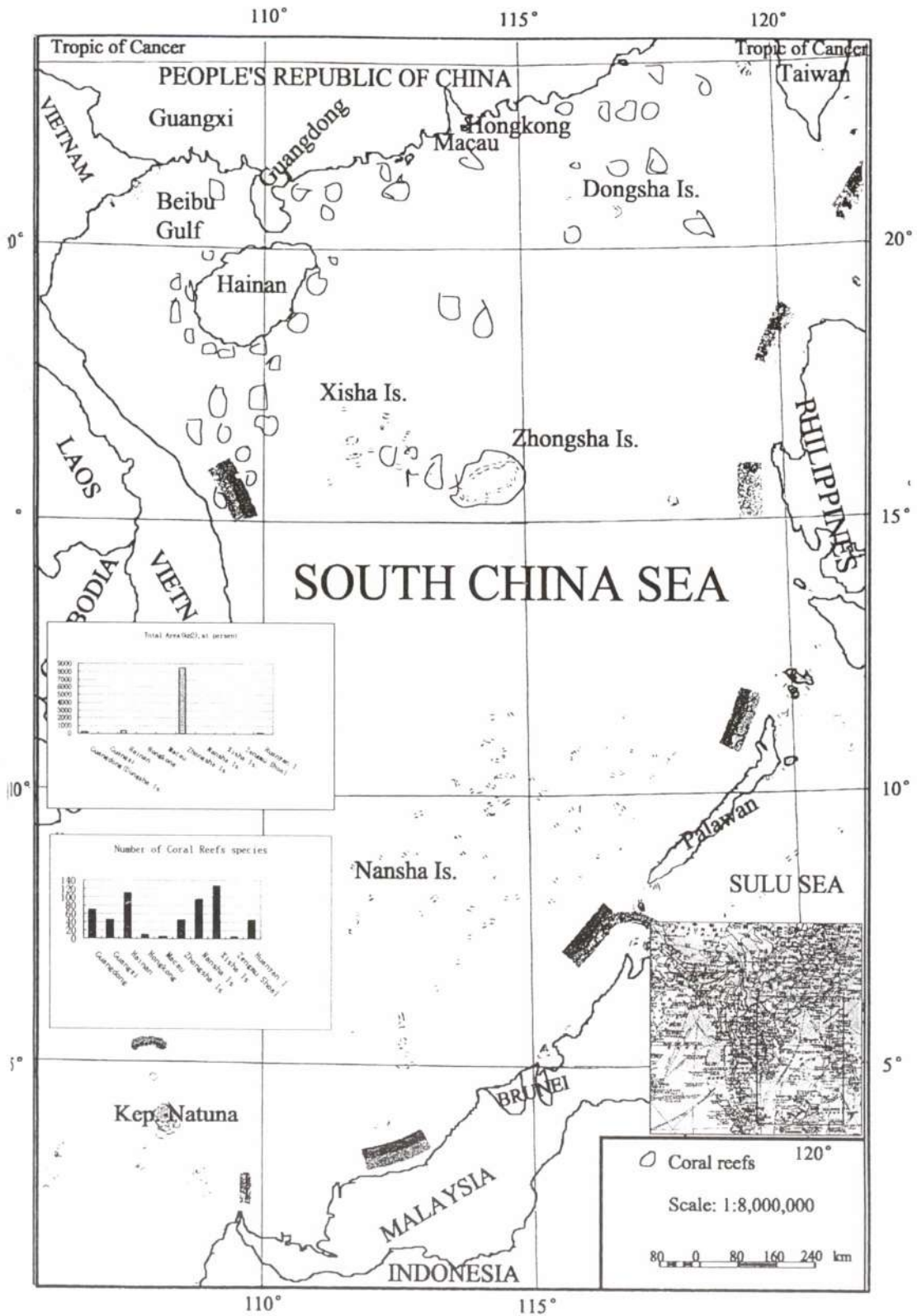


Figure 2.11 Distribution of Coral Reefs in SCS.

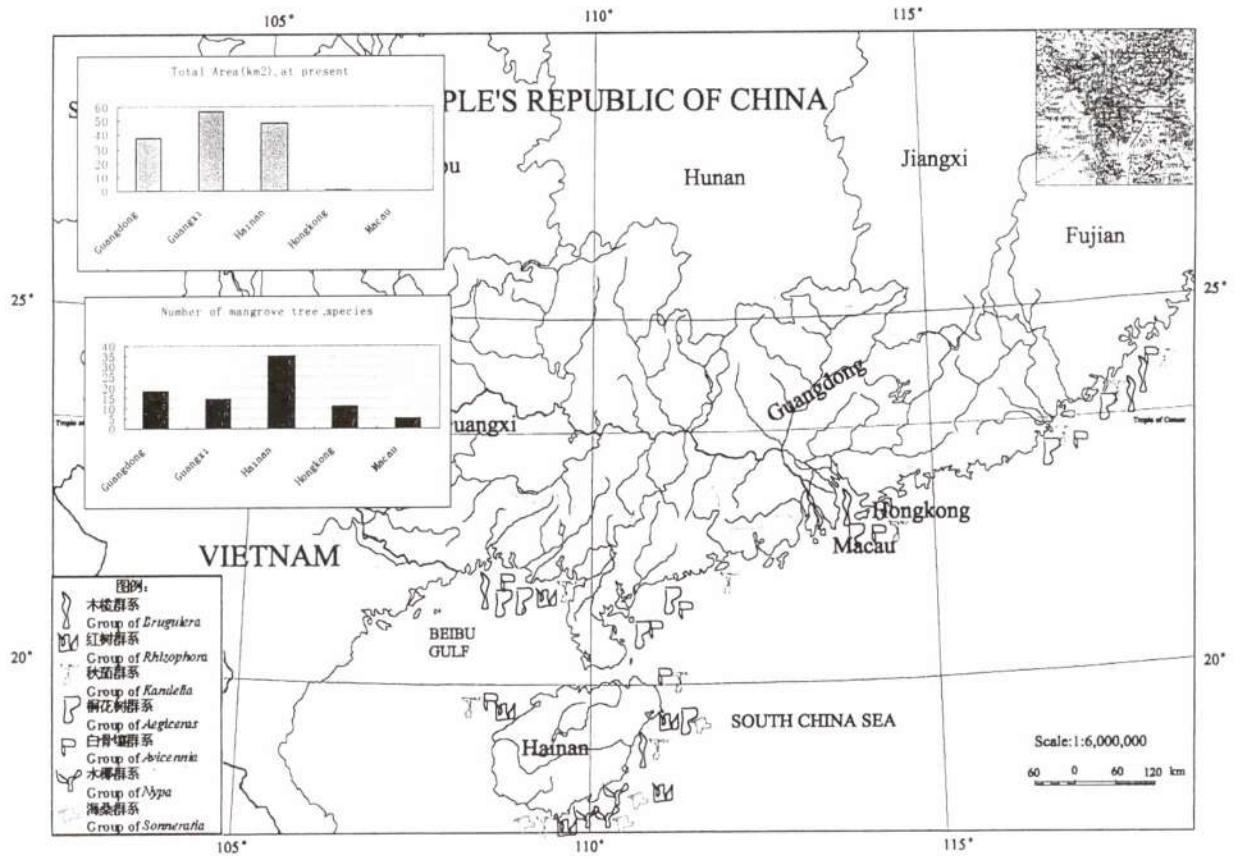


Figure 2.12 Distribution of Mangrove.



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