Yellow Sea Large Marine Ecosystem Project
A Programme of the Governments of the Yellow Sea Countries, with the assistance of the Global Environment Facility (the United Nations Development Programme, the United Nations Environment Programme, and the World Bank)

Yellow Sea Large Marine Ecosystem

Preliminary Transboundary Diagnostic Analysis

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1. BACKGROUND AND INTRODUCTION

The Yellow Sea – a Global Resource

The Yellow Sea is that semi-enclosed body of water bounded by the Chinese mainland to the west, the ROK Peninsula to the east, and a line running from the north bank of the mouth of the Yangtze River (Chang Jiang) to the south side of Cheju Island. It covers an area of about 400,000 km^2 and measures about 1,000 km (length) by 700 km (maximum width). The floor of the Yellow Sea is a geologically unique, post-glacially submerged, and shallow portion of the continental shelf. The seafloor has an average depth of 44 m, a maximum depth of about 100m, and slopes gently from the Chinese continent and more rapidly from the ROK Peninsula to a north-south trending seafloor valley with its axis close to the ROK Peninsula. This axis represents the path of the meandering Yellow River (Huang He) when it flowed across the exposed shelf during lowered sea level and emptied sediments into the Okinawa Trough. The Sea annually receives more than 1.6 billion tons of sediments, mostly from the Yellow River (Huang He) and Yangtze River, which have formed large deltas.

The Yellow Sea is connected to the East China Sea in the south, forming a linked circulation system. Major rivers discharging directly into the Yellow Sea include the Han, Yangtze, Datung, Yalu, Guang, and Sheyang. The Liao He, Hai He, and Yellow River around the Bo Hai have important effects on salinity in the western Yellow Sea, whereas the Yangtze River exerts strong influence on the hydrography of the southernmost part of the Sea. Recent reductions in Yellow River flow have led to changes in hydrography and water circulation, thereby leading to ecosystem changes. All rivers have peak runoff in summer and minimum discharge in winter.

Biotic communities of the south-eastern Yellow Sea are complex in species composition, spatial distribution, and community structure possibly due to the complicated oceanographic conditions of the area. Faunal communities are composed of various taxonomical groups of warm and cold water species as well as cosmopolitan and amphi-Pacific ones. Yet the diversity and abundance of the fauna are comparatively low. Marked seasonal variations are the main characteristics of all components of the biotic communities. Turbidity and sediment type appear to be the major parameters that affect the distribution of planktonic and benthic organisms in the coastal waters of the Yellow Sea.

Although primary productivity is important as a fundamental property of an ecosystem, no reasonable large-scale estimates are available for the Yellow Sea. Existing estimates based on local measurements vary from 68~320 g C m^{-2} yr^{-1} (Yang, 1985; Choi et al, 1988, Chung and Park, 1988). The primary productivity of the Yellow Sea seems to vary widely depending on the location and season.

The phytoplankton populations are composed mainly of neritic diatoms. The dominant species are <u>Skeletonema costatum</u>, <u>Coscinodiscus</u>, <u>Melosira sulcata</u>, and <u>Chaetoceros</u>. Their composition shows a distinct seasonal shift. Blooms occur in late winter to early spring, and summer to early autumn, and are concentrated to the southern coast of Liaoning and Shandong and the coast of Jiangsu. The average bio-mass in the northern region and the southern region in the sea is 2460 x 10^3 cells·m^{-3} or cells/m^3 and 950 x 10^3 cells·m^{-3} or cells/m^3, respectively, lower than that of the Bo Hai and East China Sea .

The average benthic bio-mass in the northern Yellow Sea Cold Water Mass and the southern Yellow Sea is 41 g/m^{2} and 20 g/ m^2, respectively. Out of the total benthic bio-mass, mollusks are most important (about 50 percent), echinoderms second (about 20 percent), polychaetes third (about 11 percent) and crustaceans fourth (about 9 percent). Among these bottom animals, most are important food items in the Yellow Sea ecosystem, and some are commercially important species (e.g., fleshy prawn, southern rough shrimp, and Japanese squid).

The fauna of resource populations in the Yellow Sea are composed of species groupings associated with various ecotypes, such as warm water species, warm temperate species, cold temperate species, and cold water species. Warm temperate species in the Yellow Sea fauna are the major components of the bio-mass and account for more than 70 percent of the total abundance of resource populations; warm water species and boreal species account for about 10 percent. The fauna in the Yellow Sea are recognized as a sub-East Asia province of the North Pacific Temperate Zone. Because most of the species inhabit the Yellow Sea year round, the resource populations in the fauna have formed an independent community.

Fish are the main living resource and 276 fish species are found. Of these, 45 percent are warm water forms, 46 percent warm temperate forms, and 9 percent cold temperate forms. The number of species of crustaceans is relatively small—only 54 species—of which warm water and boreal forms account for 65 and 35 percent, respectively. Because of the cold temperature, some warm water shrimps do not enter the northern Yellow Sea (e.g., Metapenaeus joyneri, Parapenaeopsis tenellus), while some cold water shrimps are not found in the northern East China Sea (e.g., Crangon affinis, Crangon orangon).

The species structure of the fish component of the ecosystem changed during the past 30 years. Overfishing of high quality bottom fish species has led to their replacement by lower value, smaller pelagic species. The project will develop a recovery strategy for depleted fish stocks based on an ecosystem-based perspective.

The cephalopods are composed of only 14 species. Warm water forms and warm temperate forms account for 65 and 35 percent, respectively; there are no cold water species. Of the warm temperature species, Sepia andreana and Euprymna morsei, are endemic to the Yellow Sea and do not appear in the East China Sea. Of about 11 mammal species (e.g., minke whale, sperm whale, humpback whale, fin-less porpoise), most are cold temperature forms (e.g., harbor seal, northern fur seal, Steller's sea cow lion, fin whale, blue whale, right whale, and gray whale). Of these, fin whale and right whale migrate into the northern Yellow Sea to 39°N in winter and spring, and harbor seal migrate into the northern Bo Hai in winter and spring for reproduction.

The habitats of resource populations in the Yellow Sea can be divided into two groups—nearshore and migratory. Nearshore species include skates, greenline, black snapper, scaled sardine, and spotted sardine. These species are mainly found in bays, estuaries, and around islands, and they move to the deeper waters in winter. The migratory species (e.g., small yellow croaker, hairtail, and Pacific herring) have distinct seasonal movements and some (e.g., chub mackerel, Spanish mackerel, and filefish) migrate out of the Yellow Sea to the East China Sea in winter. The distribution of these two groups often overlaps, especially in over-wintering and spawning periods.

When water temperatures begin to drop significantly in autumn, most resource populations migrate offshore toward deeper and warmer waters and concentrate mainly in the Yellow Sea depression. There are three over-wintering areas: The mid-Yellow Sea, 34 to 37°N, with depths of 60 to 80 m; the southern Yellow Sea, 32 to 34°N, with depths about 80 m; and the northern East China Sea. The cold temperate species (e.g., eel-pout, cod, flatfish, and Pacific herring) are distributed throughout these areas, and many warm temperate species and warm water species (e.g., skates, gurnard, Saurida elongata, jewfish, small yellow croaker, spotted sardine, fleshy prawn, southern rough shrimp, and cephalopods) are also found there from January to March. In the southern Yellow Sea, all species are warm temperate and warm water species (e.g., small yellow croaker, Nibea alibiflora, white croaker, jewfish, Septipinna taty, red seabream, butterfish, and chub mackerel). Their main over-wintering period is from January to April. The deep-water areas of the central Yellow Sea and northern East China Sea are the over-wintering grounds for most species that migrate over long ranges.

Little information is available about the distribution of seabirds in the Yellow Sea area and off the east coast of China, but it is believed not many birds are in the area. Two known birds are the streaked shearwater (Calonectris lecomelas) and the Bulwer's petrel (Bulweria bulwerii), both of which breed off the coast of eastern China. Of the endangered (or possibly extinct) seabirds of China, two live in the Yellow Sea region: 1) The relict gull (Larus relictus), which was collected for its breeding plumage. It used to breed near Sogo Nur, Gansu (1931 sightings), and Tanggu, Tianjin (1935 sighting and specimens). There have been no recent sightings; and 2) The Chinese crested tern (Sterna bernstein), which was last sighted at Qingdao in 1937. It may be extinct but an unconfirmed sighting of 10 to 20 birds on Thailand in 1980 has raised hopes that it might still be extant.

The dalmatian pelican (Pelecanus crispus) is bred inland at Lop jur, Xinjiang Uygur Zizhiqu, but no recent information is available. The saunders' gull (Laurua saunders) breeds in the north of China and Mongolia where its breeding grounds are unknown. However, it winters in the southern estuarine areas of Ningho, Zhejiang, and Shanghai. Of 370 bird species identified in ROK, 112 breed there and 17 localities have been designated breeding grounds.

The Yellow Sea, the East China Sea, and the East Sea/Sea of Japan were seasonally occupied by some of the large whales: fin whale (Balaenoptera physalus), humpback whale (Megaptera novaeangliae), and grey whale (Eschrichtius robustus). The grey whale may be part of a nearly extinct northwest pacific population that summers in the Okhotsk Sea. If any of these species are seen in these waters now, they represent just a remnant of the pods that used to migrate and breed there. ROK has designated the grey whale as one of its national treasures. Other endangered marine mammals that live in the region are the black right whale (Eubalaena glacialis), whitefin dolphin (Lipotes vexillifer), Kurile harbor seal (Phoca kurilensis), and Japanese sea lion (Zalophus clifornianus japonicus). The striped dolphin (Stenella coeruleoalba, northwest pacific stock) is believed exploited beyond sustainable yield.

The Yellow Sea LME is an important global resource. This international water-body supports substantial populations of fish, invertebrates, marine mammals, and seabirds. Many of these resources are threatened by both land and sea-based sources of pollution and habitat loss resulting from extensive economic development in the coastal zone, and by the unsustainable exploitation of natural resources (primarily overfishing). Additionally, there is significant international shipping traffic through the waters of the Yellow Sea, with associated threats from spills and collisions with marine mammals.

In the western Yellow Sea, pollution sources include industrial wastewater from Qingdao, Dalian, and Lianyungang port cities; oil discharged from vessels and ports; and oil and oily mixtures from oil exploration. More than 100 million tons of domestic sewage and about 530 million tons of industrial wastewater from coastal urban and rural areas are discharged into the nearshore areas of the Yellow Sea each year. The major pollutants carried by sewage and wastewater are oils, mercury, cadmium, lead, COD, and inorganic nitrogen.

The eastern Yellow Sea has bad pollution in the shallow inlets of its southern coastline where the many islands prevent mixing with open ocean water and red tides persist. The chaetognatha (Sagitta crassa and S. enflata) and the copepods (Acartia clausi, Paracalanus parvus, and Centropages abdominalis) decreased significantly in 1981 compared with 1967 figures due to an increase of marine pollution levels in Jinhae Bay. The area affected included several famous swimming beaches, tourist hotels, and places of interest. Mass mortalities of the hard clam Meretrix lusoria populations in the Jeonbug Farming Area of Gyewhari and Naechodo, in the western region of ROK, were coincident with high densities of the pathogenic bacteria Vibrio anguillarum, the parasitic cercaria Bacciger harengulae, and a high concentration of pesticides. Harmful Algal Blooms (HAB) occurring in the coastal waters off southern and eastern ROK have caused loss to the aqua-culture industry and probably large-scale mortality of natural fin- and shellfish. However, the frequency and the area of the outbreak of HABs in the coastal waters off western ROK (Yellow Sea) are lower than those off southern and eastern ROK. High turbulence intensity and turbidity caused by strong tidal current might inhibit the growth of HAB organisms.

Recently, however, the frequency and the area of the outbreaks have increased in the Yellow Sea coast, particularly, in the area where huge artificial constructions such as an underwater dam or dike were built. The constructions might restrict the circulation of water masses and reduce the turbulence intensity and turbidity. Under this circumstance red tide organisms grow fast and form red tide patches. The number and frequency of the trade ships between western cities in ROK and eastern cities in PRC have continuously increased. Therefore, the transport of red tide organisms in ballast waters might be partially responsible for the increase in the frequency and the area of red tides. Huge discharge from the Changjiang River during the summer monsoon season sometimes reach the southern end of the ROK peninsula, thereby, and might carry the seed organisms or somehow inoculate existing spores.

Ecosystem in stress

The Yellow Sea is a classic example of a semi-enclosed area, but remarkable for its massive population and increasing anthropogenic pressure. Shallow but rich in resources, it is most favorable for coastal and offshore fisheries, and its waters are a highway for international shipping.

Approximately 600 million people (approximately 10% of the world population) live in the area that drains into the Yellow Sea. Large cities near the sea with tens of millions of inhabitants include Qingdao, Tianjin, Dalian, Shanghai, Seoul/Inchon, and Pyongyang/Nampo. People of these large, urban areas are dependent on the Yellow Sea as a source of marine resources for human nutrition, economic development, recreation and tourism.

Throughout the millennia of civilization in East Asia, periods of prosperity have been those in which the nations bordering the Yellow Sea have used the Sea cooperatively and efficiently. Such was certainly the case in the Tang dynasty of PRC, the Silla dynasty of ROK, and the Nara period of Japan. Conversely, when there was bad or inefficient use of this resource, all the coastal nations suffered. As the Yellow Sea coastal countries strive to develop and improve the welfare of their people, an optimal use of Yellow Sea resources could be the beginning of a new era of cooperation.

The commercial utilization of the living resources in the Yellow Sea dates back several centuries. With the introduction of bottom trawl vessels in the early twentieth century, many stocks began to be intensively exploited by PRC, ROK, and Japanese fisherman and some economically important species such as the red seabream declined in abundance in the 1920s and 1930s (Xia 1960). The stocks remained fairly stable during World War II. However, due to a great increase in fishing effort throughout the entire Yellow Sea, nearly all the major stocks were being heavily fished by the mid-1960s. Since then, the composition of the fish catch has changed greatly, and the catch-per-unit-square kilometer has decreased to 2.3 MT in recent years.

The Yellow Sea is one of the most intensively exploited areas in the world. The number of species commercially harvested is about 100 including cephalopods and crustacea. The abundance of most species is relatively small, and only 23 species exceed 10,000 MT in annual catch. These are the commercially important species and account for 40 to 60 percent of the annual catch. Demersal species used to be the major component of the resources and accounted for 65 to 90 percent of annual total catch. The resource populations of demersal species such as small yellow croaker, hairtail, large yellow croaker, flatfish, and cod declined in bio-mass by more than 40 percent when fishing effort increased threefold from the early 1960s to the early 1980s.

Overfishing has also caused a decline in stock abundance for searobin, red seabream, Otolithoides mijuy, Nibea albiflora, and white croaker. However, under the same fishing pressure, the abundance of some species such as cephalopods, skates, and daggertooth pike-congers appears to be fairly stable. This may be due to their scattered distribution or their tolerant nature.

Shifts in species dominance in the Yellow Sea are outstanding. The dominant species in the 1950s and early 1960s were small yellow croaker and hairtail, while Pacific herring and chub mackerel became dominant during the 1970s. Some smaller-bodied, fast-growing, short-lived, and low-value fish (e.g., Setipinna taty, anchovy, scaled sardine) increased markedly in about 1980 and have taken a prominent position in the ecosystem resources thereafter. As a result, some larger-sized and higher trophic level species were replaced by smaller-bodied and lower trophic level species, and the resources in the Yellow Sea declined in quality. About 70 percent of the bio-mass in 1985 consisted of fish and invertebrates smaller than 20 cm, and the mean body length in the catches of all commercial species was only 12 cm while the mean body length in the 1950s and 1960s exceeded 20 cm. The trophic levels in 1985 and in the 1950s were estimated to be 3.2 and 3.8, respectively. Thus it appears that the external stress of fishing has affected the self-regulatory mechanism of the Yellow Sea ecosystem.

Aquaculture is a major use of the coastal waters of the Yellow Sea. Mariculture is commonly practiced in all coastal provinces of PRC, and it is most advanced in Shandong and Liaoning provinces. In both the Qingdao and Dalian regions the same fishery communes that culture invertebrates also cultivate seaweed. The major species of invertebrates cultured are oysters, mussels, razor clams, cookies, short-necked clams, pearl oysters, scallops, and hard clams. The area in mariculture in 1978 was 1.48×10^5 ha, and 5.4×10^5 ha in 1997. The yield of fresh flesh from bivalves was 2.0×10^5 t, 44 percent of the total mariculture yield in 1978; in 1997 it was 3×10^5 t. Scallops (Chlamys farreri) are luxurious seafood. Sea cucumbers (Stichopus japonicus) live below Laminaria and/or Mytilus and are harvested by divers after two years' growth. Meretrix meretrix, Mactra antiquata, Brachydontes senhousei, and Aloidis sp. are also cultured in some regions, and the large Chinese shrimp (Penaeus orientalis) also grows successfully in the coastal regions of the Yellow Sea.

The total yield of invertebrate mariculture of ROK in 1997 was 301,873 metric tons (MT) representing 29.7% of ROK's total mariculture production (1,015,134 MT), including 200,973 MT of oysters (20 percent) and 63,572 MT of mussels (6.3 percent) (MOMAF (Ministry of Maritime Affairs & Fisheries), 1998. Annual Report of Fisheries Trend. 286p.) Major species of mariculture include oyster, mussel, abalone, hard clam, short-necked clam, Cyclina, Mactra, ark shell (Anadara broughtonii), pen shell (Atrina pectinata), and hen clam (Mactra sulcataria). Various abalones (Haliotis discus hannai, H. discus, H. sieboldi, H. gigantea, H. japonica) are in high demand.

Seaweed is an important crop in the Yellow Sea. Seaweed grows naturally on the lower rocks of the intertidal/sub-intertidal region; most prefer subtropical conditions. Sargassum pallidum is dominant and Plocamium telfairiae is common in the west Yellow Sea. There, Pelvetia siliquosa is locally abundant. Bryopsis plumosa is a minor species, and Dictyopteris undulata is rare. Pelvetia siliquosa is found on the Shandong Peninsula, the Liaodong Peninsula, and the ROK Peninsula. The seaweed grows more luxuriantly in the ROK waters, and for hundreds of years the Koreans have exported large quantities of this seaweed to PRC. It was sold in North China markets under the name of deer-horn vegetable. The seaweed's availability has declined, and now the seaweed Ishige okamurai and seaweed Sargassum (Hizikia) fusiforme are marketed as substitutes—also called Lujiaocai.

The most important cultivated seaweed in PRC is the brown Laminaria japonica introduced from Hokkaido, Japan. The cold water kelp is now grown in more than 3,000 ha of PRC's coastal waters, with a production of 10,000 dry tons/year. Half of this is consumed directly and half is used for extraction of alginates. There are 15 hatcheries on the north PRC coast, and the young plants are transferred to the growing frames in the sea when the seawater temperature drops below 20°C. L. japonica grows 3-m fronds at Quingdao and 5-m fronds at Dalian where the water cools down more quickly in fall and the growing season is longer. The respective yields are 30 and 50 dry tons/ha/year.

Oil exploration has been successful in the PRC and DPRK portions of the Yellow Sea. In addition, the sea has become more important with the growth in trade among its bordering nations. The main PRC ports are Shanghai, Lu-ta, Tientsin, Qingdao, and Ch'in-huang-tao; the main TOK port is Inchon, the outport of Seoul; and that for DPRK is Nampo, the outport for P'yongyang.

Tourism is an industry in its infancy in both PRC and ROK. Several sites of picturesque beauty around the coastlines of these countries could be promoted as tourist attractions. As access to PRC and ROK becomes easier for foreign visitors, the tourist industry will expand. The Karst coast near Dalian, the granite mountains of the western Liaoning coast in PRC, and the islands and swimming beaches of ROK, in particular Cheju Island, will be in even greater demand.

INTRODUCTION TO TDA - DEFINITION

A Transboundary Diagnostic Analysis (TDA) is a scientific and technical assessment, through which the water-related environmental issues and problems of a region are identified and quantified, their causes analyzed and their impacts, both environmental and economic, assessed. The analysis involves an identification of causes and impacts at national, regional, and global levels and the socio-economic, political and institutional context within which they occur. The identification of the causes would specify sources, locations, and sectors.

The purpose of conducting a Transboundary Diagnostic Analysis (TDA) is to scale the relative importance of sources and causes, both immediate and root, of transboundary 'waters' problems, and to identify potential preventive and remedial actions. The TDA provides the technical basis for development of a Strategic Action Programme (SAP) in the area of international waters of the GEF.

The Operational Strategy states that, *"the overall strategic thrust of GEF-funded international waters activities is to meet the agreed incremental costs of:*

1. *assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them;*
2. *building the capacity of existing institutions (or, if appropriate, developing the capacity through new institutional arrangements) to utilize a more comprehensive approach for addressing transboundary water-related environmental concerns; and*
3. *implementing measures that address the priority transboundary environmental concerns".*

It is also suggested in the Operational Strategy that a SAP be formulated when the transboundary[1] concerns, the actions needed to address them or their incremental costs are not clear and that it should precede the development of any technical assistance, capacity building or investment projects to be funded by the GEF.

Therefore a SAP is required to describe a framework for regional action, to demonstrate the linkages between the national and regional actions and to identify the incremental costs (e.g., those that address primarily *transboundary* environmental concerns) of the proposed activities. The ultimate product, the SAP, is a set of targeted and costed activities (baseline and additional) which, once implemented, will together contribute to solve the major water-related environmental problems of the region and thereby will also provide significant global environmental benefits.

The transboundary character of the identified water-related environmental issues and problems and the regional and global significance of benefits to be gained by addressing the specific issues identified during the process of developing a TDA would provide the technical background for the analysis of the incremental costs of the specific actions proposed in the SAP.

Although formulation of a SAP relies on the scientific and technical justification provided in a TDA, the specific combination of activities contained in a SAP is also determined by both national and regional policy considerations that may affect project sustainability and cost effectiveness.

YSLME PRELIMINARY TDA

This Preliminary Transboundary Diagnostic Analysis (PTDA) was prepared as part of the Project Preparation exercise under the PDF-B for the Yellow Sea LME Project (YSLME). The full TDA will be prepared under the auspices of the GEF project for the YSLME, once the full GEF project is implemented.

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[1] Transboundary environmental issues within the context of a TDA include *inter alia* :
* regional/national issues with transboundary sources
* transboundary issues with national sources
* national issues that are common to a number of riparian countries and that require a common strategy and collective action to address;
* issues that have transboundary elements or implications (e.g. implications of fishery practices on biodiversity)

The purposes of preparing a Preliminary TDA as part of the Project Preparation activities are multi-fold:

- To provide background materials for the Project Brief and Project Document, illustrating the environmental context for the GEF project.
- To provide a forum for consensus-building on the environmental issues of highest priority in the Yellow Sea
- To decide on the data requirements for completing the TDA early in the GEF process, to guide the Project Implementation.

This PTDA summarizes the results from National Reports prepared by experts from ROK and PRC, as well as results from a First Regional Workshop held 26-28 October 1999 in Seoul, ROK and Second National Workshop held 18-19 January in Beijing, PRC.

2. GEOGRAPHIC SCOPE

Conducting a comprehensive transboundary diagnostic analysis is only possible if an entire water basin or Large Marine Ecosystem and its associated drainage basin is covered under the study. This is required in order that the interactions between the aquatic, terrestrial, and human sub-systems are identified in so far as they are linked through the mechanism of the hydrological cycle. More particularly, the impacts of the land-based activities on water resources and their contribution to water-related environmental stresses can be demonstrated only if all sources, sinks, and shared marine resources are included in the assessment. This successful demonstration requires the commitment of all the countries that are located in the catchment basin or surround the shared marine area to participate in the process.

The TDA must therefore include a basic geographic description of the area involved, including the water cycle within it, inputs/outputs to the system arising through atmospheric transport, the exchange of materials with neighboring watersheds or the open ocean, and characterization of the area's marine and/or freshwater ecosystem(s).

During the First Regional Workshop 26-28 October 1999, the geographic boundaries of the Yellow Sea LME were discussed. The system boundaries for the Project were defined as follows:

The Yellow Sea water body is defined by:

- to the south, the line connecting the north bank of the mouth of the Chang Jiang (Yangtze River) to the south side of Cheju ;

- to the east, the line connecting Cheju Island to Jindo Island along the coast of the ROK; and

- to the north, the line connecting Dalian to Penglai (on the Shandong Peninsula). This latter line separates the Bohai Sea from the Yellow Sea.

The coastal/upland boundary is defined as the mouths of the major rivers (as conduits of contaminant input), whereas coastal zones are defined according to existing national programs.

Although the Bohai Sea is recognized as a portion of the YSLME from a scientific perspective, specific studies and management activities are now taking place in this territorial sea. Consequently, the GEF intervention has not focused on the Bohai Sea.

3. ANALYSIS OF THE ECONOMIC, LEGAL, ADMINISTRATIVE AND POLITICAL CONTEXT AND CONSTRAINTS TO ACTION

The assessment of economic, legal, administrative and political context of the water-related environmental matters will provide the second basic component for the causal chain analyses of the major perceived issues and problems in the Yellow Sea basin.

The economic analysis will provide an account of relevant economic sectors impacting water quality and quantity, such as agriculture, forestry, energy, industry and fisheries and evaluate their contributions to national and regional economies as well as their dependence on water and related aquatic resources.

In the legal sphere the national, regional, and global context will be presented encompassing an overview of existing instruments and the capacity of the various actors to enforce their provisions. This analysis will encompass the nature of interactions between national, regional and global legal instruments (e.g., regional water quality standards) and mechanisms for further enforcement.

Criteria will be established for assessing the coverage of water and related environmental laws at the national level.

The following provides an exemplary set of questions (in this case for the water quantity sector) that can be used for this purpose:

Do water and related environmental laws and regulations:

- base water management on watershed basins and treat the river basin-coastal zone as a management continuum;
- base such laws on sustainable management principles;
- require integrated water and environmental management planning;
- prevent fragmented departmental water allocation and use decisions;
- ensure integrated economic and environmental policy and project appraisals;
- establish water management institutions as outlined below; and
- establish enforceable incentives for environmentally sustainable water use.

In dealing with the administrative context, the TDA will focus on those water and environment management institutions that are in place for the management of water resources. The assessment will cover the issues of institutional and human resource capacity and the specific mandates of the organizations. Assessment of the institutional capacities will require a consideration of issues related to technical proficiency, equipment/lab facilities and personnel/management. In assessing the institutional framework and mandates of "water" organizations, the paramount considerations will be coordination of surface and ground water management, coordination of water quality and quantity management, provision of incentives for greater economic and physical efficiencies in water use and protection of instream flow values and other public values related to water systems. Further depth of analysis can also be achieved in the assessment of institutional capacity of water management organizations by considering the following:

- capability of coordinating water plans and management procedures with other functional agencies;

- capability of considering a wide range of alternative solutions to water problems, including non-structural measures and use of economic instruments (pricing, taxes, tradable permits subsidies etc.);
- separation of functions of planning & evaluation from construction & management;
- existence of multidisciplinary expertise to carry out multiple-objective planning and evaluation;
- observation/application of "subsidiarity principle" in assigning responsibilities to agencies at national, provincial and local levels;
- existence of expertise to involve all stakeholders in the planning;
- reward structures to stimulate creativity and innovation; and
- reward structure that stimulates learning through ex-post analyses.

4. MAJOR PERCEIVED WATER-RELATED ENVIRONMENTAL ISSUES AND PROBLEMS

The identification of the major perceived[2] issues is the first step in the TDA process and it will provide the justification for the in-depth analyses. A distinction will be made between national and regional issues and then will be ranked according relative significance from the national, regional and global perspectives. As these distinctions become clearer, the emphasis in the TDA will gradually shift to those issues that are clearly demonstrated to be more significant at a regional or global level and to those issues that are characterized as transboundary.

The significance of the perceived issues and problems will be substantiated on environmental, economic, social, and cultural grounds. The economic costs and losses (consequences/ implications), in the broad sense, of a perceived issue such as "degradation of natural landscapes" could include loss of value for tourism. The scale of economic losses that are implied by not addressing the issue can be used to justify intervention at national and/or regional levels depending on whether the issue is national or transboundary in nature.

These major perceived problems were identified during a Regional Stakeholders' Workshop held in ROK in October, 1999, and agreed by the parties. There was some discussion about whether Item 7 is really a perceived problem or a root cause, but it was left in both places in this summary.

These major perceived issues and problems are based in large part on the National Reports on the Environmental Status of the Yellow Sea, prepared by the PRC and ROK in the PDF-B stage.

[2] "Perceived" is used to include issues which may not have been identified or proved to be major problems as yet due to data gaps or lack of analysis or which are expected to lead to major problems in the future under prevailing conditions.

Step I:

Major Perceived Water-Related Environmental Issues and Problems

Regional Data Summary - Step I:
Major Perceived Water-related Environmental Issues and Problems

Perceived Major Problem	Transboundary Elements
1.Decline of commercial fisheries	Virtually all the major species caught commercially in the Yellow Sea are subject to seasonal migrations from one area of the sea to another. Sustainable management requires a cooperative effort of all countries.
2. Degradation of biodiversity, loss of coastal habitats, loss or imminent loss of endangered species and their genomes	Fish spawning and nursery ground may assimilate transboundary pollution. Endemic and rare species are of regional and global significance and have life cycles that cross national borders. Migratory bird habitat are polluted by transboundary contamination or lost due to the coastal development.
3. Water Quality deterioration	Common trait for all countries and in some cases being transported transboundary
4. Unsustainable Mariculture,	Common to all countries. A potential transboundary problem related to aquaculture is the spread of pathogen or parasites across the Yellow Sea. Pollution from mariculture in each country.
5. Poor or unsatisfactory human health quality, unsanitary conditions in many beaches and bathing waters, contaminated fish and sea products	The health of the human population has been adversely affected by many environmental factors through airborne pollution and water-borne dispersion of contaminants and pathogens. Migration of contaminated fish.
6. HAB (Emerging disease)	Common to all countries to varying degrees. Mostly local causes and effects but possible transboundary migration of bloom species.
7. Inadequate capacity to assess ecosystem	Inadequate basin-scale assessment. Common to all three countries.

Step II:

Analysis of Root Causes of the Identified Concerns and Issues

5. ANALYSIS OF ROOT CAUSES OF THE IDENTIFIED PERCEIVED PROBLEMS

This analysis will identify the underlying factors or root causes that contribute to the major perceived issues and problems so that these will be addressed in the implementation of a Strategic Action Programme. As such it will improve recognition of connections between the components of the environmental and socio-economic sub-systems through a causal chain analysis.

Once the Major Perceived Issues and Problems are identified, it is necessary to address the root causes. These root causes represent the circumstances or state-of-affairs that have led to the environmental degradation and major Perceived Issues and Problems.

These seven major root causes are identified, and their specific features contributing to the Perceived Problems listed.

Regional Data Summary - Step II:
Analysis of Root Causes of the Identified Issues and Problems

Main Root Causes	Specific Features
1. Rapid growth in coastal population and urbanization	Overfishing
	Extensive use of aquaculture; increased municipal and industrial pollution
	Water use conflicts
	Land use conflicts; habitat loss
	Rapid coastal tourism and industrial development
2. Poor or ineffective legal instruments at the regional level, inadequate implementation of national regulatory instruments; lack of regional harmonization of regulations	Lack of multilateral agreements
	Inadequate international coordination
	Lack of observance of and capacity to implement international environmental laws and regulations
	Lack of common rules and regulations for harvesting practices.
	Inadequate compliance and trend monitoring; illegal fishing?
	Inadequate enforcement of environmental regulations
	Ineffective regional cooperation
	Lack of common standards for environmental laws and regulation
3. Inadequate knowledge and infrastructure base	Insufficient knowledge of fish stocks, ecology and population biology
	Insufficient knowledge of ecosystem status
	Insufficient understanding of sustainable fisheries yields in context of ecosystem health and stability
	Lack of reliable bathing and drinking water quality data
	Insufficient data on pollution and bio-accumulation
	Lack of reliable statistics on exotic and introduced species and their impacts
	Insufficient knowledge of pollution sources
	Lack of regional long-term monitoring framework
	Lack of continuous assessment of environmental quality

	Inadequate regional environmental data and information systems
	Lack of socio-economic impact assessments
	Lack of understanding of natural variability
	Insufficient scientific and technical capacity building, including training
	Lack of standardization and validation of research methodologies
4. Inadequate planning and management practices	Lack of effective planning mechanisms for urban/industrial/ recreational/agricultural/coastal zone development
	Incipient intersectoral coordination
	Rapid coastal tourism and industrial development
	Increased development of aquaculture
	Lack of consideration of natural variability including relative sea level fluctuations
5. Poor or insufficient public involvement	Incomplete identification and involvement of stakeholders
	Inadequate public awareness and education
	Deficient public participation/lack of transparency
6. Insufficient financing mechanisms and support	Insufficient funding for infrastructure and management
	Ineffective economic and financial mechanisms
	Inappropriate subsidies to industries (incl. agriculture) and fishing (overcapitalization)
7. Lack of political will	Immature stakeholder involvement
	Environment low on political agenda

6. Synthesis Matrix

Synthesis Matrix - Step II

Root Causes	Perceived Problems						
⇓	I. Decline of commercial fisheries	II. Degradation of biodiversity	III. Water quality decline	IV. Unsustainable Mariculture	V. Poor human health quality	VI. HAB (emerging desease)	VII. Inadequate capacity to monitor/assess ecosystem
1. Rapid growth in coastal population and urbanization	✔ 1, 3, 5	✔ 2, 3, 5	✔ 4, 5, 3	✔ 1, 3, 5	V ✔ 4, 5	✔ 4, 5	
2. Poor or ineffective legal instruments	✔ 1, 5	✔ 2, 5	✔ 4, 5, (3)			✔ 4, 5, (3)	
3. Inadequate knowledge and infrastructure base			✔ 4, 5, (3)				✔ 3, 4, 5
4. Inadequate planning and management practices	✔ 5, 1	✔ 2, 5	✔ 5, 4, (3)	✔ 5, 1	✔ 5, 4	✔ 5, 4	
5. Poor or insufficient public involvement	✔ 5, 1	✔ 5, 2	✔ 5, 4, (3)	✔ 5, 1	✔ 5, 4		✔ 5
6. Insufficient financing mechanisms and support			✔ 5, 4		✔ 5, 4	✔ 5, 4	✔ 5, 3
7. Lack of political will	✔ 5	✔ 5	✔ 5	✔ 5	✔ 5		

Areas of Intervention:

1 Sustainable Management of Fish Resources and Mariculture
2 Protection of Biodiversity
3 Reduce Stress on the Ecosystem
4 Improve Water Quality and Human Health
5 Sustainable Institutional and Human Development

Step III:

Priority Areas of Future Intervention

7. PRIORITY AREAS OF FUTURE INTERVENTIONS:
ANALYSIS OF AREAS WHERE ACTIONS ARE PROPOSED: PROBLEMS, STAKEHOLDERS, ACTIONS, AND OUTPUTS

The Priorities for national and regional perspectives will be clear from the output of the Policy Option analysis. Priorities at the national level should serve to establish or strengthen the foundation for interventions at regional and international scales. The cost estimates of proposed investments will be provided, to the fullest extent possible.

Data and assessment needs will be identified as a basis for future activities in the design and targeting of research as well as data collection & interpretation, monitoring and evaluation. The main objective will be to assist in overcoming the scientific uncertainties and/or barriers in the application of management and policy tools for the sustainable use of water resources.

Background information regarding management tools that are prescribed as part of the proposed solutions or that are implied in the proposed solutions will be provided.

A description of all the stakeholders, including institutions, organizations, ministries, agencies and industry related to the perceived issues will also be incorporated. The information pertaining to this list will include the effect of the issue on stakeholders, the nature and effectiveness of the interactions between the stakeholders as well as their strengths and weaknesses in view of their actual and/or potential role in managing water and water dependent resources.

These Areas of Intervention were agreed to be the priority Areas. The Sub-Areas of Intervention were further ranked by the Region according to two factors:

Priority to the Region:
- H: High
- M: Medium
- L: Low

Priority from a Transboundary Perspective (e.g., need for regional intervention)
- S: Strong
- M: Moderate
- W: Weak

These Areas of Intervention are based on the analysis of Major Perceived Issues and Problems, and Root Causes. These Areas of Intervention are focused in particular on the GEF Project Activities, rather than on the longer-term SAP activities, though there is some overlap.

These Areas for Future Intervention form the basis for the Activities developed in the Project Brief for the YSLME.

Area I. Sustainable Management of Fish Resources and Mariculture

- Assess carrying capacities for fisheries and mariculture under changing environmental conditions (H, S)
  a) Review of existing state-of-knowledge and preliminary carrying capacity analysis (retrospective)
  b) Communicate with Carrying Capacity and Climate Change of PICES, FAO and others
  c) Define major gaps in the state-of-knowledge
  d) Fill the gaps
  e) Perform iterative series of analysis of carrying capacity and issue report: use ECOPATH and ECOSIM to begin

- Assess regional fish stocks (H, S)
  a) Review of existing data and diagnosis of condition of stocks
  b) ID knowledge gaps such as stock separation
  c) Intercompare/intercalibrate methodologies
  d) Perform demonstration of a Regional Survey
  e) Develop common methodology for joint regional stock assessment and perform first analysis
  f) Create mechanism for annual stock assessment

- Develop Regional Fisheries and ecosystem Management Plans, including regional recovery programme (H, S)
  a) Establish national, bilateral, and/or regional working groups separately for fisheries and ecosystem MP.
  b) Develop concrete methodologies for management plans
  c) Create draft management plans, based on relevant data
  d) Review of management plans by appropriate Stakeholder forum
  e) Develop regional stewardship for ownership of the Management Plans

- Promote and coordinate regional mariculture and sea farming strategies (M, M)
  a) Review existing status and trends of mariculture
  b) Develop appropriate communication mechanism
  c) Develop joint applied research program for mariculture to identify sustainable approaches
  d) Pilot demonstration projects in sustainable mariculture
  e) Review effects of mariculture on biodiversity
  f) Develop projections of mariculture activity and carrying capacity for the next decade

- Assess, diagnosis and control disease associated with mariculture (M, M)
  a) Review of existing state of knowledge of disease in mariculture, particularly emphasizing emergent disease
  b) Joint development and demonstration of new technology for diagnosis and control
  c) Facilitate communication about new diseases, diagnoses, and control

- Develop and endorse bilateral or regional agreement for sustainable use of fisheries resources (H, S)
  a) Designate intergovernmental working group
  b) Develop draft regional fisheries agreement with appropriate stakeholder involvement
  c) Endorsement of the agreement

- Strengthen and enforce National and regional fisheries laws and regulations (H, S)
  a) Establish regional legal/regulatory working group
  b) Review existing national laws and regulations on fisheries and pertinent international agreements (e.g. FAO Code of Conduct and Straddling Stocks agreement)
  c) Propose measures for strengthening laws and regulations, and enforcement

Area II. Protection of Biodiversity

- Assess trends in YSLME biodiversity (H, S)
  Activities/Solutions
    a. Coordinate national analyses of existing data and trends
    b. Coordinate and develop regional biodiversity assessment, summarizing status and trends
  Expected Outputs
    a. National reports on status and trends of biodiversity
    b. Compile comprehensive regional review of status and trends of YSLME biodiversity

- Develop strategies for conserving and restoring habitats and coastal landscapes (H, S)
  Activities/Solutions
    a. Review existing national practices of conservation and restoration
    b. Develop regionally coordinated strategies of conservation and restoration in regional scientific workshop
  Expected Outputs
    a. Regionally coordinated and common strategies.

- Develop strategies for protection of vulnerable species (including rare and endangered species) and trophic linkages (H, S)
  Activities/Solutions
    a. Conduct national review of status of vulnerable species and trophic linkages
    b. Review national regulations and effectiveness of protection measures
    c. Develop regionally coordinated strategies of protection in regional scientific workshop
  Expected Outputs
    a. Regionally coordinated and common strategies for biodiversity protection

- Develop strategies for gene pool conservation (M, M)
  Activities/Solutions
    a. Determine national situations of genetic degradation of important bio-resources.
    b. Regionally determine need for conservation of gene pool.
  Expected Outputs
    a. Recommendations for conservation of specific gene pool.

- Evaluate the risk of exotic species (M, S)
  Activities/Solutions
    a. Document introduced exotic species and their pathways
    b. Assess impacts and risks
  Expected Outputs
    a. Regional assessment of risks
    b. Inventory of exotic species
    c. Proposals for regulation and control of introduction of exotic species, including implementation of IMO guidelines on ballast water management

- Develop Regional biodiversity action plan and biodiversity investment plan (H, S)
  Activities/Solutions

a. Develop outline and content of biodiversity action plan for YSLME.
b. Write national biodiversity plans
c. Compare national action plans and develop coordinated regional biodiversity plan.

Expected Outputs

a. Clarify national priorities for protecting biodiversity
b. Clarify regional priorities for biodiversity protection.

Area III. Reduce Stress on the Ecosystem

- Identify and rank the natural and human-induced stresses on the ecosystem (H, S)
  a) Retrospective analysis of trends and information on stressors
  b) Develop concrete methods for ranking procedure
  c) Identify data and information gaps
  d) Develop methods to fill gaps
  e) Rank contributions of various stressors and periodic review of trends

- Assess the carrying capacities of the ecosystem under changing human-induced and natural variability (H, S)
  a) Review of existing state-of-knowledge and preliminary carrying capacity analysis (retrospective)
  b) Communicate with Carrying Capacity and Climate Change of GLOBEC, other LMEs, and others
  c) Define major gaps in the state-of-knowledge
  d) Fill the gaps
  e) Perform iterative analysis of carrying capacity addressing decadal sustainability

- Develop strategies for monitoring changing status of ecosystem (H, S)
  a) Identify key ecosystem components
  b) Develop strategies for assessing changes in those components, linking national efforts and supplementing where necessary to obtain a regional perspective
  c) Initiate demonstration project for assessing changing conditions (new and innovative technology)
  d) Pentadal state-of-the-ecosystem reports

- Identify key ecosystem components
  e) Develop strategies for assessing changes in those components, linking national efforts and supplementing where necessary to obtain a regional perspective
  f) Initiate demonstration project for assessing changing conditions (new and innovative technology)
  g) Pentadal state-of-the-ecosystem reports

- Identify corrective measures to minimize the human-induced stress (H, S)
  a) For highest ranked human-induced stressors, determine concrete sources and root causes for the stress.
  b) Prioritize corrective actions to reduce the sources or root causes associated with the stressors.

- Identify and implement policies and legal measures to reduce the stress (H, S)
  a) Initiate working group to review the stressors and identify policy and legal instruments to reduce the stress
  b) Develop draft policies and legal measures for consideration by national and regional bodies

- Develop financial mechanisms to fund these improvements (H, S)
  a) Development Priority Investment Portfolio project for the YSLME
  b) Create sustainable mechanism for developing investment projects, including training, forums for the donor community

c) Develop strategy for long-term sustainability of investments to improve the YSLME

Area IV. Improve Water Quality and Human Health

- Assess and monitor the contaminant and nutrient inputs into the YSLME (M, S)

  Activities/Solutions

  a) Coordinate national analyses of existing data and trends
  b) Summarize contaminant and nutrient loading into the YSLME

  Expected Outputs

  a) Improved national and regional knowledge of contaminants and nutrient loading

- Develop baseline data & monitor contaminant & nutrient levels in the YSLME (H, S)

  Activities/Solutions

  a) Document baseline data
  b) Determine national and regional monitoring program
  c) Establish regional monitoring network (eg., Mussel Watch program).

  Expected Outputs

  a) Regionally coordinated monitoring programs.

- Assess and monitor HABs and emerging diseases in YSLME (M, M)

  Activities/Solutions

  a) Coordinate national analyses of existing data and trends
  b) Assess threat of emerging diseases on bio-resources and impacts to human health

  Expected Outputs

  a) Establish regional monitoring network
  b) Early warning system for disease outbreak

- Hot spots analysis and non-point sources of pollution, remediation and prevention from land- and sea- based sources (M, S)

  Activities/Solutions

  a) Assess hot spot and non point sources of water quality degradation
  b) Evaluate procedures for re-mediation and prevention
  c) Prepare preliminary investment files

  Expected Outputs

  a) Assessment of pollution sources and provide focus for re-mediation
  b) Improved water quality and cleaner beaches
  c) Improved ecosystem health
  d) Investment strategies for remediation

- Develop regional emergency prevention and contingency strategies (H, S)

  Activities/Solutions

  a) Assess national emergency and contingency capabilities
  b) Develop regional early warning system
  c) Coordinate strategies for rapid and long-term responses to catastrophic causes of pollution

  Expected Outputs

  a) Regional coordination of emergency and contingency responses

- Review and harmonize regulations and laws on water quality (H, S)

  Activities/Solutions

  a) Review and compare national regulations and laws on water quality
  b) Coordinate actions to improve water quality

  Expected Outputs

  a) Improved water quality and cleaner beaches
  b) Proposals for coordinated implementation of regulations.

- Develop strategies for assessing the fate, transport and risks of contaminant and nutrient (H, S)

  Activities/solutions

  a) Review existing understanding of fate and transport studies, including modeling
  b) Provide training in risk assessment techniques
  c) Fill modeling gaps, as required, to understand fate and transport pathways
  d) Develop strategy for risk assessment for Region

  Expected Outputs

  a) Local capability to perform risk assessment for SAP purposes
  b) Capability to quantify fates and transport of contaminants and nutrients in the YSLME
  c) Quantitative

Area V. Sustainable Regional Institutional and Human Development

- Strategy for institutional and regional agreement for managing the YSLME ecosystem (H, S)

  Activities/solutions
  a. Facilitate regional, national and local dialogues
  b. Involve stakeholders in decisions
  c. Provide for a for learning about pertinent regional agreements elsewhere

  Expected Outputs
  a. Functioning sustainable regional agreement to serve as basis for sustainable management of the YSLME

- Strengthen capacities for stakeholders (scientists, managers, decision makers, private sectors and NGOs) (H, S)

  Activities/solutions
  a. Train stakeholders in technical, scientific, socio-economic and legal areas
  b. Help develop and maintain NGO forums
  c. Establish private sector councils to assure participation in the YSLME solutions
  d. Provide for targeted public awareness and public participation

  Expected Outputs
  a. More highly trained stakeholders
  b. Public more aware
  c. Broader stakeholder involvement in the GEF process and solution orientation

- Involvement of stakeholder in the environmental and resources management and decision making (H, S)

  Activities/solutions
  a. Establish Stakeholder forums on regional, national and local levels
  b. Provide opportunities for stakeholders to participate in small grants initiatives
  c. Implement broad public awareness/public participation activities

  Expected Outputs
  a. More involved stakeholders
  b. Greater potential for sustainability of regional and national efforts

- Strengthen institutional capacities (H, M)

  Activities/solutions
  a. Provide communications and scientific equipment to support TDA/SAP activities
  b. Assist with interministerial coordination functions

  Expected Outputs
  a. Strengthened local capacities for sustained activities

- To develop regional coordination and cooperation mechanisms (H, S)

  Activities/solutions
  a. Establish regional coordination mechanism
  b. Support national inter-ministerial and intersectoral coordination

Expected Outputs

a. Functioning sustainable regional coordination mechanism
b. Effective national coordination within governments and with stakeholders
c. Effective interaction with international community and projects

- Develop financing mechanisms for long-term sustainability (H, S)

Activities/solutions

a. Implement a Priority Investment Portfolio
b. Train nationals in project development activities
c. Create/participate in regional financing forums with broad development bank participation
d. Small environmental grants program to develop ideas to feasibility stage

Expected Outputs

a. Trained local staff capable of developing investment projects
b. Attention to environmental investment through regional investment forums

- Development of regional data and information management tools (DBMS, GIS, communications and exchange) (H, S)

Activities/solutions

a. Create common data/information management capability in the region
b. Coordinate data and information exchange, display, and analysis tools
c. Provide training and compatible equipment for major participating institutions
d. Create web page and similar broad, modern communications tools

Expected Outputs

a. Functional, sustainable data and information management network for the YSLME

Regional Priorities
H- high,
M- medium,
L- low

Transboundary Nature
S- strong,
M- moderate,
W- weak

Step IV:

Detailed Information on Action Plans

8. DETAILED INFORMATION ON ACTION AREAS

To motivate and support the actions described in section 7, data from the Yellow Sea states have been summarized here. These data are taken from the National Reports prepared as part of the UNDP/GEF PDF-B Project Preparation phase, as well as from numerous publications from within each country. The uneven availability of data across countries is clear in this summary, demonstrating the need for a formal TDA data and information gathering phase to make the TDA more complete and to fill in the gaps.

Area I. Sustainable Management of Fish Resources and Mariculture

Republic of Korea

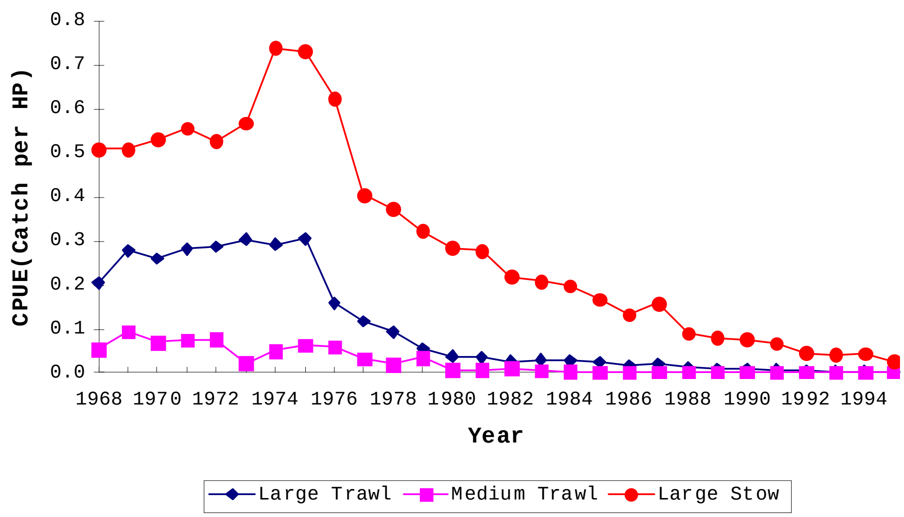
One major issue on the Yellow Sea ecosystem perceived by the general public and scientists alike is the collapse of the fisheries resources. The general increase in fishing activities since 1970s, in general, has depressed fish populations, and, in turn, requires higher fishing efforts than before to sustain the same catch (higher catch per unit effort – CPUE). Especially for demersal species, the failure of recruitment and the reduction in length are common phenomena in the Yellow Sea. The cold-water species (e.g., Pacific cod) which reside in the bottom water of the central Yellow Sea trough are almost extinct, because intensive fishing operations have been conducted in a narrow and confined region. It is obvious that fish resources in the Yellow Sea have suffered from recruitment overfishing and growth overfishing due to the high level of fishing activities. The schools of migratory species such as small yellow croaker and hairtail were chased by fishermen from overwintering areas in the East China Sea, so that the size of spawning stock has been continuously decreased during the course of spawning migration.

Coastal areas serve as the spawning as well as nursery grounds for resident species of the Yellow Sea. Many migratory species, such as skates and pomfrets, migrate seasonally between coastal and offshore areas, and are threatened by coastal development such as land reclamation and expansion of the industrial complex. The loss of spawning grounds and the habitat degradation due to pollutants are making the fertile coastal area barren.

ROK fishermen fish using trawl net, set net, long line, dredge net, stow net, gill net, and purse seine. Total catches from inshore, nearshore, and East China Sea by ROK fisheries in 1998 were approximately 0.901 million MT, but the proportion of the catches in the Yellow Sea only can not be estimated because of the lack of information. ROK trawling has been intensified since 1967 in their catches, number of hauls, and catches per haul until late 1980s whereas Japanese trawlers peaked their fishing intensity around 1965 and Chinese boats kept increasing their fishing intensity (Zhang et al., 1988). Three major fisheries (large-sized trawl, mid-sized trawl, and large stow net fishery) have been operated in the Yellow Sea and their catches per unit effort (CPUEs) have been declining since mid 1970s in ROK. Prior to mid 1970s, however, two fisheries, the large-sized trawl and stow net fishery, showed an increase in CPUE, whereas the rest remained stable. Figure I-1 shows dramatic declines of CPUEs in late the 1970s, showing that the average relative abundance of recent years was less than one-tenth of the highest in the mid 1970s.

The species composition of the catch has changed dramatically (able I-1). Statistics for catch of individual species demonstrate the sequence of decline for fisheries (Fig. I-2). Finally, the transboundary nature of one fishery, the small yellow croaker, is demonstrated by a map of the spawning areas.

<Fig. I-1> Historical CPUEs by three major fisheries, large stow net, large and medium trawls in the Yellow Sea and East China Sea during 1968-1995.

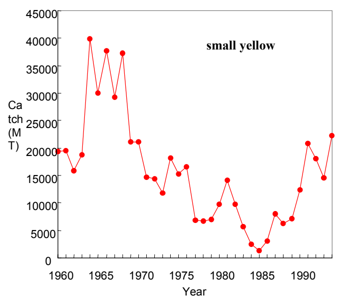


<Table I-1> Commercially targeted fisheries resources in the Yellow Sea and East China Sea

KOREAN NAME A. (Korean pronunciation)	B. COMMON NAME	C. SCIENTIFIC NAME
Demersal fish		
Ch'amjogi	Small yellow croaker	*Pseudosciaena polyactis*
Chwich'I	Hairtail	*Trichiurus lepturus*
Chwich'I	Filefish	*Navodon modestus*
Pyôngô	Pomfret	*Pampus argenteus*
Kangdari	Corvenias	*Collichthys niveatus*
Puse	Large yellow croacker	*Pseudosciaena crocea*
Poguch'i	White croaker	*Argyrosomus agentatus*
Minô	Brown croaker	*Nibea imbricatus*
Mulgajami	Roundnose flounder	*Eopsetta guigorjewi*
Nobch'I	Bastard halibut	*Paralichthys olivaceus*
Nungsôngô	Common sea bass	*Epinephelus septenfasciatus*
Taegu	Pacific cod	*Gadus macrocephalus*
Pôgô	Puffers	*Tetraodontidae*
Kaetchangô	Sharptoothed eel	*Muraenesox cinereus*
Ch'amdom	Red sea bream	*Pagrus major*
Agwi	Sea-devil	*Lophiomus setigerus*
Paendaengi	Bigeyed herring	*Harengula zunasi*
Pollak	Rockfish	*Sebastes inermis*
Yangt'ae	Flathead	*Platycephalus indicus*
Hongô	Skateray	*Rajidae*
Pelagic fish		
Myolch'i	Anchovy	*Engraulis japonica*
Chongôri	Sardine	*Sardinops nelanosticta*
Ch'ongô	Pacific herring	*Clupea harengus pallasii*
Kodungô	Mackerel	*Scomber japonicus*
Chôngaengi	Jack(horse) mackerel	*Tranchurus japonicus*
Samch'i	Spanish mackerel	*Scomberromorus niphonius*
Crustacea and Squids		
Kabojingô	Cuttlefish	*Sepia esculenta*
Kkotke	Blue crab	*Portunus trituberculatus*
Taeha	Large shrimp	*Pemaeus orientalis*
D. Ojingô	E. Common squid	F. *Todarodes pacificus*

<Fig. I-2> Annual catches of (a) small yellow croaker, (b) hairtail, (c) pomfret, (d) flounder, (e) brown croaker, (f) anchovy, (g) filefish, and (h) sharptoothed eel in the Yellow Sea and East . China Sea during 1960-1996

(a)



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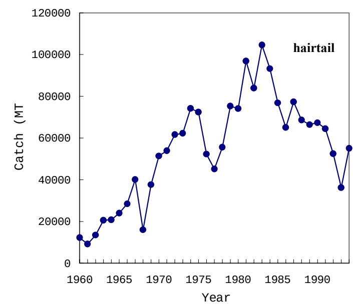

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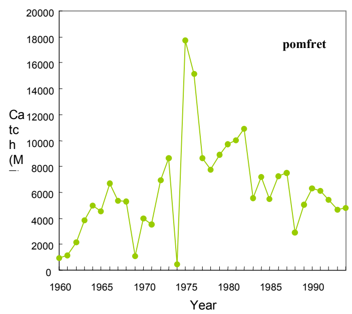

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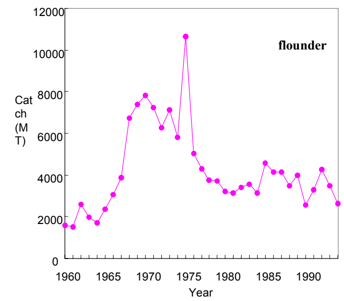

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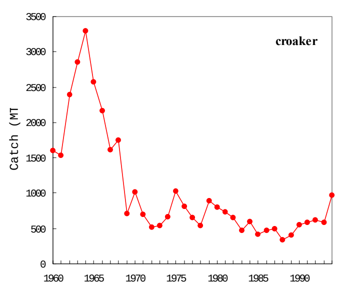
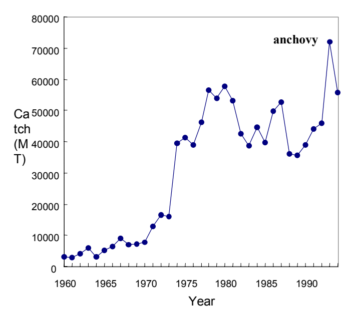
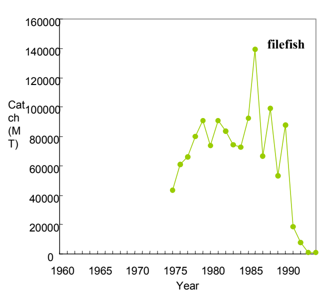
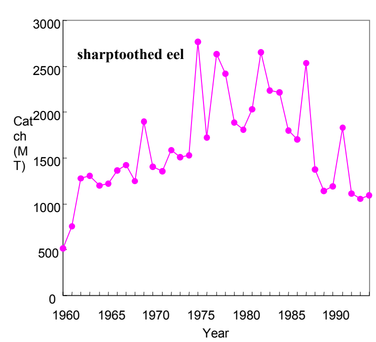
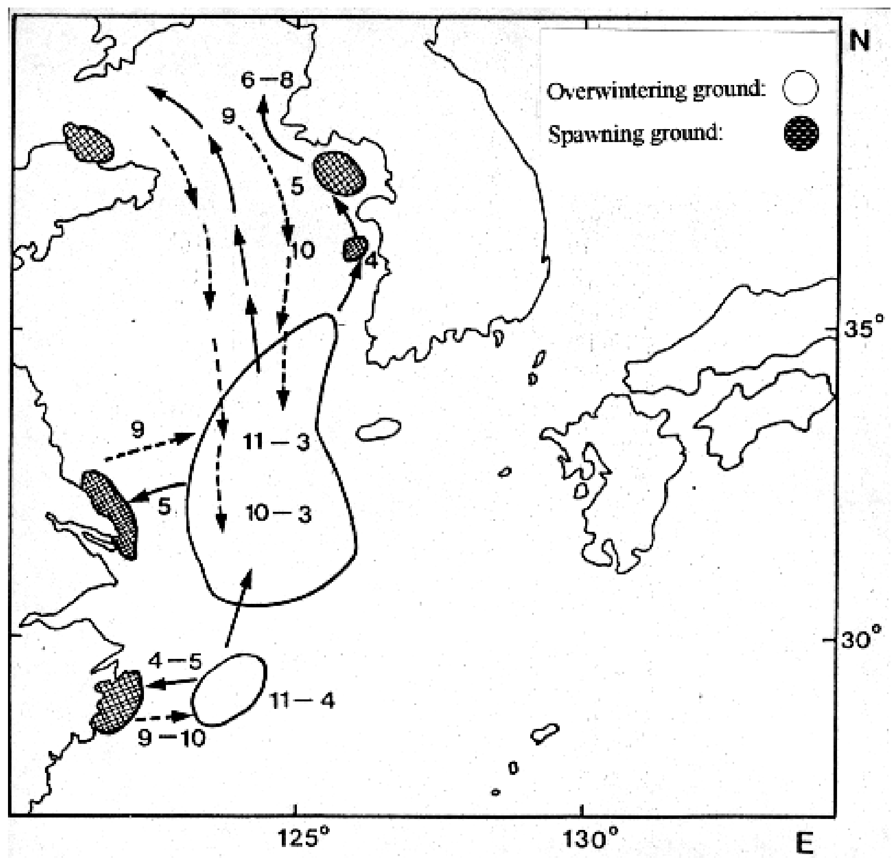








<Fig. I-3> Migration routes of small yellow croaker, *Pseudosciaena polyactis.* Numbers indicate months.



Emerging Diseases in Aquaculture

Coastal waters of the Yellow Sea are enriched with food for shellfish that include oysters, mussels, scallops, and clam mariculture. Shellfish farms placed along the coast of Yellow Sea mostly use intensive aquaculture system for high production from relatively small area. Oysters and clams are intensively cultured in the west and south coast of ROK. However, intensive aquaculture system is often suffered from outbreak of diseases or parasites due to the high density of culturing organisms

Major disease-causing agents of commercially important marine organisms are virus, bacteria, protozoan, fungi and metazoans. Table I-2 lists major diseases found among shellfishes and fin fishes reported by Office Internationale Des Epizooties (OIE) and ROK Ministry of Maritime Affairs and Fisheries.

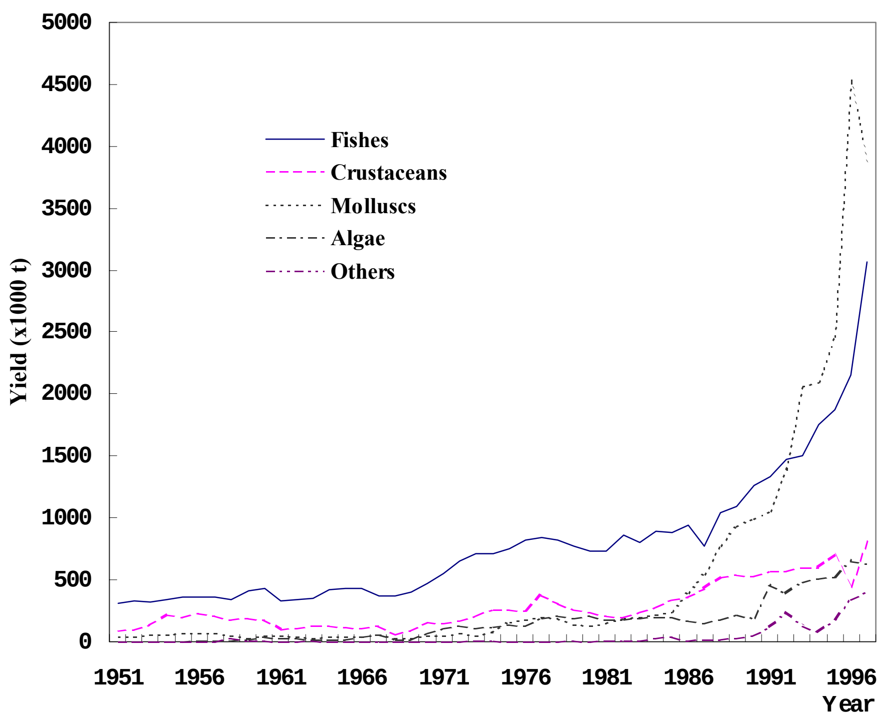
<Table I-2> Types of disease found among commercially important marine organisms.

Disease	Type of Agent	Pathogen	Hosts or Infected Organisms
Hirame Rhabdovirus (HRV)	Virus	Rhabdovirus	Olive flounder (Paralicthys olivaceus)
Birnarvirosis	Virus	Birnarvirus	Olive flounder
Lymphocystis disease	Virus	Iridovirus	Olive flounder
Yellowtail ascites virsus (YAV)	Virus	Birnavirus	Yellowtail (Seriola quinqueradiata)
Iridovirosis	Virus	Iridovirus	Marine fishes
Copepod disease	Crustacean parasite	Conchyliurus quintus, Modiolicola bifidus Hermannella longicaudata	Marine fishes
Bacciger parasitic infection	Trematoda	Cercaria pectinata	Meretrix lusori Ruditapes philippinarum Solen strictus
Birnavirosis	Virus	Birnavirus	Pinctada fucata martensii
Hematopancreatic parvovirus (HPV)	Virus	Hepatopancreatic parvovirus	Penaeid shrimps
Perkinsosis	Protozoa	Perkinsus atlanticus Perkinsus kalsoni	Ruditapes philippinarum Argopecten irradians
Bonamiosis	Protozoa	Bonemia ostrea, Boneamia sp.	Ostrea edulis
Haplosporidiosis	Protozoa	Haplosporidium nelsoni (MSX)	Crassostrea virginica Crassostrea gigas
Marteiliosis	Protozoa	Marteilia refrigens Marteilia chungmuensis	Ostrea edulis Crassostrea gigas
Cercaria Disease	Trematod	Cercaria tapes	Ruditapes philippinarum

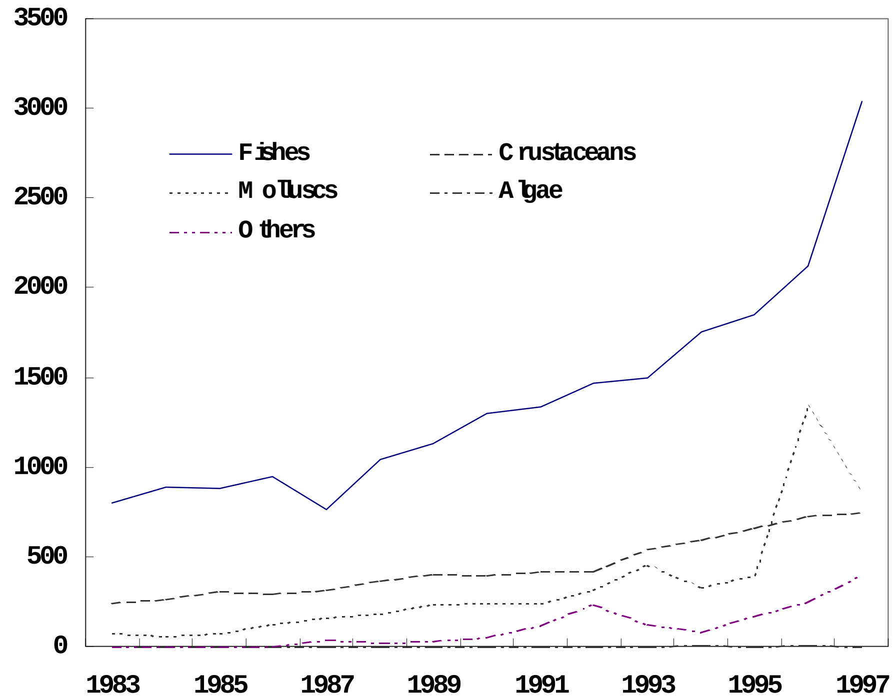
People's Republic of China

Analogous data are available for the PRC. Figure I-4 demonstrates the increase in annual fishery production from the early 1950s to present, with the yield increasing for total fisheries some thousand-fold, and fishes nearly ten-fold. In latest years, figure I-5 demonstrates the same trends. Figure I-6 demonstrates the different types of fishing gear used in the Yellow Sea and Bohai Sea.

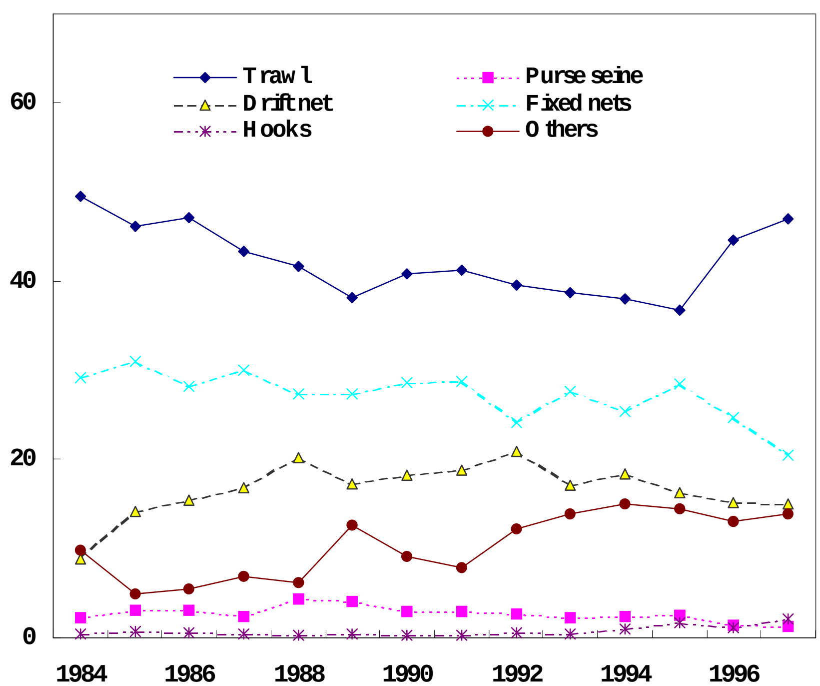
In terms of fisheries, figure I-7 demonstrates the catch of major fish species, shoing the decline in large yellow croaker and small yellow croaker, and the new dominance of fisheries for Japanese Anchovy and chub mackeral. Figure I-8 shows the annual yield of invertebrate species in the Yellow and Bohai seas, with the recent increase in northern maoxia shrimp. Shellfish culture has increased dramatically (Figure I-19), with large increases in mussels, scallops, clams, and oysters. Another demonstration that mariculture has increased dramatically is shown in a comparison of distribution of mariculture in the PRC coastal provinces in 1987 and 1997 (Figure I-10). Shandong and Liaoning provinces, in particular, show dramatic, 10-fold increases in mariculture during this time period.



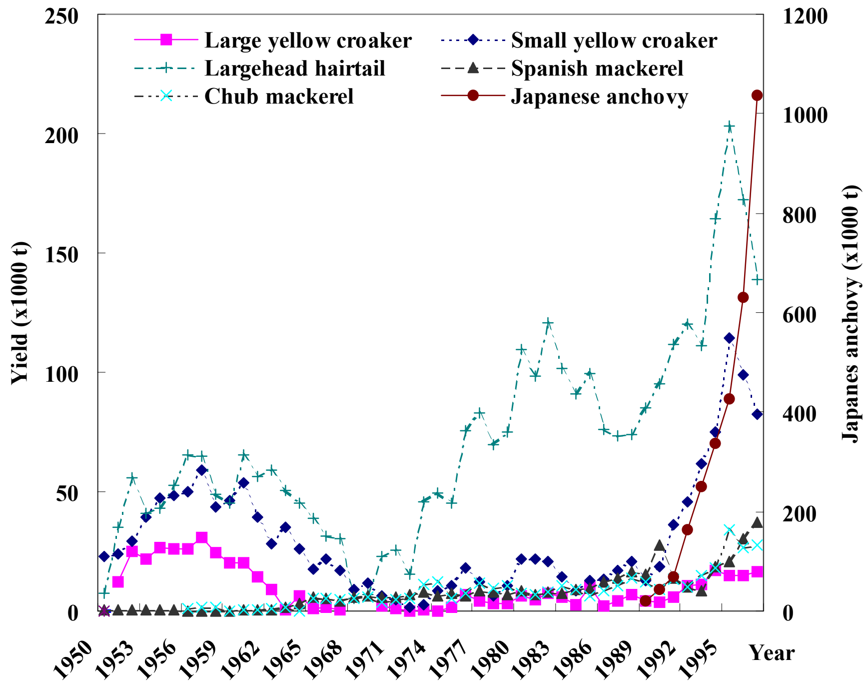
<Fig. I-4>. Annual fishery production of China in the Yellow Sea and Bohai Sea.



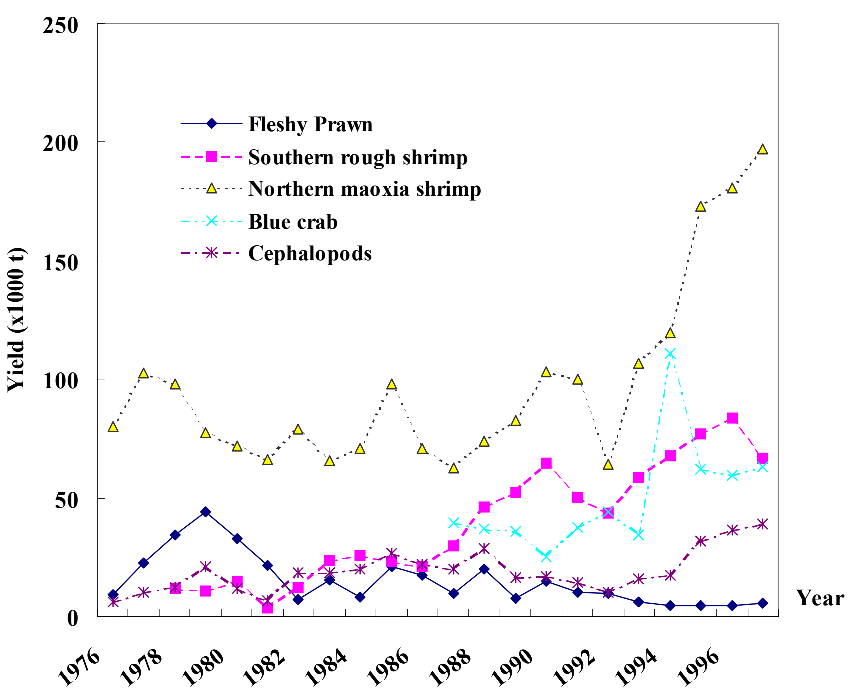
<Fig. I-5> Annual catch in the Yellow Sea and Bohai Sea.



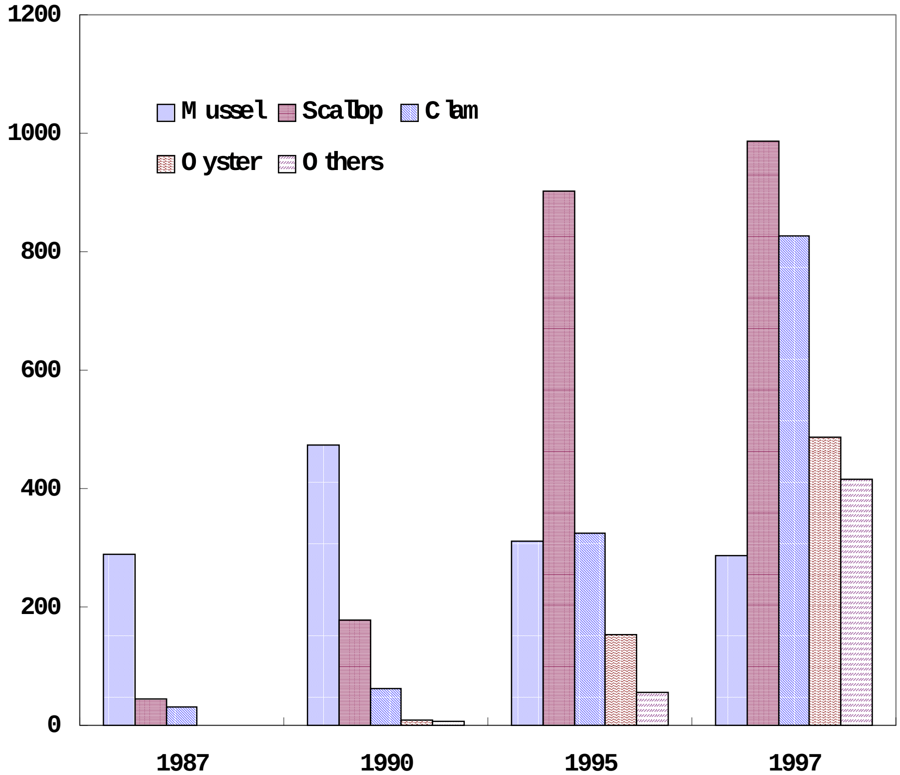
<Fig. I-6> Annual catch proportion by fishing gears in the Yellow Sea and Bohai Sea.



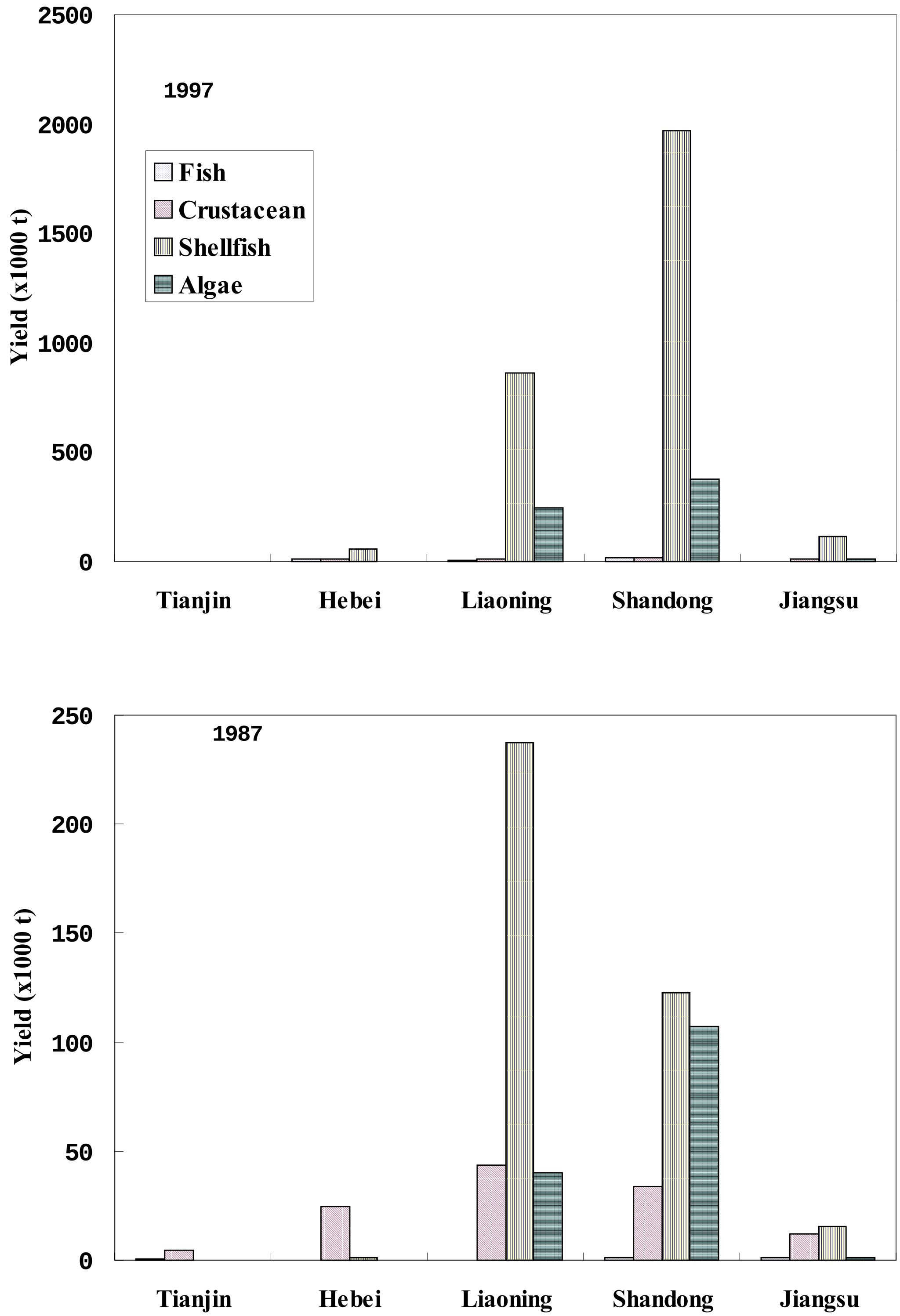
<Fig. I-7> Annual yield of major fish species in the Yellow Sea and Bohai Sea.



<Fig. I-8> Annual yield of invertebrate species in the Yellow Sea and Bohai Sea.



<Fig. I-9> Annual production of cultured shellfishes in the Yellow Sea and Bohai Sea.



<Fig. I-10> Annual production of mariculture in the coastal provinces along Yellow Sea and Bohai Sea (Top, in the year of 1997; lower, in the year of 1987).

Area II. Protection of Biodiversity

Republic of Korea

Approximately 1,600 species have been reported from marine and coastal habitats in the ROK Yellow Sea: 70 phytoplankton, 300 benthic diatoms, 300 marine algae, 50 halophytes, 500 marine invertebrates, 150 fish, 230 water birds and 10 marine mammals. Among them are 13 endangered or reserved wild animal species including spotted seal *Phoca largha*. The Yellow Sea has specific oceanographic conditions as a semi-enclosed sea, and therefore it is anticipated that endemism of benthic invertebrates might be high. However, the diversity of endemic species has not been well studied, nor is the rate of loss in the species diversity. There are no data on introduced species in the ROK Yellow Sea. Little study has been made of genetic diversity. Endangered and preserved species are listed in Table II-1.

<Table II-1> List of endangered species and preserved species of the West Coast of ROK by Natural Environment Conservation Law

Species Name	Common Name	Number of Natural monument	Remarks
Mammalia	**Mammalia**		
Lutra lutra	Otter	330	Endangered species
Callorhinus ursinus	Northern Fur Seal		Preserved species
Phoca largha	Spotted Seal	331	"
Aves	**Aves**		
Egretta europhotes	Chinese Egret	361	Endangered species
Ciconia boyciana	White Stork	199	"
Platalea leucorodia	Spoonbill	205	"
Platalea minor	Black-faced Spoonbill	205	"
Cygnus olor	Mute Swan	201	"
Haliaeetus albicilla	White-tailed Eagle	243	"
Falco peregrinus	Peregrine Falcon	323	"
Grus japonensis	Manchurian Crane	202	"
Eurynorhynchus pygmeus	Spoon-billed Sandpiper		"
Tringa guttifer	Spotted Nordmann's Greenshank		"
Phalacrocorax pelagicus	Pelagic Cormorant		Preserved species
Anser fabalis	Bean Goose		"
Anser cygnoides	Swan Goose	325	"
Cygnus columbianus	Whistling Swan	201	"
Cygnus cygnus	Whooper Swan	201	"
Anas formosa	Baikal Teal		"
Mergus squamatus	Scaly-sided Merganser		"
Grus monacha	Hooded Crane	228	"
Grus vipio	White-naped Crane	203	"
Haematopus ostralegus	Oystercatcher	326	"
Charadrius placidus	Long-billed Ringed Plover		"
Numenius madagascariensis	Australian Curlew		"
Larus saundersi	Saunder's Gull		"

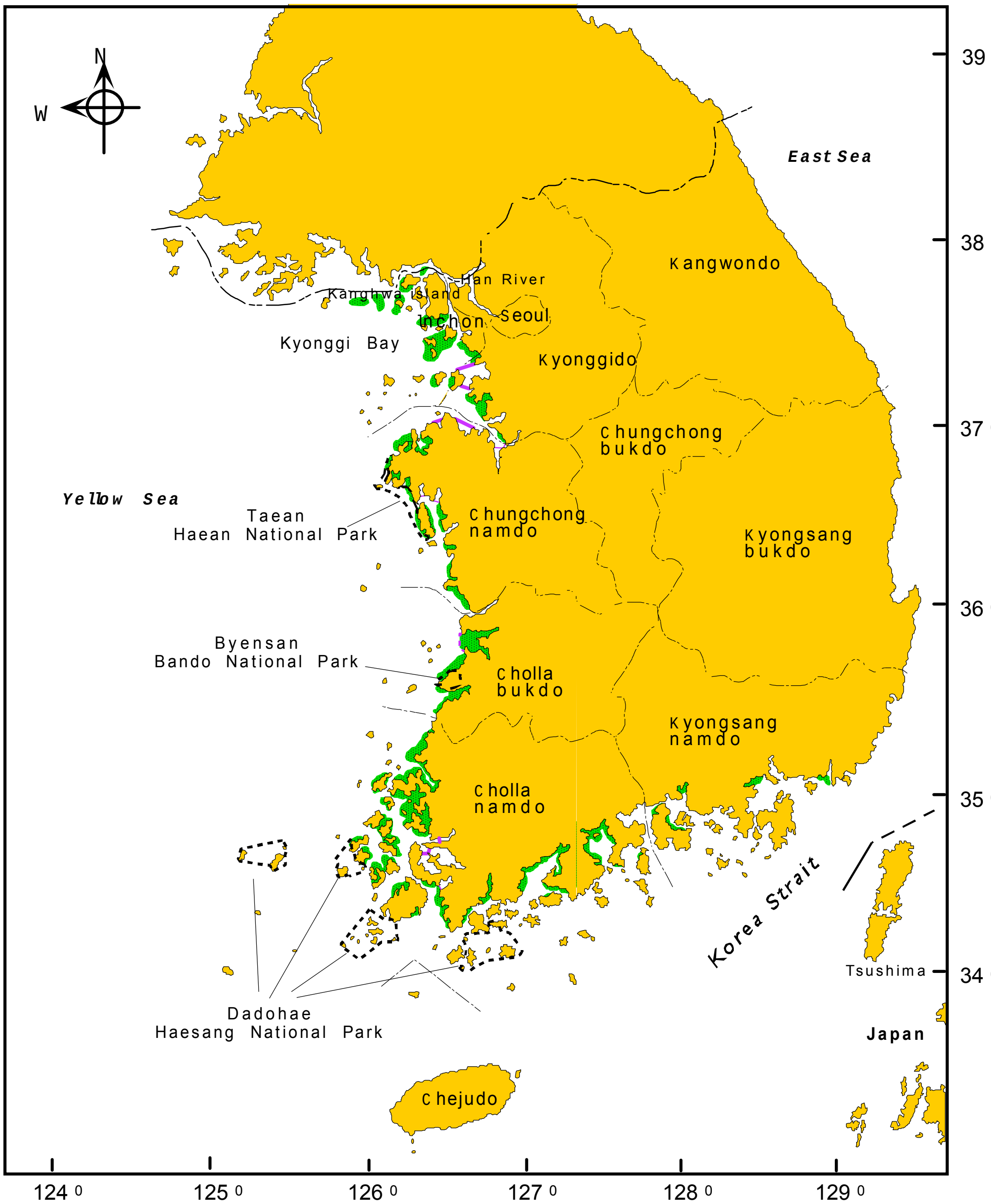
Mollusca	**Mollusks**	
Ellobium chinense		Preserved species
Clithon retropietus		"

On the West Coast, there are two national parks – Taean-Haean National Park and Tadohae-Haesang National Park - and six natural monument sites for one or two single species (Table II-2 and Figure II-1). Government agencies and NGOs concerned about the problems of habitat loss first considered protection of the coastal environment in the Yellow Sea. Their efforts have been concentrated in estuaries, tidal flats, artificial lakes and other coastal wetlands. These areas have long been recognized as special places with a unique range of life, and breeding and feeding area for water birds or migratory birds of international significance. Although there are regulations and laws such as Wetland Conservation Act, Natural Environment Preservation Act, Wildlife Preservation and Game Act etc. to conserve the coastal environment, in ROK no marine protected area is designated at present. According to water bird census investigated in coastal area every year, more than 10 sites are eligible for Ramsar sites (Figure II-2 and Table II-3).

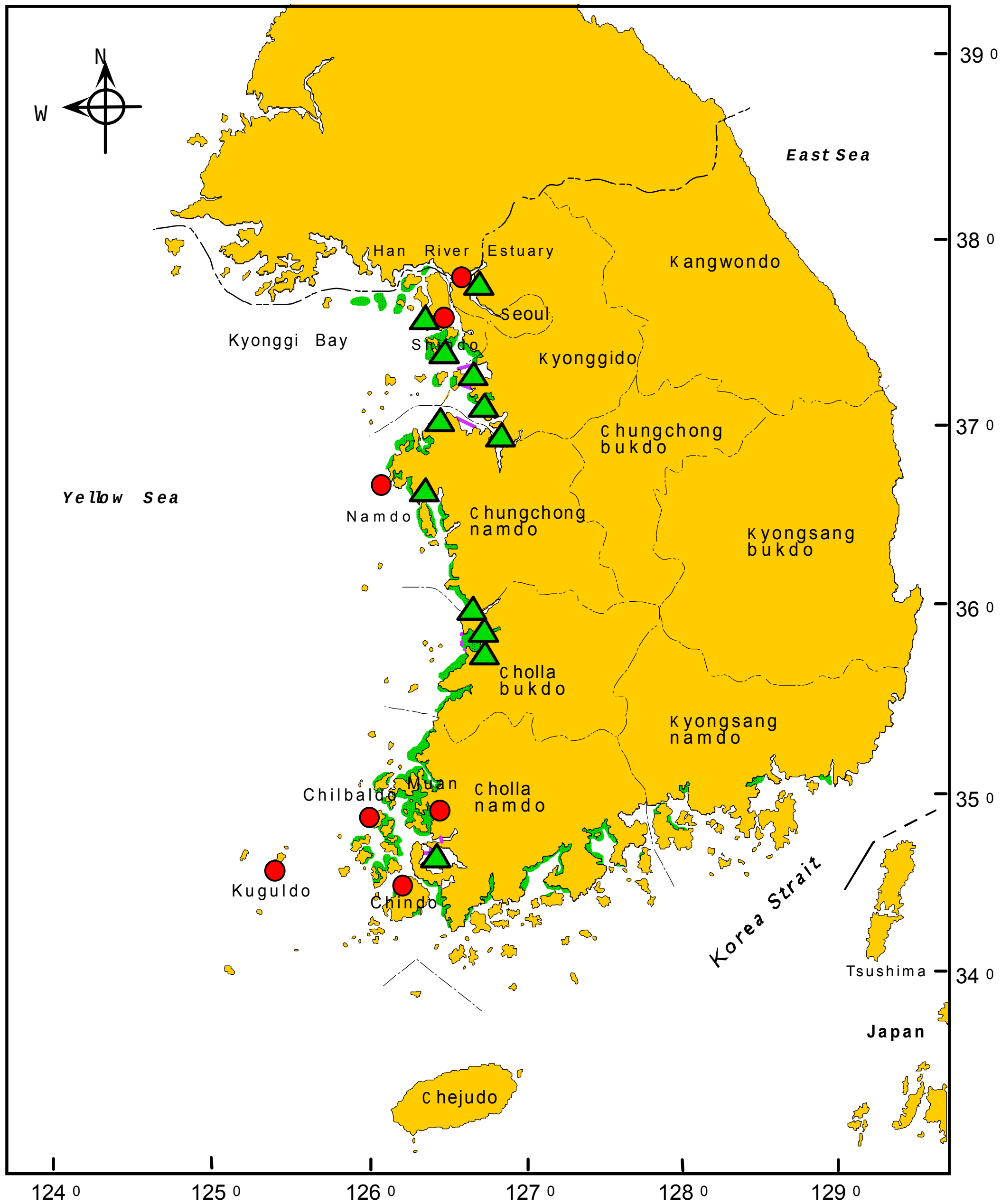
<Table II-2> List of natural monument animals inhabited in the west coast of ROK

Name of Species	Common Name	Number of Natural monument	Designated Date
Ciconia boyciana	White Stork	199	1968. 5. 30
Cygnus columbianus	Whistling Swan	201	1968. 5. 30
Cygnus cygnus	Whooper Swan	"	"
Cygnus olor	Mute Swan	"	"
Grus japonensis	Manchurian Crane	202	"
Grus vipio	White-naped Crane	203	"
Platalea minor	Black-faced Spoonbill	205	"
Platalea leucorodia	Spoonbill	"	"
Grus monacha	Hooded Crane	228	1970. 10. 30
Falco peregrinus	Peregrine Falcon	323	"
Anser cygnoides	Swan Goose	325	"
Haematopus ostralegus	Oystercatcher	326	"
Lutra lutra	Otter	330	"
Phoca largha	Spotted Seal	331	"
Egretta europhotes	Chinese Egret	361	1988. 8. 23

<Fig. II-1> Map showing marine and coastal national parks located in the West Coast of ROK.



<Fig.II-2> Map showing natural monument protection sites (solid circles) and sites in criteria of Ramsar convention distinct (solid triangles) in the West Coast of ROK



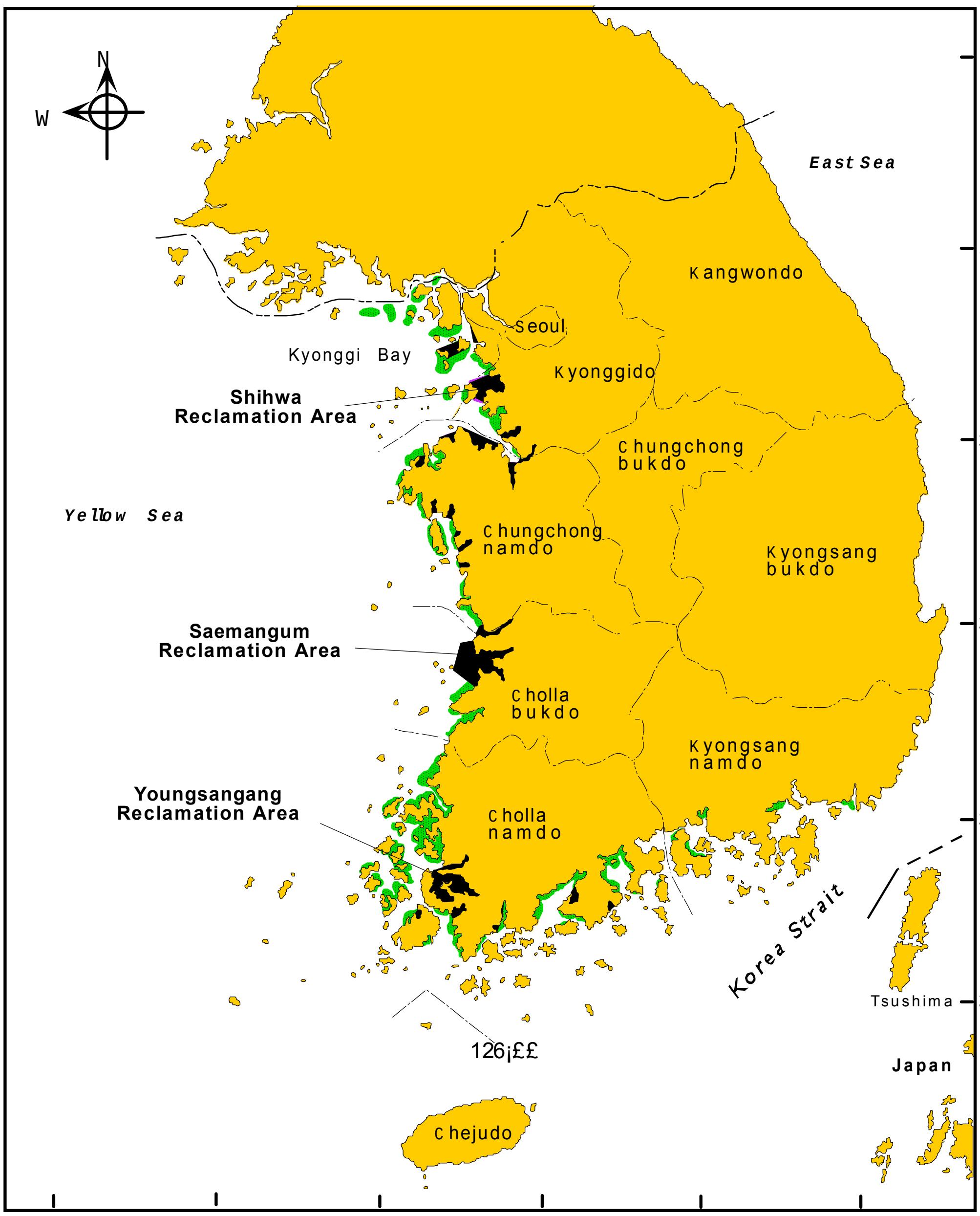
<Table II-3> Sites of coastal and estuarine wetlands in criteria using waterfowl species of Ramsar by estimation in west coast of ROK (MOE), 1997, 1998, 1999.

Sites	Major Waterfowl Species	Estimated Population	Population in World	1% level in Ramsar criteria	Remarks
Han River Estuary	White-naped Crane	385	*3,000	30	Migrated over 20,000 populations in ’96. 12 – ’97. 3.
Kangwha Island	Mongolian Plover	900	**27,000	270	
	Black-bellied Plover	580	***25,000	250	
	Dunlin	1,830	**130,000	1,300	
	Australian Curlew	445	*21,000	210	
	Black-faced Spoonbill	41	*650	7	
Youngjong Island	Mongolian Plover	870	**27,000	270	
	Snowy Plover	1,201	**25,000	250	
	Dunlin	6,707	**130,000	1,300	
Shiwha Lake	Green-winged Teal	15,000	**1,500,000	15,000	Migrated over 20,000 populations in ’99. 2.
Asan Bay	Dunlin	2,821	**130,000	1,300	Migrated over 20,000 populations in ’96. 11 - 12 and ’97. 1 - 4.
	Australian Curlew	1,540	*21,000	210	
	Greenshank	488	***40,000	400	
	Terek Sandpiper	944	***36,000	360	
Namyang Bay	Dunlin	8,000	**130,000	1,300	
	Great Knot	5,100	*330,000	3,300	
	Chinese Egret	47	*2,500	25	
Daeho Lake	Baikal Teal	25,000	*105,000	1,050	
Cheonsu Bay	Dunlin	2,097	**130,000	1,300	Migrated over 20,000 populations in ’96. 10 – ’97. 3.
	Biack-tailed Godwit	3,935	**162,000	1,620	
	Baikal Teal	110,003	*105,000	1,050	
Kum River Estuary	Dunlin	7,128	**130,000	1,300	Migrated over 20,000 populations in ’96. 11 – ’97. 3.
	Mongolian Plover	450	**27,000	270	
	Oystercatcher	1,169	*3,000	30	
Mankyung River Estuary	Saunder's Gull	410	*10,000	100	Migrated over 20,000 populations in ’96. 10 - 11 and ’97. 1 - 4.
	Great Knot	17,767	*330,000	3,300	
	White-naped Crane	130	*3,000	30	
Tongjin River Estuary	Dunlin	8,784	**130,000	1,300	Migrated over 20,000 populations in ’96. 10 - 11 and ’97. 1 - 2.
	Australian Curlew	726	*21,000	210	
	Snowy Plover	586	**25,000	250	
Youngsan River Estuary	(Eurasian) Wigeon	11,283	**1,000,000	10,000	Migrated over 20,000 populations in ’99. 2

*: Population in the world, **: Maximum population of subspecies, ***: Population on fly-way of migratory waterbirds (Rose, P.M. and D.A. Scott, 1994. Waterfowl Population Estimates. IWRB, 29.)
References: Ministry of Environment, 1997, 1998, 1999 ("Census datas of migratory waterbirds")

The main threat to the coastal habitats is land reclamation, especially at in estuaries and shallow bays. During the past decades, many sites have been reclaimed, resulting in the loss of approximately 25% of the total tidal flats in ROK (Figure II-3). The waste materials and pollutants from industrial complexes and cities located in along the coast and visitors to the coast for tourism and recreation also degrade the habitats.

<Fig. II-3> Map showing major reclamation areas reclaimed or under construction.



People's Republic of China

Analogous information is available for the PRC portion of the Yellow Sea, though the exact numbers of species differs, pointing out the need for joint work to clarify the species identification, and to harmonize methods for identifying species. Different countries have focused on different types of organisms, and the effort of study is imbalanced. The full TDA will demonstrate this balance following efforts undertaken under the GEF project.

The list of priority protected marine organisms in the Yellow Sea for the PRC is provided in Table II-4. However, whereas the ROK list focused mainly on birds, the PRC list is less intensively focused on birds and includes reptiles, fish, and other organisms.

<Table II-4> The list of priority protected marine organisms in Yellow Sea

Organisms	Level of protection
Chordata	
Mammalia	
□ Cetacea	II
Aves	
Procellariiformes	
Diomedeidae	
□ *Diomedea albatrus*	I
Pelecaniformes	
Pelecanidae	
□ *Pelecans p. philippensis*	II
Phalacrocoracidae	
□ *Phalacrocorax pelagicus*	II
Ciconiiformes	
Ciconiidae	
□ *Ciconia nigra*	I
Reptilia	
Testudoformes	
Cheloniidae	
□ *Chelonta mydas*	II
□ *Eretmochetys imbricata*	II
□ *Lepidochelys olivacea*	II
Dermochelyidae	
□ *Dermockelys corlacea*	II
Pisces	
Perciformes	
Cottidae	II
□ *Trachidermus fasciatus*	
Acipenseriformes	
Acipenseridae	
□ *Acipenser sinensis*	I
Polyodontidae	
□ *Psiphurus gladius*	I
Appendicularia (Amphioxi)	

Amphioxiformes	
Branchiosiomaiidae	
Branchtotoma belcheri tsingtauense	II
Hemichordata	
Enteropneusta	
Balanoglossidae (Ptychoderidae)	
Glassobalanus palybanchioporus	I
Harrimaniidae	
Saccoglossus hwangiauensis	I

The nature reserves and wetlands

There are 10 marine nature reserves along the Yellow Sea coast, of which two are national reserves and 8 provincial or county ones. In addition, 5 reserves are in the process of establishment (Table II-5). The important wetlands include those in Yalujiang Estuary of Liaoning, Daguhe Estuary of Shandong and Yancheng tidal flat of Jiangsu (Table II-6).

<Table II-5> Nature reserves in Yellow Sea

Name	Location	Objects of protection	Level and time	Responsible Agency
Snake Island	Dalian City Liaoning Province	Snake(*Agkishrodon shedaoensis)* Migratory birds and their habitat	National 1990	SEPA
Miaodao Archipelago	Changdao County Shandong Province	Island-sea ecosystem Migratory birds	Provincial 1991	SOA
Qiansandao Islanda	Haizhou Bay Jiangsu Province	Rare species Migratory birds	planned	SOA
Donggou Wetland	Donggang City Liaoning Province	Wetland ecosystem	County 1991	SEPA
Chenshan-tou	Rongcheng City Shandong Province	Nature landscape and Lagoon ecosystem	Provincial 1991	SOA
North-West Muddy flat Jiaozhou Bay	Jiaozhou Bay Qingdao	Mudflat ecosystem, typical north China marine fauna	planned	SOA
Yancheng	Yancheng City Jiangsu Province	Crane(*Grus japonica) And coastal mudflat*	National 1992	SEPA
Sheyang	Sheyang County Jiangsu Province	Salinized marsh ecosystem	planned	
Dafeng	Dafeng County Jiangsu Province	Estuary marsh ecosystem	planned	
Acorn worm	Jiaozhou Bay Shangdong Province	Local endemic species of acorn worm(*Saccoglossus hulangtauensis , Balanoglossus misakiensis)*	planned	SOA
Sanshan Island precious marine organisms	Dalian City Lisoning Province	Scallop (*Chlamys farreri) and A*balone (*Haliotis discus*)	Municipal	MOA
Jinshitan Geology	Dalian City Liaoning Province	Typical geological structure, palaeobiofossil and peculiar coastal landforms.	Municipal	SEPA

Changhai precious marine organisms	Changhai County Liaoning Province	Sea cucumber(*Stichopus japonicus),* scallop*(Chlamys farreri)* and abalone*(Haliotis discus)*	Municipal	SEPA
Sanggou Bay	Rongcheng City Shandong Province	Precious marine organisms	County	SEPA
Jimi	Qingdao City Shandong Province	Commercial marine organisms	County	SEPA

Note: SEPA---State Environment Protection Agency
SOA---State Oceanic Administration
MOA---Ministry of Agriculture

<Table II-6> The important wetlands along the coast of the PRC Yellow Sea

Location	Size	Other vegetation	Birds recorded and species number
Yalujian Estuary	110km^2	*Salsola glauca, Salicornia euronaea*	>70 species, *Cygnus, Egretta eulophots,* etc.
Dagu Estuary	Vast area	*Salsola glauca, Salicornia euronaea*	>206 species, *Haliaeetus albicilla, Gavia, Stellata,* etc.
Yancheng	Vast areas	*Salsola glauca.Salicornia euronaea, Zoysia japonica, Imperata cylindrica, Spartina angelica*	>226 species *Grus japonica* , some species of Anser and Anas

Area III. Reduce stress on the Ecosystem

Pollution of the Yellow Sea

Republic of Korea

Rivers

In the ROK Peninsula, several rivers significantly affect the water quality of the coastal region in the Yellow Sea. In addition, rivers rather than industrial and sewage discharges play more important roles to coastal water quality. Of seven rivers discharging from ROK into the Yellow Sea, the Han, Keum, and Youngsan Rivers contribute considerable freshwater inputs into the Yellow Sea (Table III-1).

Some aspects of pollution loads and river responses to pollution loads in the ROK are shown in Tables III-2 to III-31. Information on dissolved metals in ROK waters is provided in Tables III-7 to III-9. Use of various pesticides and fertilizers is presented in Tables III-10 to III-11. Emissions from the transport sector are shown in Tables III-12 and III-13. Maritime transport entails accidents, which have negative effects on the marine environment. Since 1991, a total number of 1,651 accidents associated with marine oil pollution have occurred, having a calculated spilled volume equivalent to 33,720 tons of oil for previous 5 years in ROK. Tables III-14 through III-16 address this source of pollution

Atmospheric inputs are presented in Tables III-17 to III-18, whereas groundwater quality is shown in Table III-19. Tissue concentrations in biota are presented in Tables III-20 to III-23. General water quality is presented in Tables III-24 to III-29. Sediment quality data are shown in tables III-30 to III-32.

<Table III-1> Major ROK rivers discharging into the Yellow Sea

Rivers	Area (km^2)	Total length (km)	Length (km)							
			Sum		Direct stream		Local stream		Associate stream	
			Sites	Length	Sites	Length	Sites	Length	Sites	Length
Han	26018.0 34473.2 (Including N. Korea)	481.7	705	7256.67	705	813.5	12	552.8	678	5890.3
Keum	9810.4	395.9	503	3741.92	503	401.9	20	362.1	472	2977.9
Youngsan	3371.3	136.0	185	1472.22	185	197.1	2	46.2	178	1228.9
Ansung	1699.6	66.4	103	622.21	103	87.6	-	-	99	534.6
Mankyung	1570.9	74.1	83	579.80	83	67.8	2	23.8	78	488.2
Sapkyo	1611.7	58.6	100	609.61	100	67.3	2	29.3	95	513.0
Dongjin	1000.4	40.9	87	446.20	87	69.8	1	18.9	82	357.5

MOE(1996)

<Table III-2> Annual variations of BOD values in main stream and tributaries to the Han River

(unit: mg l^{-1})

Year \ Stn	Soyang dam	Chungju dam	Paldang Dam	Gui	Jungrang-cheon	Noryangjin
1981	0.4	2.2	1.8	1.5	-	5.2
1982	0.4	1.7	3.2	1.5	123.0	5.4
1983	0.6	1.1	2.5	2.7	76.7	6.1
1984	0.8	1.2	1.4	2.5	7.5	6.7
1985	0.7	1.3	10.2	1.7	6.4	4.7
1986	0.9	1.1	1.4	1.7	7.6	3.6
1987	1.2	1.4	1.6	1.4	13.2	4.3
1988	1.1	1.2	1.7	1.6	20.6	4.3
1989	1.2	1.6	1.4	1.6	19.4	3.4
1990	1.4	1.4	1.2	1.5	14.3	3.4
1991	1.3	1.3	1.3	1.9	26.9	3.9
1992	1.1	1.5	1.2	1.8	25.8	3.6

MOE (1988-96)

<Table III-3> Annual variations of BOD values in main stream and tributaries to the Keum River

(unit: mg l^{-1})

Year \ Stn	Daechung dam	Kongju	Puyeo	Kabcheon	Mihocheon	Kangkyung -cheon
1981	1.9	2.1	2.0	-	-	-
1982	1.2	2.6	2.4	67.7	5.8	-
1983	1.1	2.1	2.3	39.1	9.5	-
1984	1.1	3.3	2.9	3.8	1.6	4.8
1985	1.1	2.6	2.5	3.0	1.7	5.0
1986	1.2	2.5	3.0	2.0	1.8	8.0
1987	1.3	2.3	2.9	1.5	2.0	5.7
1988	1.5	3.2	3.2	1.7	2.2	5.9
1989	1.6	3.0	3.5	2.3	2.7	7.2
1990	1.7	3.2	3.1	1.5	2.7	9.3
1991	1.6	3.1	3.0	1.7	2.8	6.8
1992	1.6	3.3	3.2	1.6	2.7	8.3

MOE (1988-96)

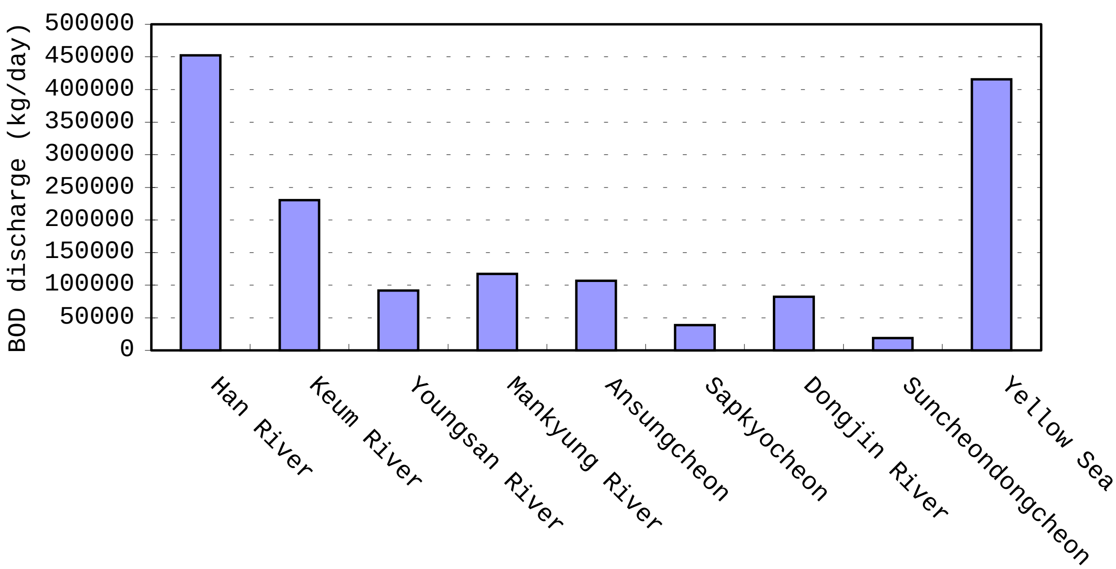
<Table III-4> Annual variations of BOD values in main stream and tributaries to the Youngsan River

(unit: mg l^{-1})

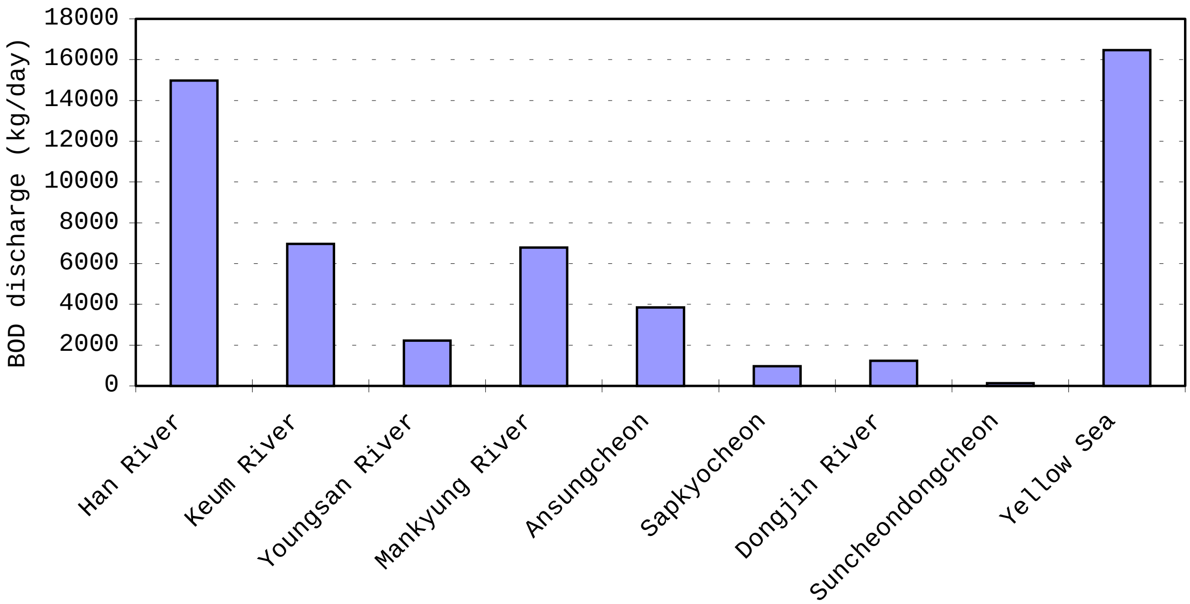
Year \ Stn	Kwangju	Naju	Kwangjucheon	Jiseokcheon	Hampyungcheon	Najudam
1981	-	3.8	3.0	-	-	-
1982	-	3.9	3.0	2.8	-	-
1983	-	5.6	2.9	1.8	-	-
1984	2.0	6.5	1.9	1.7	6.4	1.6
1985	3.0	5.2	1.9	2.1	7.2	1.5
1986	3.4	5.2	1.8	1.9	4.8	1.7
1987	2.7	4.2	1.4	1.8	5.4	1.7
1988	2.9	7.0	1.2	1.8	4.7	1.7
1989	3.9	6.6	5.2	1.5	4.0	-
1990	3.4	6.7	5.1	1.4	2.8	-
1991	2.8	5.6	4.1	1.9	3.1	-
1992	3.4	5.6	4.3	3.1	-	-

MOE (1988-96)

<Fig. III-1> Discharge rates of biochemical oxygen demand (BOD) at each of river systems before treatment (MOE, 1997).



<Fig. III-2> Discharge rates of biochemical oxygen demand (BOD) at each of river systems after treatment (1997).



<Table III-5> Annual variations of BOD values in main stream and tributaries to the Mankyung River

(unit: mg l^{-1})

Year \ Stn	Cheonju	Kimje	Cheonjucheon	Iksancheon	Irigongdan
1981	1.0	21.4	-	-	-
1982	1.6	35.8	239.4	372.1	-
1983	1.5	23.5	79.1	114.4	-
1984	1.3	11.0	1.7	161.6	143.9
1985	1.3	6.8	1.2	106.5	194.8
1986	1.3	6.8	1.2	121.2	131.7
1987	1.2	5.6	1.5	121.2	130.2
1988	1.2	7.9	1.4	119.2	113.2
1989	1.2	5.1	28.7	115.8	-
1990	1.3	4.9	20.9	-	-
1991	1.4	5.4	13.3	30.8	-
1992	1.5	6.6	12.5	17.4	-

MOE (1988-96)

<Table III-6> Estimated BOD loadings to surface water, mid-1990s (tonnes/day)

Point sources	
Domestic sewage	2,580
Industrial waste water	2,600
Livestock enterprises	480
Diffuse sources	
Urban areas	435
Rice paddies	30
Dry fields	15
Pastures	20
Uplands	80

OECD, 1998. Environmental Performance Reviews. Korea. 195pp

<Table III-7> Comparison of average concentrations of dissolved metals in ROK riverwaters (μg/kg).

Rivers	Mn	Fe	Cu	Zn	Cd	Pb	References
Keum (Kongju)	49.4	50.7	2.05	2.18	0.008	0.32	1
Han (Kwangnaru)	7.43	25.3	1.20	0.73	0.009	0.23	1
Han (Jungjido)	28.3	15.8	1.53	2.02	0.018	0.32	1
Youngsan	37.9	16.7	1.03	0.78	0.007	0.073	2
Changjiang	0.5-1.5		1.14-1.33	0.04-0.08	0.001-0.002	0.052	3,4,5
Huanghe	0.55-2.20		0.95-1.53	0.065-0.33	0.001-0.006	0.01-0.04	6
Lena		22.9	0.6	0.35	0.003-0.008	0.017	7
World average	8.2		1.59	0.6	0.023	0.104	8

(1)Choi,1998; (2) unpublished; (3) Edmond et al., 1985; (4)Wang et al., 1990; (5)Elbaz-Poulichet et al., 1990; (6)Zhang and Huang, 1993; (7) Martin et al., 1993; (8)Martin and Windom, 1991.

<Table III-8> Average contents of metals in SPMs in ROK and PRC riverwaters (μg/g)

	Fe(%)	Mn	Cu	Zn	Cd	Pb	References
Keum (Kongju)	3.3	2324	66	185	0.6	86	1
Han	3.0	1453	100	281	0.6	71	1
Youngsan	4.5	927	39	130	0.3	35	2
Changjiang	5.2		62	120	0.3	50	3,4
Huanghe	4.4	885	23	53	0.4	14	3,4
Lena			28	143		23	5
World average	4.8	1050	100	250	1.0	100	6

1) Choi (1998); 2) unpublished; 3) Zhang et al(1990);4) Huang et al(1992);
5) Martin et al.(1993); 6) Martin and Whitfield(1983)

<Table III-9> Riverine dissolved and particulate metal fluxes into the Yellow Sea

River		Cu		Zn		Cd		Pb		Water discharge (km^3/yr)[5]	Sediment discharge (10^6 ton/yr)[5]	Trapping efficiency (%)[5]
		Diss.	***Part.***	***Diss.***	***Part.***	***Diss.***	***Part.***	***Diss.***	***Part.***			
Keum[1]	(ton/yr)	23	24	11.8	149	0.10	0.4	3.14	36	6.4	1.3	65
Han[1]	(ton/yr)	63	176	33.3	494	0.58	0.9	10.3	114	25	2	50
Huanghe[2]	(ton/yr)	54.9	250	8.86	581	0.18	4.3	1.33	154	44.3	1100	99
Changjiang[3]	(ton/yr)	1146	15139	55.4	29209	1.8	78	48.0	12174	924	486	50
Estuarine modification factor[4]		1		1		5		1				

1: Choi (1998)
2: Zhang and Huang(1993) for dissolved form, and Zhang et al.(1990) and Huang et al.(1992) for particulate form
3: Edmond et al.(1985) and Elbaz-Poulichet et al.(1990) for dissolved form, and Zhang et al.(1990) and Huang et al.(1992) for particulate form
4: Martin and Windom(1991)
5: Schubel(1986)

Non-point sources of pollution

<Table III-10> Production and shipment of pesticides (M/T)

		Total	Fungicide	Pesticide	Herbicides	Others
Production	1970	**4,042**	834	1,772	1,325	111
	1975	**8,642**	1,296	5,363	1,905	78
	1980	**17,431**	5,591	7,310	3,523	1,007
	1985	**17,758**	5,771	6,622	4,031	1,334
	1990	**26,610**	8,248	9,488	6,274	2,600
	1995	**26,676**	8,085	9,527	5,756	3,308
	1996	**25,085**	7,138	8,400	6,338	3,209
	1997	**25,300**	7,079	9,493	6,264	2,464
Shipment	1970	**3,719**	767	1,735	1,122	95
	1975	**8,619**	1,232	5,171	2,139	77
	1980	**16,132**	5,448	6,407	3,374	903
	1985	**18,247**	5,955	7,052	3,994	1,246
	1990	**25,082**	7,778	9,332	5,509	2,463
	1995	**25,834**	7,910	8,892	5,817	3,215
	1996	**24,641**	7,156	8,407	5,962	3,116
	1997	**24,814**	7,332	9,161	6,043	2,278

MOE, 1998. Environmental Statistics Yearbook. 581pp

<Table III-11> Production and shipment of fertilizers (1,000 M/T)

	1975	1980	1985	1990	1995	1996	1997
Production							
	778	**1,223**	**1,179**	**1,321**	**1,435**	**1,435**	**1,373**
Nitrogen	583	729	686	867	950	975	923
Phosphorus	195	494	493	454	485	460	450
Shipment							
	719	**644**	**600**	**819**	**695**	**664**	**645**
Nitrogen	482	448	414	562	472	456	446
Phosphorus	238	196	186	256	223	209	199

MOE, 1998. Environmental Statistics Yearbook. 581pp

<Table III-12> Transport sector emissions, 1995

	Amount of pollutants (1,000 tons)					
	SO2	NOx	CO	HC	TSP	Total
Total emissions	1,532	1,152	1,109	150	406	4,349
Transport sector emissions	314	606	959	144	98	2,122
(% of total emissions)	(20)	(53)	(86)	(96)	(24)	(49)
Motor vehicle emissions	34	494	910	127	80	1,645
(% of total emissions)	(2.1)	(41)	(79)	(87)	(19)	(36)
Motor vehicle emissions in Seoul	5	93	210	29	14	351
(% of total citywide emissions)	(13)	(82)	(82)	(96)	(84)	(77)

OECD, 1997. Environmental Performance Reviews.

<Table III-13> Motor vehicle emissions in selected cities (1,000 tons)

	Seoul	Taejon	Kwangju	Incheon
Total atmospheric emissions	455	63	62	250
Motor vehicle emissions	351	46	46	83
Percentage of total emissions	(77)	(74)	(74)	(33)

OECD, 1997. Environmental Performance Reviews.

<Table III-14> Volume of cargo transportation

Description	90	91	92	93	94
Quantity of imported oil (million ton)	49	63	81	89	91
Quantity of oil transportation (million ton)	75	97	121	135	157

<Table III-15> Annual figure of oil and hazardous materials in the sea

(unit: million won)

	number of violations	quantity of spill(kl)	clean-up expense		compensation of damage	
			no. of incident	values	no. of incident	values
Total	1,651	33,720	989	39,481	37	15,575
1991	240	1,257	157	3,918	6	5,921
1992	328	2,943	177	1,315	6	324
1993	371	15,460	213	5,277	15	6,312
1994	365	456	225	473	6	130
1995	347	13,604	217	28,498	4	2,888

<Table III-16> Contents of types of marine pollution ('91-'95)

A. Geographical area

Description	Total	South Sea	Yellow Sea	East Sea
No. of violation	1651	740	557	354
Quantity of spill (Ton)	33,720.3	13,670.3	14,774.4	5,275.6

B. Origin of pollution

Total	Ship					coastal & riverine equip.	unknown polluter
	tot.	cargo ship	Oil tanker	Fishing vessel	others		
1,651	1,440	414	203	679	144	170	41

C. Cause

Total	mishandling	sea causalities	intention of discharge	damage	unknown polluter
1,651	913	307	314	76	41

D. Pollutants

Description	Total	oils					garbage	noxious substances
		tot.	fuel oil	light oil	bilge oil	others		
No. of violation	1,651	1,516	336	421	555	204	103	32
quantity of spill (tons)	33,720	31,687	4,832	11,926	760	14,168	304	1,728

Trace metals

<Table III-17> Concentrations (1) and crustal enrichment factors (2) of atmospheric trace metals in various coastal seas.

		Yellow Sea[a]		Close to pollution sources				Close to crustal source			
				North Sea[b]		Kiel Bight[c]		N.Arabian Sea[d]		Eastern Med.[e]	
Element	Unit	1	2	1	2	1	2	1	2	1	2
Al	(μg/m^3)	1.28	1	0.16	1	0.4	1.0	1.18	1	0.92	1
Fe	(μg/m^3)	0.8	1.2	0.33	3	0.4	1.4	0.91	1.1	0.57	0.9
Mn	(ng/m^3)	25.4	1.4	21	11	15.0	3.3	15	1.1	12	1.1
Cu	(ng/m^3)	6.3	8.3			7.7	29	3.2	4	4.9	8
Zn	(ng/m^3)	60.0	64	153	1132	57	170	4.3	4.3		
Cd	(ng/m^3)	0.8	714					0.05	17		
Pb	(ng/m^3)	69.0	901	147	6082	53	885	2.9	16	7.4	53

a: Choi(1998), b: Cambray et al.(1975), c: Schneider (1987), d: Sanders (1983), e: Saydam (1981)

<Table III-18> Atmospheric fluxes and total deposition into the Yellow Sea

		Coastal site[1]		Shipboard[2]				
Element	Unit	Mean[1]	Range	Mean	Range	Western Yellow Sea[3]	Yellow Sea[4]	Total deposition[5] (ton/yr)
Al	(g/m^2/yr)	1.22	0.41-3.65	0.89	0.30-2.68		0.7~6.2	510000
Fe	(g/m^2/yr)	0.75	0.25-2.26	0.52	0.17-1.54	2.9	0.67~6	320000
Mn	(mg/m^2/yr)	24.1	8.02-72.2	16.6	5.54-49.9	36.2	16~150	10000
Cu	(mg/m^2/yr)	2.4	0.81-7.23	2.82	0.97-8.69	12.4		1000
Zn	(mg/m^2/yr)	10.4	3.6-32.1	4.74	1.64-14.7	29	6.3~52	4400
Cd	(mg/m^2/yr)	0.14	0.05-0.44	0.10	0.03-0.297			59
Pb	(mg/m^2/yr)	12.0	4.1-37.1	3.50	1.21-10.8	17.3		5040

1: Choi (1998), 134 samples covering 5 years at Mallipo
2: Hong et al. (1997), 4 samples on April
3: Zhang et al. (1992)
4: Gao et al. (1992)
5: calculated based on the fluxes at coastal site and surface area of 420,000 km^2

Groundwater pollution

<Table III-19> Exceeded groundwater quality standards

Area	No. of sites	No. of sites exceeding	Result										
			%	Pollutants									
				Total	TCE	PCE	Cd	Pb	Cr^{+6}	Phenol	COD	NO^3-N	Cl^-
1993	1,546	260	16.8	249	48	9	10	10	1	-	-	171	-
1994	1,539	185	12.0	136	11	8	8	6	-	-	-	103	-
1995	1,546	156	10.1	162	19	10	-	2	-	5	8	101	17
1996	1,527	110	7.2	118	26	6	-	-	-	-	10	42	34
1997	1,513	153	10.1	158	44	13	1	-	1	-	5	81	13
Agricultural	92	2	2.2	2	-	-	-	-	-	-	-	2	-
Agricultural (veg. & fruits)	24	2	8.3	2	-	-	-	-	-	-	-	2	-
Polluted rivers	111	4	3.6	4	1	-	-	-	-	-	-	3	-
Industrial complexes	360	46	12.8	51	31	11	1	-	1	-	-	2	5
General waste landfill	185	21	11.4	20	2	-	-	-	-	-	2	16	-
Hazardous waste landfill	58	9	15.5	9	-	-	-	-	-	-	-	7	2
Mines	57	11	19.3	11	1	-	-	-	-	-	-	10	-
Nightsoil treatment facility	72	10	13.9	10	-	-	-	-	-	-	-	9	1
Health survey area	30	2	6.7	2	-	-	-	-	-	-	-	2	-
Parks	65	1	1.5	1	-	-	-	-	-	-	-	1	-
Golf course	67	3	4.5	3	-	-	-	-	-	-	-	3	-
Urban residential	324	24	7.4	25	7	2	-	-	-	-	1	12	3
Storage tank	68	18	26.5	18	2	-	-	-	-	-	2	12	2

* Note : Survey two times per year (780 sites)

Contaminant levels in fish and other biological resources

<Table III-20> Contents of trace metals in mussels (*Mytilus* spp.) from the western coast of ROK and other coastal waters of the world oceans (•g/g dry wt.)

Sampling site	*sampling period*	Cu	Zn	Cd	Pb	Hg	References
West Coast, ROK		5.9	72	2.5	0.65	-	1
West Coast, ROK	1987	11.7	77	2.39	0.31	0.039	2
West Coast, ROK	1988	7.8	81	2.29	0.7	-	2
West Coast, ROK	1985-1989	0.26-2.01*	2.14-24.5*	0.29-0.48*	0.31-0.77*	0.009-0.015*	3
" " dry basis •	1985-1989	1.53-11.8	12.6-144	1.70-2.82	1.82-4.53	0.053-0.088	
Narragansett Bay, East Coast		11	92	1.26	2.86	0.09	4
San Diego Bay, West Coast		17	273	6.53	4.43	0.19	4
Niepoort, Belgium		8.3	130	0.58	2.4	-	5
Tasmania, Australia		8.3	130	0.58	2.4	0.32	6
Tokyo Bay, Japan		10.5	243	1.5	2.0	-	7
West Greenland, Denmark	1980-1982	8.64	92.5	1.75	1.73	0.078	8
Algarve Coast, Portugal	1994	5.7	254	2.1	-	-	9

* : Concentration unit is •g/g wet wt.
1 : Lee et al.(1984)
2 : Lee et al.(1994)
3 : Choi et al.(1992)
4 : NOAA(1987)
5 : Meeus-Verdinne et al.(1983)
6 : Cooper et al.(1982)
7 : Hung et al.(1981)
8 : Riget et al.(1996)
9 : Bebianno et al.(1997)

<Table III-21> T-PCBs concentration and other data in biota.

Species	Location	site	sampling time	[a]sample size or sex	Tissue type	T-PCBs (ng/g, dry wt.)	T-PCBs (•/g, lipid wt.)	Lipid content (%, dry wt.)
Zooplankton	Incheon North Harbor	W2	05/08/98	--	bulky	119.78	0.40	30.31
		W4	05/08/98	--	bulky	98.82	0.65	15.21
Pacific oyster	Incheon North Harbor	B1	05/08/98	47.0 +/- 1.7	whole soft tissue (n=25)	421.99	2.53	16.69
		B2	05/08/98	50.3 +/- 4.7	whole soft tissue (n=13)	412.78	2.50	16.50
		B3	04/16/98	56.3 +/- 3.9	whole soft tissue (n=17)	291.06	1.88	15.55
		B4	04/16/98	50.8 +/- 5.5	whole soft tissue (n=20)	191.04	1.41	13.58
		B5	05/08/98	52.4 +/- 3.5	whole soft tissue (n=22)	261.84	1.65	15.87
		B6	05/08/98	55.7 +/- 6.0	whole soft tissue (n=20)	331.65	2.12	15.67
		B7	05/08/98	57.7 +/- 6.9	whole soft tissue (n=20)	287.03	1.52	18.94
		B9	05/08/98	51.3 +/- 2.8	whole soft tissue (n=18)	191.71	1.40	13.70
	Youngjong island	B11	05/0398	47.4 +/- 6.5	whole soft tissue (n=22)	83.98	0.66	12.70
		B12	07/98	43.1 +/- 3.4	whole soft tissue (n=38)	48.95	0.46	10.67
Chinese clams	Incheon North Harbor	B8	03/06/98	36.9 +/-1.4	whole soft tissue (n=24)	152.63	0.91	16.79
	Songdo	B10	04/16/98	38.9 +/-1.4	whole soft tissue (n=17)	56.00	0.45	12.46
Shore crab	Incheon North Harbor	B1	28/07/98	Male	whole soft tissue (n=20)	3,205.83	5.58	57.49
			28/07/98	Female	whole soft tissue (n=30)	3,709.97	5.57	66.65
	Youngjong island	B12	29/07/98	Male	whole soft tissue (n=28)	363.10	[e]NA	NA
			29/07/98	Female	whole soft tissue (n=30)	227.89	NA	NA
Goby	Incheon North Harbor	B1	14/08/98	129 +/- 5	muscle	221.10	6.07	3.64
			14/08/98		gut	2,385.13	9.44	25.26
			14/08/98		liver	4,676.14	7.02	66.65
			14/08/98	164 +/- 10	muscle	238.38	5.93	4.02
			14/08/98		gut	1,182.12	2.58	45.79
			14/08/98		liver	3,842.94	5.52	69.63

[a]Length (mm)
[e]NA = Not Analyzed

<Table III-22> Distribution of organochlorine pesticides and PCBs in bivalves collected from Chunsoo Bay (ng/g dry wt), 1998

	Mussel (3 sites)			Oyster (4 sites)			Short-neck clam (7 sites)		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
pentachlorobenzene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
α–HCH(Hexachlorohexane)	0.00	1.64	0.41	0.00	2.15	0.54	0.41	0.41	0.41
HCB(hexanchlorobenzene)	0.00	0.55	0.14	0.00	0.00	0.00	0.14	0.14	0.14
pentachloroanisole	0.00	0.60	0.30	0.00	0.29	0.12	0.30	0.30	0.30
β-HCH	1.69	12.71	4.77	0.00	0.00	0.00	4.77	4.77	4.77
PCB 52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PCB 44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heptachlor epoxide	0.00	0.91	0.28	0.00	0.00	0.00	0.28	0.28	0.28
PCB 101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
α-Chlordane	0.00	1.52	0.38	0.00	0.00	0.00	0.38	0.38	0.38
trans - nonachlor	0.00	1.25	0.59	0.00	0.00	0.00	0.59	0.59	0.59
Dieldrin	0.00	0.72	0.18	0.00	0.00	0.00	0.18	0.18	0.18
p,p' - DDE	0.00	2.93	1.76	0.00	2.10	1.22	1.76	1.76	1.76
o,p' - DDD	0.39	2.98	1.18	0.00	2.35	0.88	1.18	1.18	1.18
PCB 118	0.00	0.52	0.13	0.00	0.00	0.00	0.13	0.13	0.13
cis - nonachlor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P,p' - DDD	0.00	1.48	0.63	0.00	0.00	0.00	0.63	0.63	0.63
o,p' - DDT	0.00	0.27	0.07	0.00	0.00	0.00	0.07	0.07	0.07
PCB 153	0.00	0.89	0.56	0.67	6.35	2.74	0.56	0.56	0.56
p,p' - DDT	0.00	2.66	0.67	0.00	4.29	1.07	0.67	0.67	0.67
PCB 138	0.00	1.43	1.00	0.00	0.00	0.00	1.00	1.00	1.00
PCB 187	0.00	0.00	0.00	0.00	0.96	0.24	0.00	0.00	0.00
PCB 180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PCB 195	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PCB 206	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total PCBs	0.52	2.33	1.69	0.67	6.35	2.98	1.69	1.69	1.69

<Table III-23> Distribution of PCDD/Fs in mussels collected from coastal areas

	PCDDs	PCDFs	PCDD/Fs	TEQ
Manlipo	2.41	0.94	3.35	0.03
Daecheon	1.71	3.22	4.93	0.02
Janghang	6.83	3.98	10.81	0.01
Kunsan	12.0	18.0	30.0	0.30
Mokpo	6.45	1.32	7.77	0.02

Contamination levels in water and sediments

<Table III-24> Variation of pH in the coastal areas of the Yellow Sea

	Incheon	Asan	Daecheon	Kunsan	Mokpo
1990	8.0	8.0	-	7.6	8.0
1991	8.1	8.1	8.2	8.0	8.0
1992	8.0	8.0	8.1	7.8	7.9
1993	7.9	8.0	8.1	7.7	7.8
1994	8.0	7.7	7.9	7.8	8.0
1995	8.0	7.8	7.9	7.9	8.0
1996	7.9	8.1	8.2	8.0	8.0
1997	7.9	7.9	8.1	8.1	8.1

Ministry of Environment of ROK, 1998. Environmental Statistics Yearbook

<Table III-25> Variation of dissolved oxygen (DO) in the coastal areas of the Yellow Sea (mg/L)

	Incheon	Asan	Daecheon	Kunsan	Mokpo
1990	7.8	8.2	-	7.8	9.1
1991	7.7	6.1	7.9	6.4	9.3
1992	8.4	8.2	8.7	7.3	8.8
1993	8.1	8.5	8.2	8.0	9.3
1994	6.1	8.5	8.8	7.9	8.3
1995	8.9	9.0	9.1	8.3	9.2
1996	6.9	7.5	7.7	7.7	9.5
1997	7.9	7.3	6.5	8.3	7.9

Ministry of Environment of ROK, 1998. Environmental Statistics Yearbook

<Table III-26> Variation of total nitrogen (T-N) in the coastal areas of the Yellow Sea (mg/L)

	Incheon	Asan	Daecheon	Kunsan	Mokpo
1990	0.499	0.158	-	2.369	0.312
1991	0.824	0.219	0.225	0.335	0.198
1992	1.449	0.220	0.230	0.328	0.224
1993	1.555	0.568	0.729	0.731	0.275
1994	1.217	0.777	0.814	1.200	0.314
1995	0.762	0.782	0.628	0.973	0.611
1996	0.756	0.353	0.200	0.688	0.310
1997	0.515	0.233	0.121	0.471	0.077

Ministry of Environment of ROK, 1998. Environmental Statistics Yearbook

<Table III-27> Variation of total phosphorus (T-P) in the coastal areas of the Yellow Sea (mg/L)

	Incheon	Asan	Daecheon	Kunsan	Mokpo
1990	0.050	0.003	-	0.017	0.028
1991	0.047	0.004	0.006	0.019	0.008
1992	0.055	0.009	0.006	0.018	0.023
1993	0.013	0.009	0.002	0.019	0.020
1994	0.014	0.038	0.021	0.031	0.040
1995	0.035	0.018	0.050	0.055	0.019
1996	0.026	0.038	0.041	0.044	0.008
1997	0.025	0.009	0.009	0.025	0.009

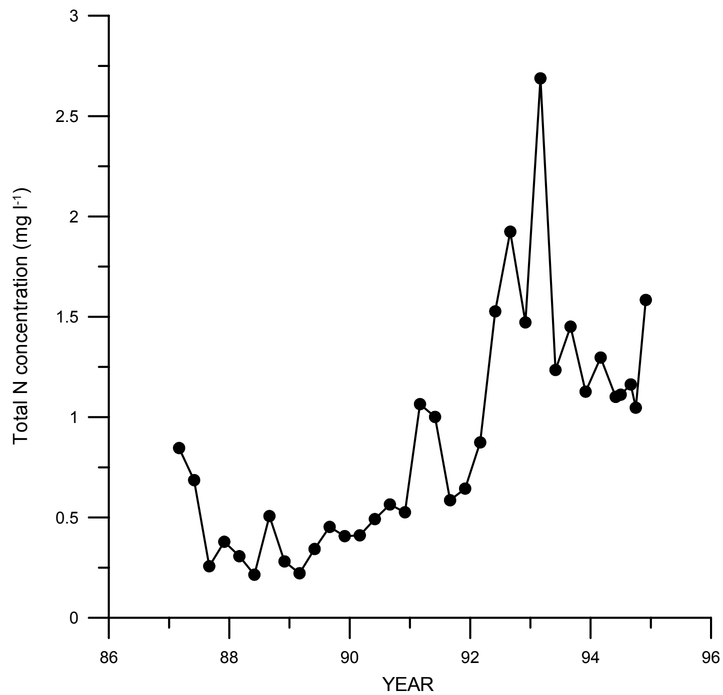
Ministry of Environment of ROK, 1998. Environmental Statistics Yearbook

<Table III-28> Range and average concentrations of dissolved metals in the surface waters from Shiwha, Asan, Kunsan, and Mokpo, west coast of ROK

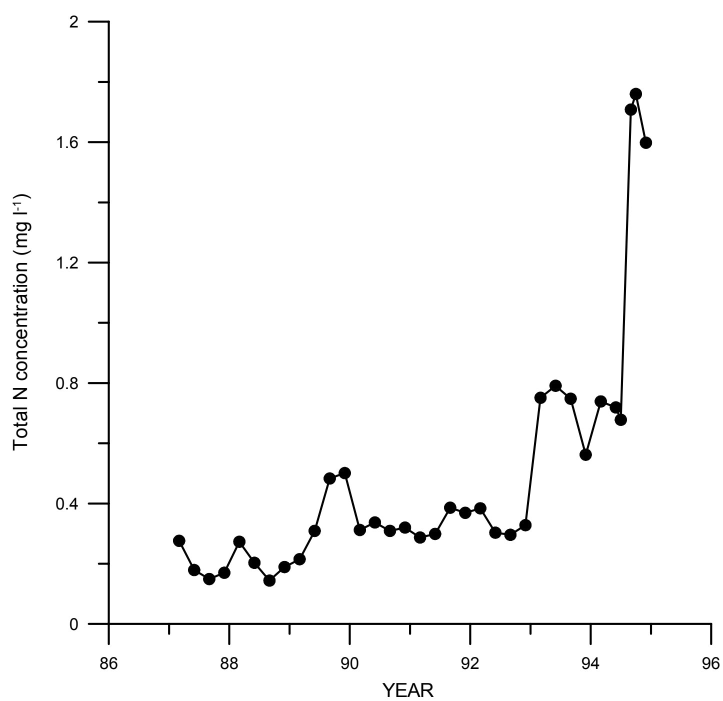
Area	*sampling period*	Cu (μg/l)	Zn (μg/l)	Cd (μg/l)	Pb (μg/l)
Shiwha	Jul-96[1]	0.42-0.79(0.61)	0.37-1.66(0.70)	0.018-0.028(0.022)	0.024-0.086(0.046)
Asan	1991-1992[2]	0.23-1.15(0.61)	0.06-0.99(0.25)	0.013-0.050(0.030)	0.011-0.169(0.034)
Kunsan	Apr-92[3]	0.59-0.10(0.78)	0.19-0.55(0.34)	0.019-0.030(0.024)	0.024-0.053(0.037)
	May-94[4]	0.52-1.59(1.23)	0.17-0.83(0.51)	0.018-0.031(0.025)	0.021-0.150(0.091)
	Apr-96[5]	0.68-1.17(0.89)	0.34-1.69(0.82)	0.012-0.026(0.019)	0.015-0.072(0.029)
Mokpo	Feb-94[4]	0.21-1.04(0.42)	0.09-3.78(0.76)	0.010-0.021(0.013)	0.019-0.059(0.033)

1: KORDI (1997), 2: KORDI (1993), 3: KORDI (1992), 4: KORDI (1994), 5: KORDI (1996)

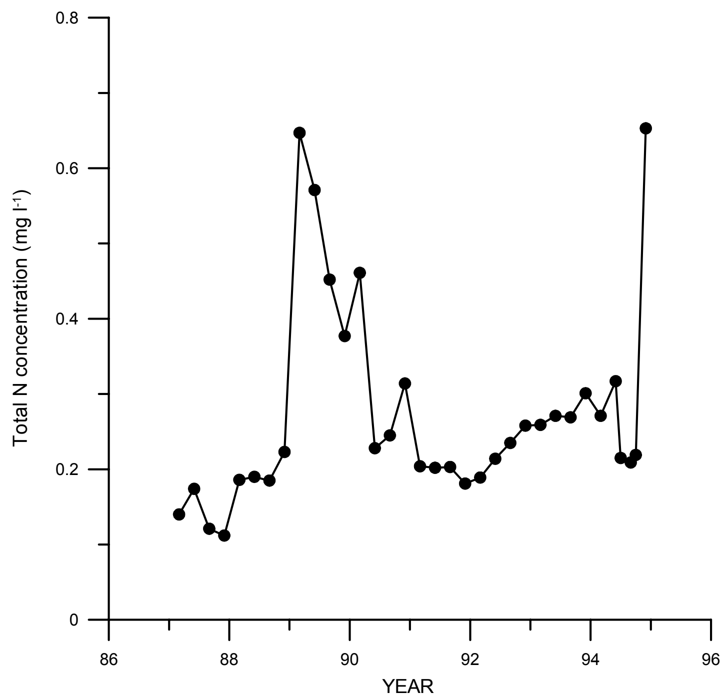
<Fig. III-3> Annual variation of total N concentration in coastal waters adjacent to Incheon



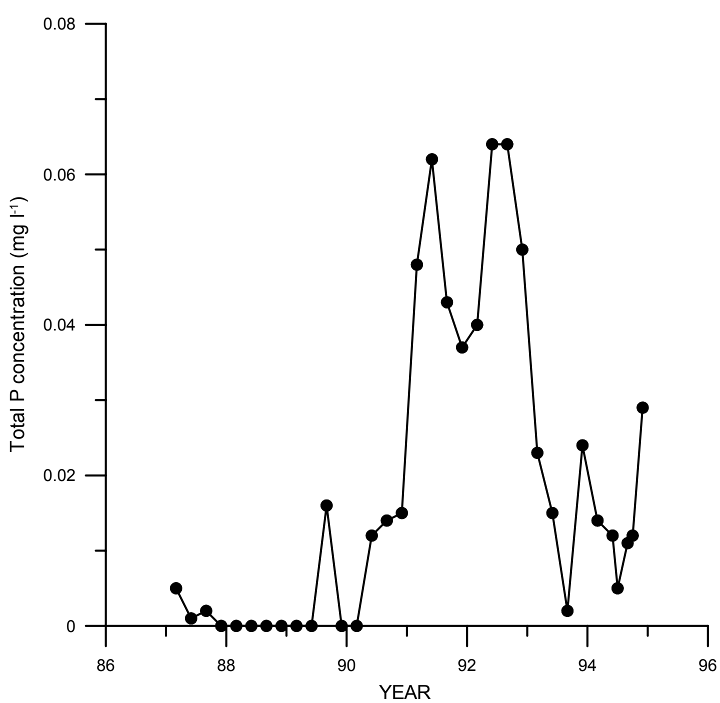
<Fig. III-4> Annual variation of total N concentration in coastal waters adjacent to Kunsan



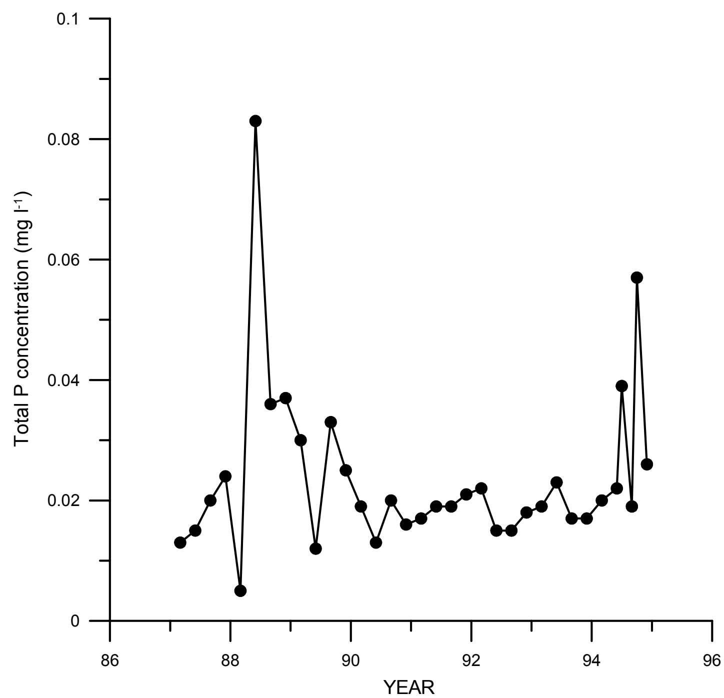
<Fig. III-5> Annual variation of total N concentration in coastal waters adjacent to Mokpo



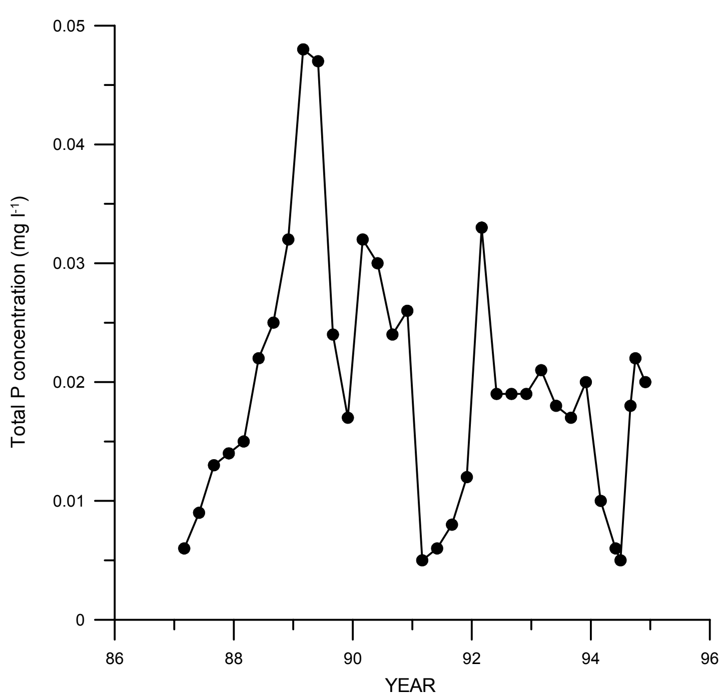
<Fig. III-6> Annual variation of total P concentration in coastal waters adjacent to Incheon



<Fig. III-7> Annual variation of total P concentration in coastal waters adjacent to Kunsan



<Fig. III-8> Annual variation of total P concentration in coastal waters adjacent to Mokpo



<Table III-29> Range and concentrations of trace metals in the Yellow Sea including seasonal variation of trace metal levels (μg/l)

	Sampling period	Cu	Zn	Cd	Pb	state	n[7]
Range and mean concentration	1991-1996[1]	0.22-0.53(0.37)	0.06-0.22(0.15)	0.01-0.05(0.03)	0.02-0.16(0.05)	diss[6]	
	1995-1997[2]	0.30-0.75 (0.52)		0.015-0.041(0.03)	<0.005-0.041(0.012)	diss	
	Feb-86[3]	0.25-0.61 (0.40)	0.11-0.93(0.28)	0.017-0.045 (0.031)		total	
Seasonal variation[4]	May-95	0.50-0.75 (0.60)		0.031-0.041 (0.036)	<0.005-0.017 (0.010)	diss	12
	Jun-96	0.30-0.66 (0.50)		0.015-0.041 (0.034)	<0.005-0.041 (0.019)	diss	15
	Oct-97	0.41-0.66 (0.51)		0.020-0.033 (0.026)	<0.005-0.026 (0.012)	diss	13
	Nov-95	0.30-0.59 (0.40)		0.018-0.034 (0.026)	0.005-0.024 (0.015)	diss	15
Ocean Margin[5]		0.090-0.278 (0.184)	0.12-0.39(0.25)	0.007-0.022 (0.015)		diss	

1: Lee et al. (1998), 2: Choi (1998), 3: Lee (1988), 4: Choi (1998), 5: Martin and Thomas (1994), range and mean concentrations in the ocean margin (coastal samples are excluded), 6: dissolved, 7: number of samples

<Table III-30> PCB contamination in surface sediments from various region (ng/g dry wt)

Location	T-PCBs conc.	Sampling Year	Sample No.
Kyeonggi Bay	<0.99-580	1995	54
	5.4-491.8	1998	17
Namyang Bay	<0.99-2.5	1996	5
Lake Shihwa	2.7-28	1996	4
Kwangyang Bay	4-60.7	1995	6

< Table III-31> Concentrations of PAHs in surface sediments in the Coastal areas of the Yellow Sea (1998)

	Janghang	Kunsan-1	Kunsan-2	Manlipo	Mokpo	Chunsoo Bay (12 Stn) Min	Max	Avg
Naphthalene	nd	7.21	5.26	nd	nd	7.80	73.73	20.16
2-Methylnaphthalene	3.48	8.68	6.02	14.80	19.53	8.03	83.68	23.25
1-Methylnaphthalene	1.08	0.00	0.00	nd	13.77	4.04	48.99	10.27
Biphenyl	9.12	10.62	10.19	36.26	8.93	2.54	25.18	7.40
2,6-Dimethylnaphthalene	4.36	4.56	2.90	19.37	21.10	3.43	40.81	10.67
Acenaphthylene	nd	nd	nd	nd	8.26	nd	4.35	0.55
Acenaphthene	nd	nd	nd	nd	10.37	nd	5.84	0.97
2,3,5-Trimethylnaphthalene	nd	2.86	1.71	3.24	0.00	nd	2.29	0.66
Fluorene	2.82	4.93	5.56	9.55	15.69	3.20	28.41	9.19
Phenanthrene	nd	9.81	3.02	13.05	18.45	6.35	66.96	18.08
Anthracene	nd	5.75	1.14	9.77	9.46	1.16	34.61	5.08
1-Methylphenanthrene	1.38	7.93	2.02	3.12	15.36	0.85	24.52	3.90
Fluoranthene	10.30	41.08	14.91	33.73	143.56	1.39	62.24	10.04
Pyrene	7.52	34.97	13.85	25.82	155.76	1.64	49.50	8.68
Benz[a]anthracene	3.53	14.68	3.87	14.33	121.08	0.52	26.16	3.82
Chrysene	4.02	13.06	4.07	16.27	64.73	0.50	44.45	5.82
Benzo[b]fluoranthene	6.94	15.63	9.63	29.27	152.33	1.15	32.70	6.25
Benzo[k]fluoranthene	4.79	14.51	9.09	23.20	133.26	nd	13.52	2.84
Benzo[e]pyrene	3.98	9.17	7.94	18.62	120.39	0.76	23.01	3.88
Benzo[a]pyrene	3.17	10.96	8.82	19.69	207.18	nd	25.35	4.87
Perylene	nd	nd	2.29	2.90	9.17	nd	14.07	1.44
Indeno[1,2,3-cd]pyrene	3.29	5.28	4.71	9.79	112.00	nd	20.69	4.18
Dibenz[a,h]anthracene	1.23	1.88	1.89	4.12	31.78	nd	6.62	0.82
Benzo[ghi]perylene	3.18	6.46	4.79	9.92	104.60	nd	22.29	4.42
Total PAHs	74.22	230.04	123.67	316.82	1496.77	44.70	777.68	167.08

<Table III-32> Comparison of organochlorine contamination in surface sediments collected from various region(ng/g dry wt)

Location (Year)	T-HCHs	T-CHLs	T-DDTs
Kyeonggi Bay (Dec. 1995)	<0.19-1.2	<0.065-130	<0.046-32
Namyang Bay (Feb. 1996)	<0.19-0.67	<0.065-0.40	0.088-0.38
Lake Shihwa (Feb. 1996)	0.59-2.4	0.10-0.92	0.62-2.3

People's Republic of China

Similar information is available from the PRC shore of the Yellow Sea, though not entirely equivalent. PRC has performed a preliminary analysis of land-based sources of pollution, separated by City or Province (Table III-33 through III-35). Water quality assessments for nutrients and other parameters are available for selected areas (Tables III-36 to III-38), whereas tissue concentrations in marine biota are presented in Tables III-39 to III-43. A summary of pollutant concentration trends in the Bohai and Yellow seas from the databases from 1990 to 1997 show, for the Yellow Sea, increases in mercury and arsenic, but decreases in cadmium, lead, PCBs, DDTs, and petroleum hydrocarbons.

Inventory of Land-based Pollution Sources

<Table III-33> Discharge and treatment of industrial wastewater by major coastal areas along Yellow Sea coast (Unit: $\times 10^4$ t)

City Or Province	Total volume of industrial Wastewater Discharge	Direct to Sea	Include					
			Treated	Rate of Treatment □%□	Up to discharge Standard	Rate up-too Standard□ %□	Treated up to Standard	Treated up to Standard Rate□% □
Tianjin	20446	803	394087	94.80	15157	74.1	4798	12.2
Hebei	80826	3060	158587	90.26	57062	70.6	24342	15.4
Liaoning	124544	23896	155617	85.60	84184	67.6	35394	22.7
Jiangsu	219677	3478	139416	74.95	151859	69.1	46618	33.4
Shandong	101018	7873	204184	85.03	47849	47.4	24459	12.0

Refer to China Marine Statistical Yearbook 1997, China Ocean Press 1997

<Table III-34> Industrial wastewater and contaminants discharged in coastal cities(1996)

city	Volume into the sea (10^4t)	Discharge of contaminants in industrial wastewater(t)							
		Hg	Cd	Cr(VI)	Pb	As	Oil	COD	TSP
Dalian	22068			0.62	0.01	0.79	726.11	20618	34250
Yantai	2575	0.01	0.09	1.15	0.20	1.05	85.12	61273	14536
Qingdao	4539	0.11	0.01	3.53	0.19	6.19	150.11	51682	20329
Lianyungang	1721			0.01		11.69	14.02	22467	9968

<Table III-35> Industrial solid wastes generated in coastal cities(1996, unit: 10^4t)

city	Total Amount	In which						
		Harmful wastes	Smelt dregs	Coal ash	Cinder	Gangue	Tailings	Others
Dalian	232		14	65	61		19	72
Yantai	664		15	97	40	39	425	48
Qingdao	338	2	18	131	73		27	87
Lianyungang	129		6	50	20		11	43

<Table III-36> Inorganic N in coastal seawater of Jiangsu Province

Year	1993	1994	1995
Rates exceeding standards(%)	51	76	78
Standardized index	1.45	1.47	2.90

<Table III-37a> Assessment of water quality in Qinghai Bay

Items	Salinity	pH	COD (mg/l)	P (•mg/l)	N (•mg/l)	Oil (mg/l)	Hg (mg/l)
Means	31.268	8.16	0.87	0.029	0.013	0.013	0.0002
Pollution index		0.47	0.29	1.93	0.13	0.26	0.40

<Table III-37b> Assessment of water quality in Rushan Bay

Items	Means	Pollution Index
Salinity	31.436	
PH	8.09	0.31
DO (mg/l)	7.02	0.71
COD (mg/l)	0.78	0.26
P (•mg/l)	0.0096	0.64
N (•mg/l)	0.082	0.82
Oil (mg/l)	0.037	0.74
Cd (mg/l)	0.00004	0.01
Pb (mg/l)	0.0097	0.19

<Table III-37c> Assessment of water quality in Dingzi Bay

Items	Means	Pollution Index
Salinity	28.932	
PH	8.09	0.31
DO (mg/l)	8.36	0.60
COD (mg/l)	0.70	0.23
P (•mg/l)	0.016	1.07
N (•mg/l)	0.036	0.36
Oil (mg/l)	0.021	0.42
Cd (mg/l)	0.0001	0.02
Pb (mg/l)	0.00886	0.18

<Table III-37d> Assessment of water quality in Bei Bay

Items	Means	Pollution Index
Salinity	30.72	
PH	8.11	0.36
DO (mg/l)	7.66	0.65
COD (mg/l)	0.58	0.19
P (•mg/l)	0.0078	0.52
N (•mg/l)	0.0017	0.02
Oil (mg/l)	0.009	0.18
Cd (mg/l)	0.00005	0.01
Pb (mg/l)	0.009	0.18

<Table III-37e> Assessment of water quality in Jiaozhou Bay

Items	Jan.	May	Sep.
PH	8.27-8.26	7.99-8.08	8.15-8.12
DO	11.34-10.54	7.10-8.36	7.39-7.03
COD	1.11-1.68	2.13-1.17	1.65-0.76
N	0.113-0.138	0.154-0.038	0.101-0.019
Oil	0.48	0.081	0.034
Hg		$2.4x10^{-5}$	$2.5x10^{-4}$
Pb	0.025	0.020	0.027
Cd	$1.8x10^{-4}$	$4.2x10^{-4}$	$1.0x10^{-4}$
Cr	$5.8x10^{-3}$	$3.5x10^{-3}$	$2.1x10^{-3}$
Phenol	$2.5x10^{-3}$	$3.1x10^{-3}$	$6.7x10^{-3}$
666	$3.8x10^{-5}$	$1.2x10^{-4}$	$1.2x10^{-4}$

<Table III-37f> Assessment of water quality in Tangdao Bay

Items	Means	Pollution Index
Salinity	30.003	
PH	8.24	
DO (mg/l)	6.86	0.73
COD (mg/l)	0.99	0.33
P (•mg/l)	0.002	0.13
N (•mg/l)	0.006	0.06
Oil (mg/l)	0.023	0.46
0.92	0.00046	
Cd (mg/l)	0.0001	0.02
Pb (mg/l)	0.01	0.2

<Table III-37g> Assessment of water quality in Cuijialu Bay

Items	Means	Pollution Index
Salinity	31.530	
PH	8.15	
DO (mg/l)	9.24	0.54
COD (mg/l)	0.97	0.32
P (•mg/l)	0.01	0.67
N (•mg/l)	0.006	0.06
Oil (mg/l)	0.025	0.5
Cd (mg/l)	0.00006	0.012
Pb (mg/l)	0.007	0.14

<Table III-37h> Assessment of water quality in Chenjiagong Inner Bay April

Items	Means	Pollution Index
Salinity	31.307	
PH	7.99	
DO (mg/l)	8.84	0.57
COD (mg/l)	1.00	0.27
P (•mg/l)	0.004	0.20
N (•mg/l)	0.02	0.36
Oil (mg/l)	0.018	0.002
Cd (mg/l)	0.00001	0.14
Pb (mg/l)	0.007	0.10

<Table III-38> Monitoring results in coastal waters of Dalian City □mg/l□

Areas	**Dalian Bay**				**South Sea Area**			
Items	N	Oil	COD	P	N	Oil	COD	P
1995	0.724	0.075	0.81	0.016	0.198	0.048	1.23	0.0361
1996	1.1	0.055	1.09	0.0129	0.229	0.029	1.13	0.0226

Residue levels of pollutants in organisms

<Table III-39> The mean contents of heavy metals in organisms from Yellow Sea

Species or class	Mean concentration□10^{-6}wet weight□			
	Hg	Cd	Pb	As
Ruditapes philippniensis	0.008	0.14	0.12	0.489
Scapharca subcrenata	0.008	1.14	0.12	0.397
Shellfish	0.011	0.56	0.11	0.423
Ulva pertuna	0.006	0.04	0.27	0.370
Fish	0.024	0.02	0.08	0.340

<Table III-40> The mean contents of petroleum hydrocarbons in organisms from Yellow Sea

Organism	**Mean concentration□10-^{6}wet weight□**
Ruditapes philippniensis	20□4
Scapharca subcrenata	13□7
Shellfish	19□5
Fish	2□01

<Table III-41> Contents of PAHs in shellfish, fish and alga from Yellow Sea

G. Pollutants	Mean concentration□10^{-9}wet weight□		
	shellfish	**Fish**	*Ulva pertuna*
naphthalene	1.7	6.1	2.5
fluorene	1.0	2.0	0.7
phenanthrene	3.3	3.5	3.5
anthene	2.0	1.5	2.5
fluoranthene	4.2	1.4	1.7
pyrene	3.9	0.7	3.1
chrysene	39.4	-	21.2
benzo(a)anthracene	82.7	-	-
benzo(a)pyrene	-	-	-
benzo(e)pyrene	-	-	-
PAHs	22.0	13.2	18.9

<Table III-42> Mean concentrations of DDT and PCBs in organisms from Yellow Sea□10-^{9}wet weight□

Organisms	DDTs	PP'-DDE	PP'-DDT	PP'-DDD	OP'-DDT	PCB
Ruditapes philippniensis	6.1683	0.7393	3.6 362	2.7228	0.0874	1□6331
Scapharca subcrenata	1.0486	0.8391	0.2489	0.2805	0.2320	5□2587
Shellfish	16.9342	1.3370	1.5650	1.5848	1.4646	1□8243
Fish	8.2660	2.3527	1.6233	4.7879	0.3067	0□9346

<Table III-43> The rates over standard of pollutant contents in shellfish and fish from Yellow Sea

Pollutant	**Organism**	**standard[1)] □10^{-6}wet weight□**	**The rates over standard□%□**
Hg	Shellfish	0.3	0
	Fish	0.3	0
Cd	Shellfish[2)]	2.0	Some exceeding standard
	Fish	0.1	0
Pb	Shellfish	1.0	0
	Fish	1.0	0
As	Shellfish	1.0	0
	Fish	0.5	0
DDTs	Shellfish	0.1	Some exceeding standard
	Fish	0.1	Some exceeding standard
PCBs[3)]	Shellfish	0.1	0
	Fish	0.1	0
Petroleum hydrocar-bons[4)]	Shellfish	20	Some exceeding standard
	Fish	20	0

Note:1□□China food standard□2□WHO food standard□3□IJC Aquatic Life Guideline□4□□Project of organism qualities(No. 3 marine institute SOA)

<Table III-44> The results of t-test from the database of 1997 and 1990 of Bohai and Yellow Sea

Pollutant	Bohai and Yellow Sea	Yellow Sea
Hg	Decreased	Increased
Cd	Decreased	Decreased
Pb	Significantly increased □α=0.05□	Decreased
As	Significantly increased □α=0.05□	Significantly increased □α=0.05□
PCBs	Decrease	Decreased
DDTs	Decreased	Decreased
Petroleum hydrocarbons	Decreased	Decreased

Area IV. Water Quality and Human Health

Republic of Korea

Water quality and human health is less of a transboundary issue in the Yellow Sea. However, some data are presented in this Preliminary TDA to demonstrate the general quality indicators. In the ROK, beach monitoring for various years from 1996 through 1999 are presented, including COD, ammonia, and suspended solids (Table IV-1). Pesticides in food are shown in Tables IV-2 to IV-5. Trace metals in food are shown in Table IV-5.

<Table IV-1> National wide beach water quality investigation for four years (KFEM, 96-99)

Beach	COD(mg/l)					NH3-N(mg/l)					SS(mg/l)				
	96'	97'	98'	99'	M	96'	97'	98'	99'	M	96'	97'	98'	99'	M
Taechun	1.2	2.4	4.6	1.0	**2.3**	0.03	0.48	0,45	0.03	**0.24**	2	12	7	17	**9**
Manripo	0.4	5.2	3.4	1.4	**2.6**	0.02	0.05	0.06	0.01	**0.03**	4	22	4	6	**9**
Mongsanpo	1.8	4.6	4.4	1.4	**3.0**	0.03	0.28	0.13	0.01	**0.11**	3	25	8	6	**10**
Pyunsan	1.6	5.6	4.6	2.4	**3.5**	0.02	0.17	0.22	0.06	**0.26**	3	11	9	10	**8**
Kyeogpo	2.0	9.0	2.4	1.8	**3.8**	0.03	0.41	0.06	0.01	**0.12**	4	7	7	6	**6**
West Sea Mean	**1.4**	**5.3**	**3.8**	**1.6**	**3.0**	**0.02**	**0.27**	**0.18**	**0.02**	**0.12**	**3**	**15**	**7**	**9**	**8**
Songjung	0.8	2.6	1.6	2.2	**2.2**	0.01	0.06	0.06	0.32	**0.11**	3	8	5	6	**5**
Kwanganri	1.6	3.6	2.4	2.2	**2.2**	0.03	0.17	0.28	0.11	**0.14**	4	21	16	7	**12**
Haeundae	1.4	4.8	2.4	2.4	**2.4**	0.02	0.52	0.10	0.14	**0.19**	3	13	5	8	**7**
Yulpo	1.4	4.6	0.8	1.4	**2.0**	0.05	0.09	1.59	0.42	**0.53**	4	11	15	3	**8**
Daekwang	1.0	1.6	3.6	3.0	**3.0**	0.10	0.18	0.01	0.04	**0.08**	3	14	11	6	**8**
Sangju	1.8	2.8	3.2	1.0	**1.0**	0.01	0.91	0.05	0.07	**0.26**	3	4	6	7	**5**
Wahyun	1.8	2.6	2.0	2.4	**2.4**	0.02	0.23	0.04	0.19	**0.12**	4	4	4	5	**4**
Hakdong	0.6	1.2	2.0	1.2	**1.2**	0.02	0.04	0.13	0.11	**0.07**	2	4	7	7	**5**
Narodo	3.2	8.4	1.2	2.4	**2.4**	0.07	0.38	0.09	0.25	**0.19**	5	15	5	8	**8**
Namildae	2.6	7.6	4.8	1.8	**1.8**	0.15	0.29	0.09	0.05	**0.14**	5	18	8	5	**9**
South Sea Mean	**1.6**	**3.9**	**2.2**	**2.0**	**2.4**	**0.04**	**0.28**	**0.24**	**0.17**	**0.18**	**3**	**11**	**8**	**6**	**7**
Jungmun	1.0	1.2	2.4	1.0	**1.4**	0.02	1.5	0.08	0.04	**0.42**	3	5	10	8	**6**
Hamduk	1.6	2.0	2.4	1.2	**1.8**	0.03	0.35	0.10	3.99	**1.11**	2	8	9	8	**6**
Hyupjae	1.2	1.0	1.6	1.8	**1.4**	0.03	0.56	0.06	0.14	**0.19**	3	10	8	7	**7**
Pyosun	1.4	1.0	3.6	1.6	**1.9**	0.01	0.50	0.15	0.03	**0.17**	3	4	5	6	**4**
Cheju Mean	**1.3**	**1.3**	**2.5**	**1.2**	**1.5**	**0.02**	**0.74**	**0.10**	**1.05**	**0.47**	**3**	**7**	**8**	**7**	**6**
Ilsan	0.4	3.8	5.6	2.4	**3.0**	0.01	1.92	0.33	0.07	**0.58**	2	15	8	6	**7**
Hwajinpo	2.4	1.6	1.2	2.0	**1.8**	0.01	0.12	0.06	0.02	**0.05**	5	6	5	6	**5**
Naksan	1.0	3.2	0.8	1.4	**1.4**	0.02	0.20	0.07	0.16	**0.11**	4	8	6	8	**6**

Hachodae	2.0	2.4	1.6	1.6	**1.9**	0.04	0.31	0.05	0.25	**0.16**	3	13	11	2	**7**
Kyeonpodae	2.0	1.6	0.8	1.0	**1.3**	0.04	0.59	0.15	0.12	**0.22**	3	4	6	16	**7**
Okgye	0.4	3.4	1.6	1.6	**1.7**	0.04	0.14	0.07	0.28	**0.13**	3	6	5	4	**4**
Mangsang	0.6	2.4	2.0	1.2	**1.5**	0.06	0.20	0.11	0.13	**0.11**	3	7	13	7	**7**
Maengbang	0.6	1.4	1.6	1.8	**1.3**	0.01	0.51	0.25	0.05	**0.20**	3	5	5	7	**5**
Taejin	1.8	1.4	0.4	1.8	**1.3**	0.04	0.13	0.06	0.05	**0.07**	3	4	5	6	**4**
Kwansung						0.03	1.33	0.07	0.04	**0.36**	2	12	3	8	**6**
Jinha						0.04	0.17	0.09	0.09	**0.09**	3	16	4	8	**7**
East sea Mean	**1.2**	**2.4**	**1.7**	**1.6**	**1.7**	**0.03**	**0.51**	**0.12**	**0.11**	**0.19**	**3**	**9**	**6**	**7**	**6**
Total mean	**1.1**	**3.2**	**2.6**	**1.5**	**2.1**	**0.03**	**0.45**	**0.18**	**0.32**	**0.24**	**3**	**11**	**7**	**7**	**7**

<Table IV-2> Pesticides residues detected in domestic products

Pesticide	Domestic products (no. of detection)	Range & Avg. (ppm)
carbaryl	rice (1), potato (1), soy bean (1), red bean (1), garlic (1), radish (1), chinese cabbage (1) and grape (1)	0.001-0.007 0.002
isoprocarb	Barley (3), red bean (3), rice (2), radish (2), chinese cabage (2), tomato (2), potato (1), green bean (1), red pepper (1), carrot (1), garlic (1), water melon (1) and grape (1)	0.001-0.019 0.004
carbofuran	soy bean (3), red bean (2), red pepper (2), garlic (2), pumpkin (2), rice (1), potato (1), sweet potato (1), carrot (1), spinach (1), tomato (1) and grape (1)	0.001-0.011 0.002
aldicarb	green bean (4), barley (3), carrot (3), garlic (3), tomato (3), orange (3), water melon (3), grape (3), rice (2), soy bean (2), green bean (1), onion (1), cucumber (1) and apple (1)	0.001-0.027 0.004
oxamyl	grape (4), carrot (2), green bean (1), radish (1), spinach (1), onion (1), pumpkin (1), persimmon (1) and orange (1)	0.001-0.021 0.005
ethiofencarb	barley (9), rice (4), red bean (4), garlic (3), sweet potato (2), pumpkin (2), apple (2), grape (2), potato (1), soy bean (1), red pepper (1), carrot (1), radish (1), lettuce (1), spinach (1), tomato (1), orange (1) and peach (1)	0.001-0.007 0.002
pirimicarb	red pepper (3), orange (3), spinach (1), peach (1), grape (1)	0.010-0.248 0.048
cyhalothrin	peach (3), red pepper (1), carrot (1) and onion (1)	0.002-0.066 0.029

cypermethrin	soy bean (5), lettuce (4), chinese cabbage (3), tomato (3), peach (3), barley (2), red bean (1), spinach (1) and cucumber (1)	0.001-0.075 0.016
permethrin	onion (5), red pepper (1), carrot (1), garlic (1), orange (1), water melon (1) and grape (1)	0.013-0.0125 0.046
deltamethrin	rice (7), chinese cabbage (3), lettuce (3) and apple (1)	0.021-0.052 0.027
bendiocarb	grape (3), garlic (3), water melon (2) rice (1), sweet potato (1), red bean (1), chinese cabbage (1) and red pepper (1)	0.001-0.015 0.003

<Table IV-3> Pesticides residues detected in imported products

Pesticide	Imported products (no. of detection)	Range & Avg. (ppm)
carbaryl	Banana (3), grape fruit (2), oat (1), lemon (2), almond (1), orange (1) and pineapple (1)	0.001-0.182 0.038
isoprocarb	wheat (3), grape fruit (2), lemon (1), banana (1), almond (1), orange (1), and pineapple (1)	0.001-0.135 0.017
carbofuran	Pineapple (3), lemon (2), banana (2), grape fruit (2) and almond (2)	0.001-0.007 0.002
aldicarb	Orange (4), lemon (3), pineapple (3), kiwi fruit (2), wheat (1) and almond (1)	0.001-0.254 0.029
oxamyl	Wheat (1)	0.001
ethiofencarb	grape fruit (5), banana (3), wheat (3), lemon (3), almond (3), orange (3), pineapple (3) and kiwi fruit (1)	0.001-0.130 0.018
cypermethrin	Almond (4), mango (1), lemon (1), kiwi fruit (1) and pineapple (1)	0.017-0.406 0.085
permethrin	Mango (1) and kiwi fruit (1)	0.028-0.072 0.050
bendiocarb	grape fruit (4), orange (3), lemon (2), pineapple (2), banana (2), wheat (1), mango (1), kiwi fruit (1) and almond	0.001-0.037 0.008

<Table IV-4> Maximum level of pesticide residue level found in ROK

Pesticide	Max level (ppm)	Year	Source
alpha-BHC	0.0155	1977	KFDA
gamma-BHC	0.015	1970, 1971	KFDA
total BHC	0.03326	1973	KFDA
Heptachlor epoxide	0.002	1972	KFDA
Endrin	0.002	1972	KFDA
Dieldrine	0.0005	1972	KFDA
Aldrin	0.004	1972	KFDA
DDT	0.006	1993	KFDA
Diazinon	0.086	1989	NIAST
MEP	0.1626	1983	KFDA
Malathion	0.090	1988	KFDA
EPN	0.083	1988	KFDA
MPP	0.0972	1988	KFDA
PAP	0.0625	1983	KFDA
Dimethoate	0.0494	1988	KFDA
Captan	0.1143	1991	KFDA
NAC	0.836	1989	KFDA
Folpet	0.014	1991	KFDA
Carbofuran	0.001	1995	KFDA
Methyl bromide	0.58	1991	KFDA
Tiophanate-methyl	0.005	1991	KFDA
Isoprothiolan	1.14	1995	NIAST
Tricyclazole	1.36	1995	NIAST
Edifenphos	0.13	1995	NIAST
IBP	0.09	1995	NIAST
BPMC	1.00	1995	NIAST
Fenobucarb(BPMC)	0.019	1996	UNU

<Table IV-5> Range and mean values of trace metals in cereals, pulses, potatoes, vegetables and fruits in ROK

sample	No. of sample	Metal	Minimum value(mg/kg)	Maximum value(mg/kg)	Mean value(mg/kg)
Rice	20	Hg	0.002	0.005	0.004
		Pb	0.02	0.31	0.11
		Cd	0.009	0.044	0.026
		As	0.31	1.89	1.05
		Cu	0.03	0.21	0.1
		Mn	1.27	9.21	4.52
		Zn	2.38	11.36	6.61
Barley	20	Hg	0.001	0.003	0.002
		Pb	0.04	0.25	0.13
		Cd	0.008	0.041	0.021
		As	0.53	4.08	1.68
		Cu	0.03	0.24	0.09
		Mn	2.14	12.08	6.81
		Zn	3.03	18.77	10.18
Wheat	20	Hg	0.001	0.004	0.002
		Pb	0.03	0.27	0.12
		Cd	0.007	0.053	0.021
		As	0.41	4.01	1.66
		Cu	0.03	0.26	0.12
		Mn	3.14	11.63	6.57
		Zn	3.27	16.23	8.27
Green bean	20	Hg	0.001	0.004	0.003
		Pb	0.01	0.28	0.11
		Cd	0.013	0.072	0.031
		As	0.69	4.67	2.42
		Cu	0.03	0.26	0.11
		Mn	2.14	12.82	7.47
		Zn	5.91	19.71	12.04
Soy bean	20	Hg	0.001	0.003	0.002
		Pb	0.03	0.28	0.12
		Cd	0.011	0.098	0.030
		As	1.11	5.57	2.72
		Cu	0.03	0.18	0.08
		Mn	4.92	19.77	10.34
		Zn	6.61	26.55	14.58
Red bean	20	Hg	0.001	0.002	0.002
		Pb	0.04	0.31	0.15
		Cd	0.016	0.045	0.031
		As	0.51	4.51	1.86
		Cu	0.04	0.29	0.13
		Mn	3.97	13.24	7.43
		Zn	4.88	18.15	9.79
Potato	20	Hg	0.001	0.002	0.002
		Pb	0.03	0.15	0.10
		Cd	0.012	0.035	0.020
		As	0.11	1.78	0.93

<Table IV-5> Range and mean values of trace metals in cereals, pulses, potatoes, vegetables and fruits in ROK (continued)

		Cu	0.02	0.16	0.08
		Mn	0.35	3.16	1.15
		Zn	1.29	6.11	3.60
Sweet Potato	20	Hg	0.001	0.003	0.002
		Pb	0.02	0.19	0.10
		Cd	0.007	0.031	0.016
		As	0.32	2.91	1.30
		Cu	0.02	0.16	0.08
		Mn	1.07	7.83	4.36
		Zn	0.66	3.67	1.64
Red pepper	20	Hg	0.0006	0.0022	0.0010
		Pb	0.004	0.038	0.014
		Cd	0.003	0.041	0.015
		As	0.39	1.63	0.86
		Cu	0.003	0.029	0.013
		Mn	0.38	5.31	2.67
		Zn	1.74	4.54	3.01
Carrot	20	Hg	0.0005	0.0067	0.0013
		Pb	0.003	0.051	0.014
		Cd	0.001	0.041	0.014
		As	0.16	0.82	0.42
		Cu	0.002	0.028	0.012
		Mn	0.27	2.63	0.90
		Zn	1.11	4.47	2.05
Garlic	20	Hg	0.0006	0.0044	0.0014
		Pb	0.002	0.037	0.012
		Cd	0.004	0.053	0.022
		As	0.58	2.07	1.08
		Cu	0.015	0.040	0.025
		Mn	0.43	4.13	1.79
		Zn	1.43	5.51	2.91
Radish	20	Hg	0.0005	0.0010	0.0009
		Pb	0.002	0.019	0.009
		Cd	0.003	0.016	0.009
		As	0.06	0.43	0.21
		Cu	0.006	0.036	0.015
		Mn	0.21	3.71	1.26
		Zn	0.96	2.28	1.52
Chinese Cabbage	20	Hg	0.0006	0.0017	0.0010
		Pb	0.004	0.041	0.011
		Cd	0.004	0.020	0.001
		As	0.15	0.98	0.39
		Cu	0.005	0.033	0.013
		Mn	0.98	14.47	4.84
		Zn	0.98	4.94	2.49
Lettuce	20	Hg	0.0006	0.0022	0.0014

<Table IV-5> Range and mean values of trace metals in cereals, pulses, potatoes, vegetables and fruits in ROK (continued)

Lettuce		Pb	0.002	0.024	0.011
		Cd	0.004	0.074	0.023
		As	0.14	1.11	0.43
		Cu	0.004	0.040	0.017
		Mn	0.57	15.12	4.56
		Zn	1.35	13.45	4.13
Spinach	20	Hg	0.0010	0.0038	0.0024
		Pb	0.003	0.039	0.013
		Cd	0.008	0.077	0.032
		As	0.26	3.64	1.59
		Cu	0.006	0.041	0.018
		Mn	1.34	12.12	4.41
		Zn	1.26	18.13	7.80
Onion	20	Hg	0.0005	0.0013	0.0009
		Pb	0.001	0.046	0.014
		Cd	0.003	0.043	0.019
		As	0.09	0.82	0.31
		Cu	0.006	0.047	0.018
		Mn	0.68	5.42	2.12
		Zn	1.01	5.01	2.22
Cucumber	20	Hg	0.0005	0.0015	0.0008
		Pb	0.002	0.051	0.024
		Cd	0.001	0.016	0.008
		As	0.23	0.99	0.50
		Cu	0.002	0.024	0.012
		Mn	0.56	5.55	1.69
		Zn	0.47	3.09	1.58
Tomato	20	Hg	0.0005	0.0010	0.0009
		Pb	0.004	0.061	0.018
		Cd	0.001	0.034	0.008
		As	0.34	0.75	0.52
		Cu	0.002	0.018	0.008
		Mn	0.49	2.57	1.09
		Zn	0.45	1.58	0.90
Pumpkin	20	Hg	0.0005	0.0010	0.0007
		Pb	0.007	0.091	0.028
		Cd	0.002	0.013	0.006
		As	0.22	1.15	0.52
		Cu	0.003	0.019	0.009
		Mn	0.41	4.63	1.33
		Zn	0.57	4.56	2.16
	20	Hg	0.0015	0.0082	0.0042
		Pb	0.006	0.042	0.018
Angelica keiskei Koidz		Cd	0.008	0.048	0.022
		As	1.02	3.91	1.92
		Cu	0.003	0.041	0.021

<Table IV-5> Range and mean values of trace metals in cereals, pulses, potatoes, vegetables and fruits in ROK (continued)

		Mn	0.31	5.83	2.88
		Zn	0.81	6.37	3.61
Tangerine	20	Hg	0.0005	0.0011	0.0009
		Pb	0.003	0.024	0.010
		Cd	0.001	0.019	0.006
		As	0.16	0.41	0.25
		Cu	0.002	0.041	0.017
		Mn	0.46	1.41	0.84
		Zn	0.23	2.63	0.88
Peach	20	Hg	0.0005	0.0020	0.0009
		Pb	0.009	0.092	0.023
		Cd	0.003	0.023	0.009
		As	0.15	0.86	0.52
		Cu	0.003	0.017	0.009
		Mn	0.39	1.72	0.90
		Zn	0.42	1.77	0.87
Apple	20	Hg	0.0006	0.0027	0.0013
		Pb	0.003	0.410	0.016
		Cd	0.001	0.008	0.003
		As	0.05	1.02	0.42
		Cu	0.004	0.038	0.016
		Mn	0.48	1.71	0.89
		Zn	0.12	1.06	0.40
Water melon	20	Hg	0.0005	0.0014	0.0008
		Pb	0.003	0.021	0.008
		Cd	0.001	0.011	0.004
		As	0.28	0.80	0.45
		Cu	0.002	0.210	0.010
		Mn	0.33	1.56	0.93
		Zn	0.46	1.63	1.12
Grape	20	Hg	0.0005	0.0016	0.0009
		Pb	0.006	0.051	0.018
		Cd	0.002	0.017	0.009
		As	0.12	1.28	0.48
		Cu	0.004	0.034	0.014
		Mn	0.44	2.84	1.27
		Zn	0.10	6.42	2.58
Persimon	20	Hg	0.0006	0.0024	0.0012
		Pb	0.002	0.048	0.016
		Cd	0.003	0.016	0.008
		As	0.06	0.74	0.31
		Cu	0.011	0.072	0.035
		Mn	0.75	12.77	4.66
		Zn	0.08	0.89	0.35

People's Republic of China

For the PRC, the quality of coastal waters is indicated by exceedence areas (e.g., oil, inorganic nitrogen, inorganic phosphorus), and an index is developed along with a water quality class range (Table IV-6). No data on contaminants in foodstuffs was available for the preliminary TDA.

<Table IV-6> The comprehensive quality status of coastal waters in Yellow Sea and Bohai Sea in 1996

Sea areas	Items exceeded standards	Comprehensive index	Water quality class range*
Liaodong Bay	IN,IP,Oil	0.74	B_1
BohaiSea Bay	IN,Oil	0.81	B_2
Laizhou Bay	IN,IP,Oil	0.92	B_2
Middle Bohai sea		0.34	A_1
Dalian Bay	IN	0.90	B_2
North Yellow Sea	IN,Oil	0.90	B_2
South Yellow Sea		0.33	A_1
Jiaozhou Bay	IN,Oil	0.65	B_1
Jiangsu coast	IN	2.04	C_2
Changjiang Estuary	IN,IP	2.29	C_2

*note: A - the first order sea water; B - the second order sea water; C - the third order sea water; D - below the third order sea water. Superscript1: near to the low limit of this criteria, supercrispt2: near to the super limit of this standard. IN- inorganic nitrogen, IP - inorganic phosphorus.
Source: Chinese marine statistics yearbook 1997 China Ocean Press(1997) pp161

ANNEX A
List of Acronyms/Abbreviations

CD	Compact Disc
DBMS	Data Base Management System
DPRK	Democratic People's Republic of Korea
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
GIS	Geographic Information System
GLOBEC	Global Ocean Ecosystem Dynamics
HAB	Harmful Algal Bloom
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
LME	Large Marine Ecosystem
NGOs	Non-Governmental Organizations
NOWPAP	Northwest Pacific Action Plan
PDF	Project Development Facility
PICES	North Pacific Marine Science Organization
PRC	People's Republic of China
PTDA	Preliminary Transboundary Diagnostic Analysis
ROK	Republic of Korea
SAP	Strategic Action Program
SOA	State Oceanic Administration
TDA	Transboundary Diagnostic Analysis
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
YSLME	Yellow Sea Large Marine Ecosystem

ANNEX B
List of Organizations
Contributing to the National Reports

Republic of Korea Governmental Organizations
Ministries
Ministry of Maritime Affairs and Fisheries
Ministry of Foreign Affairs and Trade
Ministry of Science and Technology
Ministry of Environment

Local Governments
Inchon Metropolitan City
Kyunggi-Do Province
Chollabuk-Do Province
Chollanam-Do Province
Chungchongnam-Do Province
Pyongteek City Hall

Agencies
National Fisheries Research and Development Institute
National Oceanographic Research Institute

Republic of Korea Scientific Organizations
Research Institute
Korea Ocean Research and Development Institute
Korea Maritime Institute
Korea Research Institute for Human Settlements
Korea Basic Science Institute

Universities
Chonnam National University, College of Natural Sciences
Chungnam National University, Department of Oceanography
Dong-A University, Department of Planning and Landscape
Ewha Womans University, Division of Natural Sciences-Biological Sciences
Hannam University, College of Natural Science, Biology
Hanyang University, Department of Earth and Marine Science
Kunsan University, Department of Oceanography
Mokpo University, Department of Marine Resources
Inha University, Department of Oceanography
Pukyung National University, Department of Marine Biology
Pusan University, Department of Oceanography
Seoul National University, Department of Oceanography
The University of Suwon, Department of Biology
Woosuk University, Department of Biology
Yosu National University, Department of Marine Science and Technology

Private Sector
Sam Woo Environmental Consultant Corporation, Marine Environment Research Institute
ROK Environmental Research Center for Hydrosphere Co., Ltd.
Korea Ocean Science and Engineering Corporation

Republic of Korea Other
UNDP ROK

People's Republic of China Governmental Organizations
The Committee of Environment and Resources, State Congress
The State Environmental Protection Agency
The Ministry of Land and Resources
State Oceanic Administration and the North Sea Branch, SOA
The Ministry of Agriculture (the Fisheries Administration)
The Ministry of Transportation (the Port Administration, and the Bureau of Maritime Affairs)
The branches of these organizations in the provinces Liaoning, Shandong, Jinagsu and the Shanghai City
The navy departments concerning the marine environment

People's Republic of China Institutions and Universities
Ocean University of Qingdao
School of Aquaculture, Shandong
The Center of Fisheries Information, Chinese Academy of Fishery Sciences
The Center of Marine Environment Forecasting
The Center of Marine Standards and Metrics
The Center of Ocean Information, SOA
The Dalian College of Fisheries
The Dalian University of Science and Technology
The First Institute of Oceanography, SOA
The Institute of Fisheries Science, Dalian
The Institute of Fisheries, Hebei
The Institute of Mariculture Research, Shandong
The Institute of Marine Development Strategy, SOA
The Institute of Marine Environment Protection, SOA (The Center of Marine Environment Monitoring)
The Institute of Marine Fisheries, Liaoning
The Institute of Marine Geology, Ministry of Land and Resources
The Institute of Marine Meterology, Dalian
The Institute of Marine Resources, Liaoning General University
The Institute of Marine Techniques
The Institute of Ocean Information Techniques, Dalian Maritime University
The Institute of Oceanology, Academic Sinica
The Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

People's Republic of China Associations and Non-governmental organizations
The Chinese Society of Oceanography
The Chinese Society of Environment Sciences
The Chinese Society of Ecology
The Chinese Society of Fisheries
The Chinese Society of Oceanography and Limnology
The Chinese Association of Wild Animal Protection

The committees of scientific and technological cooperation in the coastal cities and provinces of Yellow Sea
The Qingdao Society of Ecology

ANNEX C
Ongoing and Past Projects
Relevant to The Implementation Of The SAP

GEF/UNDP Projects

Preparation of a Strategic Action Programme (SAP) and Transboundary Diagnostic Analysis (TDA) for the Tumen River Area, its coastal regions and related Northeast Asian Environs (approved)

The purpose of this project is to prepare a Transboundary Diagnostic Analysis (TDA) and a Strategic Action Programme (SAP) for the Tumen River Economic Development Area. The implementation of the SAP will assist in the implementation of the Memorandum of Understanding among the Tumen River Area Development Programme member states by integrating and applying sound land and water resource management strategies. The implementation of the SAP will also entail a number of interventions focused on the conservation of biodiversity designed to obtain national, regional and global benefits, with GEF financing their incremental cost. The SAP will provide a common framework for the identification and formulation of strategies, programmes and projects, responding primarily to transboundary issues of environmental management.

Building Partnerships for the Environmental Protection and Management of the East Asian Seas (approved)

The East Asian Seas Region faces serious transboundary environmental challenges to the sustainable development of its coastal and marine areas. Existing national management approaches are still sectoral and actions tend to focus on problems that are visible and of immediate concern, and are geared towards responding to environmental crises. Regional action plans have yet to be effectively implemented. This project attempts to reduce or remove the critical barriers (e.g., inadequate policy; limited investment; disparate institutional capacity) to effective environmental management. The project design is based on two management frameworks tested in the GEF pilot phase, namely: a) integrated coastal management, which addresses land-water interactions and the negative impacts of human activity; and b) risk assessment/risk management which focuses on human activities and their impact in sub-regional seas. The project integrates these two management frameworks, thereby providing comprehensive coverage of the marine and coastal environment, and the related land- and sea-based environmental issues. These activities, reinforced with appropriate coastal/marine policy and environmental investment options, will enable the deployment of a strategic approach to address multi-focal environmental concerns through a sustainable regional mechanism, especially transboundary environmental issues arising from population pressure and national economic development. This project is part of a GEF programmatic approach to the East Asian Region where multiple international waters projects are being targeted to reverse transboundary environmental degradation of the shared waters. The global environmental benefits to be derived from the project are the cumulative environmental improvements at the site, national and regional levels that will be achieved mainly through intergovernmental, interagency and inter-sectoral partnerships.

Wetland Biodiversity Conservation and Sustainable Use in PRC (approved)

PRC has over 25 million hectares of natural wetlands, supporting high global biodiversity. Rates of wetland degradation are high due to human development pressures, and nearly 40% of all wetlands of international importance are under threat. Wetlands have also assumed an added importance in the light of recent catastrophic flooding throughout PRC. The Biodiversity Conservation Action Plan, Agenda 21 and the draft National Wetland Conservation Action Plan provide the foundation for the conservation and better management of PRC's wetland resources. However, barriers to effective conservation of global wetland biodiversity remain. The proposed project will remove barriers at four representative but different sites with high global biodiversity importance (Sanjiang Plain, Ruoergai Marshes, Yancheng Coast and Dongting Lakes). A national coordination component will also ensure that lessons learned from this project will be appropriately transferred to other wetlands in PRC. To complement the protection of biodiversity, the project will work with local communities to develop improved, sustainable livelihoods and alleviate poverty in and around the wetland areas. GEF support will be closely allied with new Government programmes that conserve biodiversity, ensure locally sustainable development and relieve future flooding events.

Reversing Degradation Trends in the South China Sea (awaiting approval)

Major outcomes will include an approved Strategic Action Programme that will include, a targeted and costed programme of action and a recommended legal framework for improved regional co-operation in the management of the environment of the South China Sea; a series of national and regional management plans for specific habitats and issues; 9 demonstration management activities at priority transboundary sites; a regional management plan for maintenance of transboundary fish stocks; pilot activities relating to alternative remedial actions to address priority pollutants and adopted water quality objectives and standards. Activities include national level analyses and reviews and management of demonstration activities and regional harmonisation and co-ordination of national level actions.

Conservation of Globally Significant Wetlands in the Republic of Korea (PDF B)

The overall objective of the PDF-B project is to undertake the necessary preparatory work for the development of a full GEF project to conserve globally significant wetlands and the biodiversity along the west coast of the Republic of Korea. These wetlands have tremendous global significance for conservation because they serve as breeding, resting and wintering sites for migratory and rare bird species in the East Asian region.

The full GEF Project shall strengthen the relation and cooperation efforts between government and local communities to protect and manage the selected globally significant wetlands. The project will develop and implement a well-defined strategic plan for the conservation and management of the coastal wetlands. The plan will include the identification and classification of wetland biological resources and socio-economical assessments, review and analysis of present wetland conservation policies and related legal instruments. Education and public awareness campaigns for wetlands conservation will also be undertaken.

- To be executed by the Ministry of Environment
- PDF-B request of US$345,500 with US$156,500 govt. co-financing
- PDF-B to be submitted to March 2000 bilateral review

Biodiversity Management in the Coastal Area of DPRK's West Sea (approved)

Goal: The planned and sustainable development of the coast of the Gulf of West ROK, with a focus on globally significant biodiversity, human health and quality of life, thus securing a balance between protection of natural resources and environmentally-sound development.

Objectives:
The project has 5 main objectives as follows:-

1. Strengthened planning process for effective wetlands management at national and local levels.
2. A strengthened Environmental Impact Assessment (EIA) process.
3. Enhanced public awareness of natural resources and biodiversity values through increased participation in protected areas management.
4. Implementation of the Integrated Coastal Area Management Plan in Mundok County to demonstrate biodiversity conservation with sustainable development.
5. Improved management practices in industries and other sectors with potential environmental impacts

Other Projects:

Coastal Biodiversity Management of DPR Korea's West Sea (MSP)

This Project will protect globally significant biodiversity in the wetlands of the DPR Korea's West Sea Coast and will operate on three broad levels. At the Provincial and National level planning processes will be enhanced through capacity building, increased public involvement and the development of broad-scale planning processes for South Pyongan Province. At the County level a fully developed ICAMP will be implemented in the Mundok County coastal zone, and finally at the local level demonstrations of effective and integrated coastal zone management plans will be implemented for the biodiversity conservation, agriculture and other related sectors, focussing on and around the Mundok MBWR.

The project expects to remove specific barriers and threats to biodiversity conservation within the project area principally through the strengthening of coastal planning and management in South Pyongan Province.

The broad goal of the project is the planned and sustainable development of the coast of the Gulf of West Korea, with a focus on globally significant biodiversity, human health and quality of life, thus securing a balance between protection of natural resources and environmentally-sound development.

Four immediate objectives have been identified, these are:-

1. Planning process for wetlands management effective at national and local levels.
2. Public awareness of natural resources and biodiversity values achieved through increased participation in protected areas management.
3. Implementation of the Integrated Coastal Area Management Plan in Mundok County to demonstrate biodiversity conservation with sustainable development.
4. Management practices in agriculture and other sectors with potential environmental impacts improved.

- To be UNOPS executed, (thus strengthening links to YSLME Project Brief)
- Total Budget US$1,238,513: GEF request US$742,523

- Project duration: 4 years
- MSP Brief substantially complete and will be submitted in the near future.

Coastal Resource Conservation and Environmental Management Project for the Bohai Sea

This project, funded by the Asian Development Bank and executed by the Ministry of Agriculture of the PRC, focuses on the establishment of a Bohai Sea Coastal Resources Management Plan. It includes elements of objectives, management principles, strategy for management, and recommended actions. The recommended actions include institutional coordination, public participation and awareness, environmental monitoring and information systems, marine pollution control, capture fisheries management, mariculture development, ecosystem conservation, harmful algal blooms, and research. This project forms a solid basis for ecosystem-based management that complements the proposed GEF project for the remainder of the YSLME.

China-GLOBEC Study

China-GLOBEC II, entitled "Ecosystem Dynamics and Sustainable Utilization of Living Resources in the East China Sae and the Yellow Sea", has been approved as a programme of National Key Basic Research and Development Plan in China, with funding of $4.5 M for the period of 1999-2004. Nine academic institutions and about 100 scientists are involved in the programme and the major institutions are Yellow Sea Fisheries Research Institute of the Ministry of Agriculture, Second Institute of Oceanography of State Oceanic Administration, Institute of Oceanology of Chinese Academy of Sciences, and Ocean University of Qingdao.

The programme goals are to
1. identify key processes of ecosystem dynamics, and improve predictive and modeling capabilities in the East China Sea and the Yellow Sea; and
2. provide scientific underpinning for the sustainable utilization of marine living resources and rational management system of fisheries and other marine life.

The scientific objectives of the programme are to:
1. determine the impacts of key physical processes on biological production;
2. determine the cycling and regeneration mechanisms of biogenicelemnet;
3. determine the basic production processes and zooplankton role in the ecosystem; and
4. determine the food web trophodynamics and shift in dominant species.

NEAR-GOOS

NEAR (North-East Asian Region)-GOOS is a regional pilot project of GOOS in the North-EastAsian Region, implemented by PRC, Japan, the ROK and the Russian Federationas a WESTPAC Activity. Oceanographic data and relevant products within the NEAR-GOOSsystem are open to all users free of cost.

NEAR-GOOS demonstrates the usefulness of a regional ocean observing system for the purpose of encouraging such efforts for the rest of the world as part of the strategy of GOOS. NEAR-GOOS was established further to Draft Resolution 57 (DR.57) at the 27th Session of the General Conference of UNESCO in 1993. A detail of the planning is found in the Initial Phase of an Implementation Plan for North-East Asian Regional GOOS. More information on the Implementation Plan can be obtained through the GOOS Project Office in Paris.

The first aim of NEAR-GOOS is to share oceanographic data in real time via the Internet to support daily mapping of sea conditions in marginal seas bordered by NEAR-GOOS countries.

The goals of the NEAR-GOOS are as follows:

i) to improve ocean services in the region,
ii) to provide data and information useful in the mitigation of the effects of natural disasters caused by waves, storm surges, and sea ice,
iii) to increase the efficiency of fishing vessels,
iv) to provide information useful in pollution monitoring
v) to monitor parameters useful to mariculture, particularly with regards to harmful algal blooms,
vi) to provide information on the health of the coastal zone for recreation purposes,
vii) to provide data sets required for data assimilation, modeling and forecasting.

NORTHWEST PACIFIC ACTIN PLAN (NOWPAP)

The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) and three Resolutions were adopted at the First Intergovernmental Meeting (Seoul, 14 September 1994), which was attended by Japan, People's Republic of China, Republic of Korea and Russian Federation.

The implementation of the Action Plan will comprise a number of projects running in parallel. These projects will be entrusted to national institutions to the extent that the institutions are capable. In this, the institutions will be supported by relevant regional and international organizations, particularly those that are already active in the region. Where necessary, national institutions will be strengthened to enable them to participate effectively in the various projects.

In view of the multiple projects that are possible and the scattered nature of the various activities, as well as the wide scope of input possible from both within and outside the region, implementation of the Action Plan must be coordinated. A network of participating institutions coordinated by regional activity centres will be established for this purpose." Four Regional Activity Centres (RAC's) are proposed to be created to cover activities listed in the Action Plan:

Activity Centre 1: Regional Marine and Coastal Information Management. The priority project, NOWPAP/1: Comprehensive Database and Information Management System is in its first phase, namely, preparation of proposals. The Centre will be in charge of implementing the NOWPAP/1 phase II in cooperation with IOC and UNEP-EAP/AP for establishment of a comprehensive database and regional information management system. Although concrete activities should be determined during the first phase of NOWPAP/1, activities relevant to maintenance of a regional informational system, collection of GIS maps and images, training activities on data and information management are considered to be main activities of the Centre. From the perspective of use of database and information to be collated, this Centre should be located closer to the NOWPAP Regional Coordinating Unit (NOWPAP/RCU) when it is established.

Activity Centre 2: Monitoring and Assessment of Marine, Coastal and Associated Freshwater Environments. The priority project, NOWPAP/3: Regional Monitoring System is in its first phase, namely, preparation of proposals. The Centre will be in charge of implementing the

NOWPAP/3 phase II for establishment of a regional monitoring network. Also, it is entrusted to carry out routine assessment of the state of the marine, coastal and associated freshwater environments. Therefore, although details of the NOWPAP/3 Phase 2 is being discussed, the main tasks of the Centre will include development of pilot regional monitoring activities, development and implementation of regional data quality and analytical control methods, training courses relevant to monitoring methodologies and data and analytical control.

Activity Centre 3: Marine Pollution Preparedness and Response. Under NOWPAP/4, the NOWPAP Forum on Marine Pollution Preparedness and Response has been established. This Centre will be charged with secretariat function for this NOWPAP Forum with technical support from UNEP and IMO. The initial tasks of the Forum were defined at the First Forum meeting in Toyama, July 1997, and the Centre will coordinate the initial and subsequent tasks of the Forum. Close cooperation should be maintained with IMO, as well as NOWPAP RCU.

Activity Centre 4: Biodiversity and Specially Protected Areas. Although no activity has been initiated in this field, considering that the NOWPAP region has maintained an important ecosystem relevant to marine, coastal and associated freshwater environments, it is recommended to initiate activities and to create a Centre in this field.

ANNEX D
List of Conventions and Agreements

Republic of Korea

With respect to pollution in the marine environment, the solution to this common problem must be found in global, regional, and bilateral frameworks. To this end, ROK has been implementing a total of twenty-four international legal instruments in efforts to prevent, control and reduce marine pollution.

However, as indicated in the following tables, most of the international legal instruments were introduced or adopted only during the past two decades, due to then ROK's immature and still developing economic situation. Now, as a member of the contributing global society, ROK is participating in international environmental treaties and is also planning to implement more of such treaties as soon as her domestic enforcement mechanisms are in place.

<Table 4-1> ROK and global environmental treaties

(Date : Day/Month/Year)

Title	Date of Signature	Date of ratification/ accession(a)	Date of entry into force for ROK
International Convention for the Prevention of Pollution of the Sea by Oil, 1954(as amended in 1962 and in 1969)	-	31 07 78(a)	31 10 78
International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 relating thereto	-	23 07 84(a)	23 10 84
International Regulations for Preventing Collisions at Sea,1960	-	-	-
1972 Amendments to the 1960 International Regulations for Preventing Collisions at Sea	-	29 07 77(a)	29 07 77
International Convention for the Safety of Life at Sea, London, 1974	-	31 12 80(a)	31 03 81
Convention on the High Seas, 1958, Geneva	-	-	-
Convention on the Continental Shelf, 1958, Geneva	-	-	-
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969, Brussels	-	-	-
Protocol Relating to Intervention on the High Seas in Cases of Marine Pollution by Substances other than Oil, 1973, London	-	-	-
International Convention on Civil Liability for Oil Pollution Damage, 1969, Brussels	-	18 12 78(a)	18 03 79
International Convention on the Establishment of an International Fund for Compensation of Oil Pollution Damage, 1971, Brussels	-	08 12 92(a)	08 03 93

<Table 4-1> ROK and global environmental treaties (continued)

International Convention on the Liability of Operators of Nuclear Ships, 1962, Brussels	-	-	-
Convention Relating to the Civil Liability in the Field of Maritime Carriage of Nuclear Materials, 1971, Brussels	-	-	-
International Convention Relating to the Limitation of the Liability of Owners of Sea-going Ships, 1959, Brussels	-	-	-
Protocols Amending the International Convention Relating to the Limitation of the Liability of Owners of Sea-going Ships, 1979, Brussels	-	-	-
Convention on Limitation of Liability for Maritime Claims, 1976, London	-	-	-
Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matters, 1972, London	-	21 12 93(a)	20 01 94
Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water, 1963, Moscow, London, Washington	-	24 07 64(a)	24 07 64
Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and Ocean Floor and in the Subsoil thereof, 1971, London, Washington, Moscow	-	25 06 87(a)	25 06 87
Convention on the Prohibition of Military or any Other Hostile Use of Environmental Modification Techniques, 1977, Geneva	-	02 12 86(a)	02 12 86
Convention on the Conservation of Migratory Species of Wild Animals, 1979, Bonn	-	-	-
Convention on International Trade in Endangered Species of Wild Flora and Fauna, 1973, Washington	-	07 09 93(a)	07 10 93
United Nations Convention on the Law of the Sea, 1982, Montego Bay	14 03 83	29 01 96	28 02 96
International Convention for the Regulation of Whaling, 1946, Washington	-	29 12 78(a)	29 12 78
International Convention for the High Seas Fisheries of the North Pacific Ocean, 1952, Tokyo	-	-	-
Interim Convention on Conservation of North Pacific Fur Seals, 1957, Washington	-	-	-
Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971(as amended in 1982 and in 1987)	-	28 03 97(a)	28 07 97
Convention Concerning the Protection of the World Cultural and Natural Heritage, 1972, Paris	-	14 09 88(a)	14 12 88
Vienna Convention for the Protection of the Ozone Layer, 1985, Vienna	-	27 02 92(a)	27 05 92
Montreal Protocol on Substances that Deplete the Ozone Layer, 1987	-	27 02 92(a)	27 05 92

<Table 4-1> ROK and global environmental treaties (continued)

London Amendment to Montreal Protocol on Substances that Deplete the Ozone Layer, 1990	-	10 12 92(a)	10 03 93
Copenhagen Amendment to Montreal Protocol on Substances that Deplete the Ozone Layer, 1992	-	02 12 94(a)	02 03 95
Agreement on the Network of Aquaculture Centres in Asia and the Pacific, 1988, Bangkok	-	-	-
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1989, Basel	-	28 02 94(a)	29 05 94
International Convention on Maritime Search and Rescue, 1979, Hamburg	-	04 09 95(a)	04 10 95
United Nations Framework Convention on Climate Change, 1992, New York	13 06 92	14 12 93	21 03 94
Convention on Biological Diversity, 1992, Rio de Janeiro	-	03 10 94(a)	01 01 95
International Plant Protection Convention, 1951, Rome	-	08 12 53(a)	08 12 53
The Convention on Civil Liability for Oil Pollution Damage Resulting from Exploration of Seabed Mineral Resources, 1977, London	-	-	-

People's Republic of China

There exist no special international agreements on the protection of the Yellow Sea Environment at present. International legal system related to the protection of the Yellow Sea environment is composed of universal international conventions which are applicable to the Yellow Sea. Among these conventions, the main ones are:

United Nations Framework Convention on Climate Change
Concluded in New York on 22 May 1992 and effective as of 21 March 1994. Chinese Premier signed the convention on 11 June 1992. The Standing Committee of the National People's Congress of China ratified this convention on 7 November 1992. China deposited the instrument of ratification on 5 January 1993.

Convention on Biological Diversity
Concluded in Nairobi on 1 June 1992 and effective as of 29 December 1993. Chinese Premier signed the convention on 11 June 1992. The Standing Committee of the National People's Congress of China ratified this convention on 7 November 1992. China deposited the instrument of ratification on 5 January 1993 and the convention entered into force for China on 29 December 1993.

United Nations Convention to Combat Desertificaton in those Countries Experiencing Serious Drought and /or Desertification, Particularly in Africa
Concluded in Paris on 14 October 1994 and effective as of 27 September 1996. The Standing Committee of the National People's Congress of China ratified this convention on 30 December 1996. China deposited the instrument of ratification on 18 February 1997 and the convention entered into force for China on 19 May 1997.

Convention on International Trade in Endangered Species of Wild Fauna and Flora
Concluded in Washington on 3 March 1973 and effective as of 1 July 1975. China deposited the instrument of accession on 8 January 1981 and the convention entered into force for China on 8 April 1981.

Amendment to Article XXI of the Convention on International Trade in Endangered Species of Wild Fauna and Flora
Concluded on 30 April 1983. China deposited the instrument of acceptance on 7 July 1988.

United Nations Convention on the Law of the Sea
Concluded at Montego Bay on 10 December 1982 and effective as of 19 November 1994. The Standing Committee of the National People's Congress of China ratified this convention on 15 May 1996. China deposited the instrument of ratification on 7 June 1996 and the convention entered into force for China on 7 July 1996.

Convention on the Prevention of Marine Pollution By Dumping of Wastes and other Matters
Concluded in London, Washington, Moscow and Mexico on 29 December 1972 and effective as of 30 August 1975. China deposited the instrument of accession on 14 November 1985 and the convention entered into force for China on 15 December 1985.

1989 Amendment of the Convention on the Prevention of Marine Pollution By Dumping of Wastes and other Matters
China accepted by acquiescence and the Protocol entered into force for China on 19 May 1990.

International Convention on Civil Liability for Oil Pollution Damage
Concluded in Brussels on 29 November 1969 and effective as of 19 June 1975. China deposited the instrument of acceptance on 30 January 1980 and the convention entered into force for China on 30 April 1980.

Protocol to the International Convention on Civil Liability for Oil Pollution Damage
Concluded in London on 19 November 1976 and effective as of 8 April 1981. China deposited the instrument of accession on 29 September 1986 and the convention entered into force for China on 28 December 1986.

Protocol of 1978 Relating to the 1973 International Convention for the Prevention of Pollution From Ships
Concluded in London on 17 February 1978 and effective as of 2 October 1983. China deposited the instrument of accession on 1 July 1983 and the convention entered into force for China on 2 October 1983.

Protocol of 1978 to Amendment of 1973 International Convention for Prevention of Pollution From Ships and Appendix I(MARPOL73/78)
Concluded in London on 17 February 1978 and effective as of 7 September 1984. China accepted by acquiescence on 7 January 1986 and the convention entered into force for China on the same date.

Protocol of 1990 to Amendment of 1973 International Convention for Prevention of Pollution From Ships and Appendix I.V(MARPOL73/90)

China accepted by acquiescence and the Protocol entered into force for China on 17 March 1992.

International Convention Relating to intervention on the High Seas in Case of Oil Pollution
Concluded in Brussels on 29 November 1969 and effective as of 6 May 1975. China deposited the instrument of accession on 23 February 1990 and the convention entered into force for China on 24 May 1990.

Protocol Relating to Intervention on the High Seas in Case of Marine Pollution By Substances other than Oil
Concluded in London on 2 November 1973 and effective as of 30 March 1983. China deposited the instrument of accession on 23 February 1990 and the convention entered into force for China on 24 May 1990.

International Convention for the Regulation of Whaling
Concluded on 2 December 1946 and effective as of 10 November 1948. China acceded to this convention by notice on 24 September 1980 and the convention entered into force for China on the date of notification.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal
Concluded in Basel in 1989 and effective as of 5 May 1992. China signed this convention on 22 March 1990, deposited the instrument of ratification on 17 December 1991 and the convention entered into force for China on 5 May 1992.

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
Concluded in New York on 4 August 1995 and has not become effective. China signed this convention on 6 November 1996.

Convention on Wetlands of International Importance Especially as Waterfowl Habitat
Concluded on 2 February 1971 and effective as of 21 December 1975. China deposited the instrument of accession on 31 March 1992 and this convention entered into force for China on 31 July 1992.

Convention on the International Maritime Organization
Concluded on 6 March 1948. China deposited the instrument of acceptance on 1 March 1973 and the convention entered into force for China on the same date.

International Maritime Organization Convention as Amendment in 1991
Concluded in London on 7 November 1991 and has not gone into effect. China deposited the instrument of acceptance on 27 October 1994.

Convention establishing International Maritime Organization as Amended in 1993
Concluded on 4 November 1993 and has not become effective. China deposited the instrument of acceptance on 27 October 1994.

Convention on the International Maritime Satellite organization

Concluded in London on 3 September 1976 and effective as of 16 July 1979. China signed the convention on 13 July 1979 and the convention entered into force for China on 16 July 1979.

Operation Agreement on the International Maritime Satellite organization
Concluded in London on 3 September 1976 and effective as of 16 July 1979. China signed the convention on 13 July 1979 and the convention entered into force for China on 16 July 1979.

Protocol of 1984 to Amendments of the International Convention on Civil Liability for Oil Pollution Damage
Concluded in London on 25 May 1984 and has not gone into effect. China signed the Protocol on 22 November 1985.

Convention for A North Pacific Marine Science organization
Concluded in Ottawa on 12 December 1989 and effective as of 24 March 1992. China signed the convention on 22 October 1991 and the convention entered into force for China on 24 March 1992.

International Convention on Oil Pollution Preparedness, Response and Cooperation
Concluded on 30 November 1990 and effective as of 13 May 1995. China deposited the instrument of accession on 30 March 1998 and the convention entered into force for China on 30 June 1998.

Kyoto Protocol of the United Nations Framework Convention on Climate Change
Concluded on 11 December 1997 and has not gone into effect. China signed the convention on 29 May 1998.

Protocol of 1992 to Amendments of the International Convention on Civil Liability for Oil Pollution Damage (1969)
Concluded in London on 27 November 1992 and effective as of 30 May 1996. China deposited the instrument of accession on 5 January 1999 and the Protocol will enter into force for China on 5 January 2000.

Protocol 1992 to Amendment of the International Convention on the Establishment of an International Fund for Compensation for oil Pollution Damage (1971)
Concluded on 27 November 1992 and effective as of 30 May 1996. With respect to China, this Protocol is now only applicable to Hong Kong; China deposited the instrument of accession on 5 January 1999 and the Protocol will enter into force for China on 5 January 2000.

ANNEX E
Map of the YSLME Region

ANNEX F
References

Beaver, J.R. and T.L. Crisman, 1982. The trophic response of ciliated protozoans in freshwater lakes. Limnol. Oceangr., 27(2): 241-253.

Brodeur, R. D., and D. M. Ware. 1992. Long-term variability in zooplankton biomass in the subarctic Pacific Ocean. Fish. Oceanogr. 1(1):32-38.

Bruland, K.W., 1983. Trace elements in sea-water. In: *Chemical Oceanography*, (eds) Riley, J.P. and R. Chester Vol. 8. Academic Press, London, pp. 157-220.

Buskey, E.J., 1993. Annual pattern of micro and mesozooplankton abundance and biomass in a subtropical estuary. J. plankton Res., 15(8): 907-924.

Byrd, J.T., Lee, K.W., Lee, D.S. and Smith, R.G., 1990. The behavior of trace metals in the Geum estuary, Korea. *Estuaries*, 13, 8-13.

Cheng TW, Zhao CN (1985) Input of water discharge and particulate matters to the ocean and effect on the offshore by the main rivers in China. Acta Oceanologica sinica 4:460-471

Chikuni, S. 1985. The Fish Resources of the Northwest Pacific. FAO Fisheries Tech. Paper. 266. Rome. FAO.

Cho B.C., J.K. Choi, C.S. Chung and G.H. Hong, 1994. Uncoupling of bacteria and phytoplankton during a spring diatom bloom in the mouth of the Yellow Sea. Mar. Ecol. Prog. Ser., 115: 181-190.

Cho, Y.G., 1994. Distribution and origin of metallic elements in marine sediments around Korean Peninsula. *Ph.D. thesis*, SNU, 262pp.

Cho, Y.G., C.B.,Lee and M.S., Choi, 1999. Geochemistry of surface sediments off the southern and western coasts of Korea. *Mar. Geol*., 159; 111-129

Choi J.K., S.K. Kim, J.H. Noh and K.C. Park, 1995. The study on the grazing rate of protozooplankton in the microbial food web of Incheon coastal waters. J. Kor. Soci. Oceangr., 30(5): 458-466.

Choi, H-G., J-S. Park and P-Y. Lee, 1992. Study on the heavy metal concentration in mussels and oysters from the Korean coastal waters. *Bull. Korean Fish. Soc*., 25(6): 485-494.

Choi, J. K., J. H. Noh, K. S. Shin, and K. H. Hong. 1995. The early autumn distribution of chlorophyll-a and primary productivity in the Yellow Sea, 1992. The Yellow Sea. 1:68-80.

Choi, J. K., Y. C. Park, Y. C. Kim, Y. C. Lee, S. K. Son, H. J. Hwang, B. S. Han, and C. S. Jung. 1988. The study on the biological productivity of the fishing ground in the western coastal area of Korea, Yellow Sea. Bull. Nat. Fish. Res. Dev. Agency. 42:143-168.

Choi, K.S., and Park, K.I., 1997. Report on the occurrence of *Perkinsus* sp. in the manila clams, *Ruditapes philippinarum* in Korea. J. Aquaculture 10: 227-237.

Choi, M.S., 1998. Distribution of trace metals in the riverine, atmospheric and marine environments of the western coast of Korea. *Ph.D. thesis*, SNU, 338pp.

Choi, M.S., C.B. Lee and Y.G. Cho, 1995. Trace metals of suspended particulate matters in the Keum River (in Korean)., *J. Kor. Soc. Ocean.,* 30(5), 371-381.

Choi, M.S., J.H. Chun, H.J. Woo and H.-I. Yi, 1999. Change of heavy metals and sediment facies in surface sediments of the Shihwa Lake. *Kor. Environ. Sci. Soc*. Accepted.

Chung CS, Hong GH, Kim SH, Lim JH, Park JK, Yang DB (1998) Shore based observation on wet deposition of inorganic nutrients in the Korean Yellow Sea coast. The Yellow Sea 4:30-39

Chung, K. H., and Y. C. Park. 1988. Primary production and nitrogen regeneration by macrozooplankton in the Kyunggi Bay, Yellow Sea. J. Oceanol. Soc. Kor. 23(4):194-206

Collar, N. J., Gonage, L. P., and Wege, D.C.. 1993. INCN Red Data Book, 3rd ed., Simthsonian Institute Press.

Duce RA, Arimoto R, Ray BJ, Unni CK, Harder PT (1983) Atmospheric trace elements at Enawetak

Edmond, J.M., A. Spivack, B.C. Grant, H. Ming-Hui, C. Zexiam, C. Sung and Z. Xiushau, 1985. Chemical dynamics of the Changjiang estuary. *Cont. Shelf Res*., 4(1/2): 17-36.

Elbaz-Poulchet, F., J.M. Martin, W.W. Huang and J.X. Zhu, 1987. Dissolved Cd behavior in some selected French and Chinese estuaries. Consequences on Cd supply to the ocean. *Mar. Chem*., 22: 125-136.

Elbaz-Poulichet F., Huang, W.W., Martin, J.M., Seyler, P., Zhong, X.M. and Zhu, J.X., 1990. Biogeochemical behavior of dissolved trace elements in the Changjiang estuary. In: *Proceedings of the International Symposium on the Biogeochemical Study of the Changjiang Estuary and its Adjacent Coastal Waters of the East China Sea,* (eds) Guohui Y., Martin, J.M., Jiayi, Z., Windom, H. and Dawson, R., China Ocean Press, 293-311.

Gao, Y., R. Arimoto, R.A. Duce, D.S. Lee and M.Y. Zhou, 1992. Input of atmospheric trace elements and mineral matter to the Yellow Sea during the spring of a low-dust year. J. Geophy. Res., 97(D4):3767-3777.

GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Pollution) (1989) The atmospheric input of trace species to the world ocean. IMO/FAO/UNESCO/WMO/

Goldberg, E.D., 1980. The international mussel watch. National Academy of Sciences, Washington, DC

Goldberg, E.D., T.B. Vaughan, J.W. Farrington, G. Harvey, J.H. Martin, P.L. Parker, R.W. Risebrough, W.M. Robertson and E. Schneider, 1978. The Mussel Watch. Environ. Conser., 5(2): 101-125.

Hong et al. (eds) Health of the Yellow Sea, The Earth Love Publication Association, Seoul, 1998, p 193-209

Hong, G.H., Kim, S.H., and Chung, C.S., 1997. Contamination in the Yellow Sea proper: A review. Ocean Res. 19(1): 55-62.

Hong, G.H., S.-H. Kim, D.B. Yang and G.H. Lim, 1997. Atmospheric input of trace metals over the Yellow Sea: Shipboard results, April 1995. In "Proceedings of The International Symposium on The Health of The Yellow Sea", KORDI. 91-119.

Hong, S. Y. and Chang, Y. T., 1997, Integrated coastal management and the advent of new ocean governance in Korea : Strategies for increasing the probability of success, The International Journal of Marine and Coastal Law, vol 12, N.2 p.141-161.

Hong, S. Y. and Lee, J. H., 1995, National level implementation of chapter 17: the Korean example, Special Issue, Earth Summit Implementation: Progress Achieved on Oceans and Coasts, Ocean & Coastal Management, vol 29, p.231-249.

Hong, S. Y., 1991, An assessment of coastal zone issues in the Republic of Korea.Coast.Manage. 19(4) : 391-415

Huang, W.W. and J. Zhang, 1990. Effect of particle size on transition metal concentrations in the Changjiang (Yangtze River) and the Huanghe (Yellow River), China. *Sci. Tot. Environ*., 94: 187-207.

Huang, W.W., J. Zhang and Z.H. Zhou, 1992. Particulate element inventory of the Huanghe (Yellow River): A large, high-turbidity river. *Geochim. Cosmochim. Acta,* 56: 3669-3680.

Hwang, K.C., 1983. Heavy metal content of oyster, *Crossostrea gigas*, and sea water in Hansan-Geoje Bay. *MS thesis*, Pusan National University, 37pp.

Inha University, 1996. The Exploitation Research of Marine Resources on the Yellow Sea, pp. 557 (in Korean).

Je, J.-G. 1999. Coastal Wetland of Korea: Current status and Protection. Nature Conservation, 105: 10-15. (in Korean)

Jeon, H.J., Y.C., Park and K.H. Chung, 1994. Distribution of nutrients and trace metals in coastal environment of Incheon. *Yellow Sea Res.,* 6:41-71.

Jin, X. 1996. Variations in Fish Community Structure and Ecology of Major Species in theYellow/Bohai Sea. Dr. Thesis. University of Bergen, Norway.

Jin, X. and Tang, Q. 1996. Changes in fish species diversity and dominant species composition in the Yellow Sea. Fisheries Research 26 (3/4):337-352.

Kahng, S.H., Oh, J.R., Shim, W.J., and Shim, J.H., 1996. Imposex as an evidence of TBT pollution in the Chinhae Bay. J. Malaco. Soc. Korea 12(2): 123-131

Kang, Y. Q. and Lee, B.D., 1985. On the annual variation of Mean Sea Level along the Coast of Korea. The Journal of the Oceanological Society of Korea. 20(1): 22-30.

Kang, Y.J. 1987. A rational approach for management of fisheries resources in coastal and offshore. Unpublished manuscript.

KFEM, 1997. http://www.KFEM.or.kr/KFEH/ACT-MAIN.html (in Korean)

Kim, J.K., 1998b. Environmental monitoring in Cheonsoo Bay area. BSPG 96256-1063-3. 900 p.

Kim, J.Y. and J.I. Kim 1994. A role of the Yellow Sea on the recruitment of mackerel. Proceeding of the 3rd ISMSYS: 224-230.

Kim, O. K., and Oever, P.,1992. Demographic transition and patterns of natural resources use in the Republic of Korea. Ambio 21(1) : 56-62.

Kim, S., Jung, S. and Zhang, C.I., 1997. The effect of seasonal anomalies of seawater temperature and salinity on the fluctuation in yields of small yellow croaker, Pseudosciaena polyactis, in the Yellow Sea. Fisheries Oceanography. 6: 1-9.

Kim, S.K., 1999. Environmental fate of PCBs in Incheon North Harbor Ecosystem. MS thesis, Seoul National University, 126pp

Koh, Chul-Hwan, 1996, Function and Value of Tidal Flats, in the Seminar on the Preservation and Efficient Utilization of wetlands, The Ministry of Environment.

KORDI, 1980. Marine Geology and Resources of the Yellow Sea, pp. 254 (in Korean).

KORDI, 1988. A Biological Study of the Yellow Sea, pp. 182.3. KORDI, 1985. A Study on the Atlas of Marine Resources in the Adjacent Seas to Korea, pp. 523 (in Korean).

KORDI, 1988. A study on the coastal water and pollution and monitoring. BSPG 00057-184-4.

KORDI, 1989. Sea/Air exchange in Yellow Sea(I), pp. 58 (in Korean).

KORDI, 1989. A study on the coastal water and pollution and monitoring. BSPG 00083-242-4.

KORDI, 1990. A study on the coastal water and pollution and monitoring. BSPG 00112-315-4.

KORDI, 1992. A study on the investigation and countermeasure of marine pollution in the Yellow Sea. BSPG 00170-505-4.

KORDI, 1993. A study on the investigation and countermeasure of marine pollution in the Yellow Sea. Annual report (1st year).

KORDI, 1994. A Study on the Real Time Forecast System of Oceanic Diffusion for environmental Preservation of the Yellow Sea, pp. 108 (in Korean).

KORDI, 1994. Management Technique for Marine Environmental Protection : A Study on the Investigation and Countermeasure of Marine Pollution in the Yellow Sea, pp. 297 (in Korean).

KORDI, 1994. Monthly mean sea surface winds over the East China Sea, pp. 91 (in Korean).

KORDI, 1994. Yellow Sea Large Marine Ecosystem : A Project Development, pp. 339 (in Korean).

KORDI, 1994. A study on the investigation and countermeasure of marine pollution in the Yellow Sea. Annual report (2nd year).

KORDI, 1996. Marine Environmental Monitoring and Assessment Technology : A Study on the Investigation and Countermeasure of Marine Pollution in the Yellow Sea, pp. 346 (in Korean).

KORDI, 1996. A study on the investigation and countermeasure of marine pollution in the Yellow Sea. BSPN 00301-948-4.

KORDI, 1997. A study on environmental changes in Shihwa lake. BSPN 96325-985-4.

KORDI, 1998. A Study on Water Circulation and Material Flux in the Yellow Sea, pp. 105 (in Korean).

KORDI, 1998. Integrated Survey on Environment and Ecosystem of the Yellow Sea, pp. 610 (in Korean).

KORDI, 1998. Ocean Circulation in the Western and Middle Part of East China Sea, pp. 278 (in Korean).

KORDI, 1998. Study on the Development of Hydrocarbon Resources in Yellow Sea, pp. 408 (in Korean).

KORDI, 1998. Study on Water Circulation and Material Flux in the Yellow Sea : On the Material Balance and Biological Cycle of the Yellow Sea, pp. 437 (in Korean).

KORDI, 1998. Yellow Sea Warm Current in the Western Area of Cheju-do, pp. 52 (in Korean).

KORDI. 1998. Tidal flat Studies for conservation and sustainable use. KORDI Repoart BSPE 97611-00-1058-3. 312pp (in Korean).

KORDI. 1998. Tidal Flat Studies in Korea. Ocean Research, 20(2) Special Issue; 57-235.

Korea China Joint Ocean Research Center, 1998. Guide to the Oceanographic Institutions and the Oceanographers of China, pp. 464 (in Korean).

Korea China Joint Ocean Research Center, 1999. Bibliography of the Yellow Sea Oceanography, pp. 345 (in English).

Korea Institute of Geology, Mining & Materials, 1991. Comparative Study on Sedimentary Basins of Korea and China in the South Yellow Sea, pp. 69 (in Korean).

Korea Legislation Research Institute, 1998, Statutes of the Republic of Korea.

Kwon, M.S., 1996, Marine pollution legislation in the Republic of Korea, In: Proceedings of the Regional Network on the Legal Aspects of Marine Pollution, Inception Workshop, 18-19 March, 1996, Philippines.

Kwon, Y.J. et. al. 1998. Endangered and reserved wild species in Korea. 301pp, Kyohak Publishing Co., Seoul. (in Korean)

Lee S. G and Sutinen, J. G., 1999, Large Marine Ecosystems, Socioeconomic and Governance: Implication for Korea. Korea Observer, 30(1) 9-58.

Lee, C.B., 1985. Sedimentary processes of fine sediments and the behavior of associated metals in the Keum estuary, Korea. In: *Marine and Estuarine Geochemstry*, (eds) Siglo A.C. & Hattori A., Lewis Pub., Inc., 209-225

Lee, C.B., 1992. The behavior of dissolved iron and its variability in the Keum estuary, a macrotidal system on the western coast of Korea. *J.Oceanol. Soc. Korea*, 27: 101-111

Lee, C.S., 1996. The present situation of marine pollution incidents and removal system and the prospects around Korean coastal sea. In: Proceedings of the International Workshop and Symposium on Environmental Restoration for Enclosed Seas. 261-275. Toyohashi, Japan.

Lee, C.W., M.K. Hong, I.S. Kwak, K.S. Park, H.K. Yun, J.J. Moon, I.H. Kang, M.H. Choi and H.D. Lee, 1995. Monitoring Program on Pesticides Residues in Food. The Report of National Institute of Health, Vol. 32(2), 470-482, 1995.

Lee, C.Y., Y.S. Qin, and R.Y. Liu. 1998. Yellow sea atlas. Inha University and Chinese Academy of Sciences, 524p.

Lee, D.S., 1988. Distribution of heavy metals in Korean coastal waters. In: *Co-operation for Environmental Protection in the Pacific,* UNEP Regional seas reports and studies No. 97. 255-268 pp.

Lee, D.S., K.T., Kim, G.H., Hong and S.H., Lee, 1989. Concentrations of heavy metals in the Han river and its tributaries, *J. Korea Soc. W.P.R.C*. 47-56.

Lee, E-H., B-H., Ryu and S-T., Yang, 1975. Suitability of shellfish for processing. 2. Seasonal changes in heavy metal content of baby clam, *Bull. Korean Fish. Soc.* 8(2): 85-89.

Lee, J.H., H.-J. Lie, B.W. An, and Y. Tang, 1999, Seasonal variability of water balance in the Yellow Sea, In Progress in Coastal Engineering and Oceanography, Ed. by B.H. Choi, KESOE, 13-24.

Lee, K.W., H.S., Kang and S.H. Lee, 1998. Trace elements in the Korean coastal environment. *Sci. Tot. Environ*. 214, 11-19.

Lee, S. D., 1991, National Legislation for Marine Environmental Protection: The Korean Experience, presented at The International Conference on Maritime Issues in the 1990's: Antarctica, Law of the Sea, and Marine Environment, Seoul, July 9-10, 1991.

Lie, H.J., 1998, A study on water circulation and material flux in the Yellow Sea, Current measurement and circulation of the Yellow Sea, 97-LO-01-03-A-01, MOST, 348pp. (in Korean)

Liu C, Zhang J, Yu Z, Shen Z (1998) Atmospheric transport of heavy metals to the Yellow Sea.

Martin, J.M. and A.J. Thomas, 1994. The global insignificance of telluric input of dissolved trace metals (Cd, Cu, Ni and Zn) to ocean margins. *Mar. Chem.,* 46, 165-178.

Martin, J.M. and H.L. Windom, 1991. Present and future roles of ocean margins in regulating marine biogeochemical cycles of trace elements. In: *Ocean Margin Processes in Global Change,* (eds) Mantoura, R.F.C., J.-M. Martin and R. Wollast. John Wiley & Sons

Martin, J.M. and M. Whitfield, 1983. The significance of the river input of chemical elements to the ocean. In: *Trace Metals in Sea Water* (eds) Wong, C.S., E. Boyle, K.W. Bruland, J.D. Burton and E.D. Goldberg. Plenum Press. New York and London. pp.920.

Martin, J.M., D.M. Guan, F. Elbaz-Poulichet, A.J. Thomas and V.V. Gordeev, 1993. Preliminary assessment of the distributions of some trace elements (As, Cd, Cu, Fe, Ni, Pb and Zn) in a pristine aquatic environment: the Lena River estuary (Russia). *Mar. Chem.,* 43: 185-199.

Ministry of Construction and Transportation, 1996, National Coastal Zone Assessment Project- Formulating Institutional Mechanism of Integrated Coastal Management, pp. 637.

Ministry of Construction, 1990, Basic Plan on Reclamation of Coastal Region, Seoul, Korea-The Ministry of Marine Affairs and Fisheries (MOMAF), 1998, Korean Wetlands.MOE, 1996. Environmental statistics yearbook. Ministry of Environment. Republic of Korea. 648 p.

MOE, 1988. Environmental statistics yearbook. No. 1. Ministry of Environment. Republic of Korea.

MOE, 1989. Environmental statistics yearbook. No. 2. Ministry of Environment. Republic of Korea.

MOE, 1990. Environmental statistics yearbook. No. 3. Ministry of Environment. Republic of Korea.

MOE, 1991, National Report of the Republic of Korea to UNCED 1992, pp.103.

MOE, 1991. Environmental statistics yearbook. No. 4. Ministry of Environment. Republic of Korea.

MOE, 1992. Environmental statistics yearbook. No. 5. Ministry of Environment. Republic of Korea.

MOE, 1993. Environmental statistics yearbook. No. 6. Ministry of Environment. Republic of Korea.

MOE, 1994. Environmental statistics yearbook. No. 7. Ministry of Environment. Republic of Korea.

MOE, 1995. Environmental statistics yearbook. No. 8. Ministry of Environment. Republic of Korea.

MOE, 1996. Environmental statistics yearbook. Ministry of Environment. Republic of Korea. 648pp.

MOE, 1997, Environment White Paper.

MOE, 1998. Environmental Statistics Yearbook. 581pp

MOE. 1994. Environmental Protection in Korea. 292pp.

MOENV (Ministry of Environment), 1998. Environmental Protection in Korea. 622pp.

MOMAF, 1997. Korean fisheries yearbook. Ministry of Maritime Affairs and Fisheries. Republic of Korea.

MOMAF, 1998, Maritime Affairs and Fisheries White Paper (1993-1997), pp. 799.

MOMAF. 1998. Tidal Flats in Korea. (in Korean)

National Park Authority. 1997. National Park of Korea. 137pp.

NFRDA, Korea, 1975. Survey of water pollution in surrounding waters of Korea. Tech. Rep. NFRDA, 30: 133-140.

NFRDA, Korea, 1977. Survey of water pollution in surrounding waters of Korea. Tech. Rep. NFRDA, 34: 53-67.

NFRDA, Korea, 1979. Survey of water pollution in surrounding waters of Korea. Tech. Rep. NFRDA, 47: 92-100.

NFRDA, Korea, 1980. Survey of water pollution in surrounding waters of Korea. Tech. Rep. NFRDA, 52: 90-99.

NFRDA, Korea, 1983. Comprehensive study on marine pollution for the conservation of the Korean coastal ecosystem with respect to culture areas and fishing grounds. Tech. Rep., 58: 495-579.

NFRDA, Korea, 1985. Comprehensive study on marine pollution for the conservation of the Korean coastal ecosystem with respect to culture areas and fishing grounds. Tech. Rep., 63: 229-346.

NSO, 1996. Population and housing census report, National Statistical office, Republic of Korea. CD-ROM.

NSO, 1997. Korea statistical yearbook, National Statistical Office, Republic of Korea. CD-ROM.

OECD, 1998. Environmental Performance Reviews. Korea. 195pp

Pace, M.L., 1982. Planktonic ciliates: their distribution, abundance and relationship to microbial resources in a monomictic lake. Can. J. Fisher. Aquat. Sci., 39: 1106-1116.

Park, G.S. and J.K. Choi, 1997. Microzooplankton assemblages: Their distribution, Trophic role and relationship to the environmental variables. J. Kor. Soci. Oceangr., 32(3): 145-155.

Park, K.B. 1978. History of the Korean Herring Fisheries. Thesis Collection of the National Fisheries University of Pusan, 21: 21-59.

PICES. 1996. Science Plan. Scientific Report No. 6. PICES.

Pomeroy, L.R. 1974. The ocean's food web: a changing paradigm. Bioscience, 24: 499-5004.

ROK. 1998. National Biodiversity Strategy. 85pp.

ROK. 1999. Wetland Conservation Act.

Sanders, G.S., 1983. Metals in marine atmospheric particles. Ph.D. Thesis, University of Liverpool.

Saydam, A.C., 1981. The elemental chemistry of Eastern Mediterranean atmospheric particulates. Ph.D. Thesis, University of Liverpool.

Schneider, B.,1987. Source characterization for atmospheric trace metals over Kiel Bight. Atmos. Environ., 21, 1275-1283.

Schubel, J.R., H.-T. Shen and M.J. Park, 1986. Comparative analysis of estuaries bordering the Yellow Sea. In: *Estuarine Variability,* Academic Press, Inc., 509 pp.

Sherman, K. and Tang, Q.1999. The Large Marine Ecosystems of the Pacific Rim. Blackwell Science.

Shim, J.H., S.H. Yoon, S.S. Yoon, D.H. Choi and B.C. Cho, 1995. Abundances and bacterivory of heterotrophic and mixotrophic nanoflagellates in an estuarine system of the Mankyung and Dongjin Rivers, Korea. J. Kor. Soci. Oceangr., 30(5): 413-425.

Shim, W.J., Oh, J.R., Kahng, S.H., and Shim, J.H., 1998. Accumulation of tributyl- and triphenyltin compounds in Pacific oyster, *Crassostrea gigas*, from the Chinhae Bay system, Korea. Archives of Environmental Contamination and Toxicology. 35: 41-47.

Talbot, V. and A. Chegwidden, 1982. Cadmium and other heavy metal concentrations in selected biota from Cockburn Sound, Western Australia. *Aust. J. Mar. Freshw. Res*., 33, 779-788.

Tang, Q. 1989. Change in the biomass in the Yellow Sea ecosystem. In: Biomass yields and geography of large marine ecosystems. P7-35. ed. by K. Sherman and L.M. Alexander. AAAS Selected Symposium 111. Westview Press, Inc. Boulder, CO.

Tang, Q.1993. The effect of long-term physical and biological perturbations on the contemporary biomass yields of the Yellow Sea ecosystem. In: Large marine ecosystems: Sress, mitigation, and sustainability. P79-93. ed. by K. Sherman, L.M. Alexander and B.D. Gold. AAAS Symposium. AAAS Press, Washington, DC.

The World Resources Institute, 1994, World Resources, 1994-95, Oxford Univ. Press, Washington, DC.

UN, 1997. World Population Prospects, 1950-2050. UN Population Division, New York.

UNU, 1996. http://www.geic.or.jp/landbase

Valencia, M.J., 1987. International Conference on the Yellow Sea: Transnational Ocean Resource Management Issues and Options for Cooperation. Occasional Papers of the East-West Environment and Policy Institute. Paper No. 3. 166 p.

Wang, Z., B., Zhang, J., Zhang and Y., Lu., 1990. Biogeochemical behaviors of dissolved trace metal in the Changjiang estuary and its adjacent area. In: *Proceedings of the International Symposium on the Biogeochemical Study of the Changjiang Estuary* *and its Adjacent Coastal Waters of the East China Sea*, (eds) Guohui Y., Martin, J.M., Jiayi, Z., Windom, H., and Dawson, R., China Ocean Press, 280-292.

Williams, P.J.L., 1981. Incorporation of microheterotrophic processes into the classic paradigm of the food web. Kiel Meer., 5: 11-28.

Won, J.H., 1973. The concentrations of mercury, cadmium, lead and copper in fish and shellfish of Korea. *Bull. Korean Fish. Soc*., 6: 1-19.

Won, K.P., C.M. Kim, Y.S. Sho, S.C. Jung, S.Y. You, K.H. Song, J.S. Kim, H.D. Kim and K.S. Kim, Study on the trace metal contents in food: On the trace metals contents of cereals, pulses and potatoes in Korea. The Report of National Institute of Health, Vol. 32(2). 456-469.

Yoo, J. C., and Lee, K. S., 1998. Current status of birds on the west coast of Korea and a recommendation for conservation. Ocean Res. 20(2) : 131-143.

Yoon, M.B., M.-H. Suh and Y.-M. Lee. 1998. Natural Monuments of Korea in color. 693pp. Kyohak Publishing Co., Seoul. (in Korean)

Zhang, C., and S, Yoo. 1993. Current Status of the Yellow Sea LME and Suggestions for Future Research Paper presented at the International LME Symposium and Workshop on the Status and Future of Large Marine Ecosystems of the Indian Ocean, Mombasa, Kenya, 28 March-2 April 1993.

Zhang, C.I. and S. Kim. 1999. Living marine resources of the Yellow Sea ecosystem in Korean waters: Status and perspectives. In: Sherman, K. and Q. Tang (eds.), Large Marine Ecosystems of the Pacific Rim: Assessment, Sustainability, and Management. Blackwell Science, Inc. pp. 163-178.

Zhang, C.I., Kim, J.M., and Huh, H.T. 1988. Current Status of Fisheries Resources and Their Rational Management in the Yellow and East China Seas. In Y.B. Go, (ed.), Proceedings of Symposium on Development of Marine Resources and International Cooperation in the Yellow Sea and East China Sea, Cheju, Korea, 19-22 October 1988, pp. 71-96.

Zhang, J. and Huang, W.W., 1993. Dissolved trace metals in the Huanghe: the most turbid large river in the world, *Wat. Res.,* 27: 1-8.

Zhang, J., 1995. Geochemistry of trace metals from Chinese river/estuary systems: an overview. *Est. Coast. Shelf Sci.,* 41: 631-658.

Zhang, J., Huang, W.W. and Martin, J.M., 1988. Trace metals distribution in Huanghe (Yellow River) estuarine sediments, *Est. Coast. Shelf Sci*., 26, 499-516.

Zhang, J., J.M. Martin, A.J. Thomas and P. Nirel, 1990. Fate of the particulate elements in the Changjiang estuary and the East China Sea. In: *Proc. Int. Symp. on the Biogeochemical Study of the Changjiang Estuary and its Adjacent Coastal Waters of the East China Sea,* (eds) Guohui Y., J.M. Martin, Z. Jiayi, H. Windom and R. Dawson. China Ocean Press, pp. 220-244.

Zhang, J., W.W. Huang and J.H. Wang, 1994. Trace-metal chemistry of the Huanghe (Yellow River), China – Examination of the data from in situ measurements and laboratory approach. *Chem. Geol.,* 114: 83-94.

Zhang, J., W.W. Huang, S.M. Liu, L.O. Yu and J.H. Wang, 1992. Transport of particulate heavy metals towards the China Sea: a preliminary study and comparison. Mar.Chem., 40, 161-178

Zhao, Y.Y., Yan, M.C. and Jiang, R.H., 1995. Abundance of chemical elements in continental shelf sediment of China. *Geo-Mar. Lett*., 15, 71-76.