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**Third Meeting of the Regional Working Group for the Fisheries Component**
*Weihai, China, 25-28 October 2006*

# Report of Fisheries Regional Data Synthesis

The results from the activity to collect national fisheries data and information from China and Republic of Korea were compiled to create a regional synthesis. This work was carried out from June to September 2006. The results of the regional synthesis will contribute to the Fisheries Chapter of the Transboundary Diagnostic Analysis (TDA).

A consultant from Pukyong National University, Korea, was contracted to prepare the regional synthesis, and the draft final report is attached hereafter. During the 3rd RWG-F Meeting, the consultant will present his results-to-date, highlight the regional status and trends of importance, and show the fisheries data gaps.

After reviewing the report and presentations, participants will discuss the information presented, and suggest how certain notable data and information could be included in the fisheries section of the TDA.

It should be noted that due to the delay in receiving national reports on data and information collection, the preparation of the regional synthesis was also delayed, which in turn, negatively impacted the preparation schedule of the regional TDA.

GEF

UNDP

Yellow Sea

**UNDP/GEF Project entitled "Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem"**

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# Report of Fisheries Component's Regional Data and Information Synthesis

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**Final Draft Report for Fisheries Component's**
**Regional Data and Information Synthesis**

## 1 BACKGROUND OF ASSIGNMENT

The plan of UNDP/GEF Yellow Sea Project – Reducing Environmental Stress in the Yellow Sea Large Ecosystem (YSLME) – is to prepare a regional synthesis of the fisheries data and information collected from the People's Republic of China and the Republic of Korea (hereinafter referred to as China and Korea, respectively) as well as to input it to the Trans-boundary Diagnostic Analysis (TDA). The formats and types of data and information to collect from the nations were agreed by the members of the Regional Working Group-Fisheries (RWG-F) of the UNDP/GEF Yellow Sea Project at the RWG-F's first and second meetings (RWG-F Report of UNDP/GEP Project, 2005). In addition, it was agreed that natural and socio-economic data/information should be included in the formats for analysis.

The statement of work issued by the Project Management Office (PMO) gives a guideline to carry out the main responsibility of preparing a regional synthesis report containing an assessment of the national fisheries and mariculture data and information collected from the nations.

The report should include:

1. A scientifically-sound assessment of national fisheries and mariculture data and information collected from China and Korea as well as review of national reports,
2. A synthesis and summary of the national data to provide a regional picture of both fisheries and mariculture status and trends in the Yellow Sea (illustrated through appropriate tables and figures),
3. A determination of the gaps in fisheries and mariculture information based on the available information and data generated through any other sources and,
4. An analysis of the regional problems in fisheries and mariculture, and results for the development of the Trans-boundary Diagnostic Analysis (TDA).

This paper describes not only the review of national report of China and Korea but also the Fisheries Component's regional data and information synthesis in accordance with the statement of work of PMO.

## 2 METHODS USED TO CARRY OUT ASSIGNMENT

The basic goal of this chapter is to create a long-term database using both national fisheries data, mainly fishery-dependent and auxiliary data acquired from China and Korea in the Yellow Sea. Then, this database can be used in the TDA for evaluation of commercially and/or economically important trans-boundary stocks. Furthermore, the combined data and information will be very useful for the ecosystem-based fisheries management in this region (Pauly et al., 2000).

Fishery-independent information, especially both biological and ecological data on the same species studied from respective national institutes will be compared to figure out scientific information gaps and/or discrepancies. It is quite clear that if different values on population parameters of the same species in a habitat would be used for stock assessment, the results could cause significant bias and also advise wrong recommendation to decision-makers (Gulland, 1983)..

### 2.1 Description of fisheries

The main idea is to evaluate the historical trends in both quantitative fluctuations and relative abundance (ex, CPUE: catch per unit of effort) from landing and fishing effort exerted to catch marine animals moving or distributing in between the two nations in the Yellow Sea. An attempt to standardize fishing effort between different types of fishing gears will be made from available data if possible.

#### 2.1.1 Quantitative analysis in landings (or catches)

- Comparison of long-term fluctuations of total annual landings
- Temporal variations of commercially important species

#### 2.1.2 Fishing effort analysis

- Type of fishing gear operating and amount of fishing effort for each different fishery (boats, tonnage and KW etc.)
- Long-term trends on fishing effort

#### 2.1.3 Feasibility study on standardization of fishing effort between different fishing gears

- Fishing effort for a single species fishery
- Fishing effort for multi-gear fishery
- Synthesis of fishing effort through standardization of fishing effort

#### 2.1.4 Estimation of relative abundance by species

- Catch per unit of effort (CPUE) for a single species fishery
- CPUE by species from multi-species and multi-gear fisheries
- CPUE from synthesis data between the two nations

#### 2.1.5 Experimental survey data

- Seasonal biomass trend for each species
- Early life history analysis

### 2.2 Biological and ecological studies

Population characteristic estimates for commercial fish species (or more species if available) studied between China and Korea will be compared to find out whether or not there are any significant differences in scientific findings between the same species in the Yellow Sea ecosystem.

Available data and information will be used to estimate fisheries reproduction potential as ecosystem indicators (Gislason et al., 2000).

- Growth pattern: growth equation, size at capture, maximum age and length-weight relationship
- Reproduction biology: fecundity, spawning time, size at spawning, sex ratio, life span etc.
- Migration patterns: spawning, nursery and wintering migration routes and areas

### 2.3 Status of mariculture

Aquaculture fisheries have a highly important role to play in comprehensive use of the sea together with some land-based use. Similarly to capture fisheries, mariculture in the Yellow Sea and its adjacent area has developed remarkably in recent years. Therefore, the general features to understand the current aspects in this region should be indispensably described on the basis of data and information collected from the two countries.

- Historical production trends by cultured animal and by habitat
  - Fishes, shrimp, shellfish and seaweeds etc.
- Patterns for feeding category
  - One without feeding and the other with feeding, and kind of feeding
- Locations and size of farming
  - Development of mariculture from artisanal fishery to industrial fishery
  - Changes in cultured animals and seaweeds

### 2.4 Socio-economic data and policy

The YSLME project should be focused on socio-economic benefits as they are related to resource sustainability options (Elsevier science, 2003). In this section, however, some data and information currently available from the two countries are only tabulated because of lack of data and information to analyze.

The long-term data and information are included in the tables:

- Number of fishing vessels and fishermen involved in fisheries
- Fisheries incomes and consumption per capita
- Fisheries export and import trends

Fisheries policies, on the other hand, will be reported with summary of main important fisheries management laws and regulations of the two nations.

### 2.5 Business travel

During the project period, business trips were necessary so that some field works could be done to meet this proposal.

- Confirmation and endorsement of data and information provided from the two countries to relevant scientists and/or institutes
- Interview with scientists and decision-makers
- Visiting fisheries-related archives etc.
- Participation of the 3rd RWG meeting

Business travel to relevant fisheries institutes

#### 2.5.1 Chinese institutes:

- National Marine Data and Information Service (NMDIS)
- Chinese Academy of Sciences
- Yellow Sea Fisheries Research Institute (YSFRI)

#### 2.5.2 Korean institutes:

- Ministry of Maritime Affairs and Fisheries (MOMAF)
- National Fisheries Research and Development Institute (NFRDI)
- Korea Ocean Research and Development Institute (KORDI)
- National Federation of Fisheries Cooperatives (NFFC)
- Korea Institute of Marine Science and Technology Promotion (KIMST)

### 2.6 Conclusion of the project requirements

All results and findings obtained through this proposed implementation, not only with the review of current data and national report but also the methodology for synthesis report, will be sufficiently met with the required services of the project. They will include: a scientifically-sound assessment of national fisheries and mariculture data and information between China and Korea, a synthesis and summary of the national data to provide the regional picture of fisheries/mariculture status and trends in the Yellow Sea, description of both data and information gaps as well as problems in capture fisheries and mariculture fisheries through the in-depth analysis, and relevant advices/ recommendations for development of the TDA.

## 3 REGIONAL SYNTHESIS OF DATA AND INFORMATION

### 3.1 Review of national fisheries and research programs

According to Contract No., CONOIA32201 data collect issued by the PMO on behalf of the YSLME Project, the national reports of data and information collection from both China (Yellow Sea Fisheries research Institute of CAS) and Korea (West Sea Fisheries Research Institute of NFRDI) include the following four major sectors: fisheries data, mariculture data, socio-economic data and legislation information.

More detailed tasks to provide the above sectors are elaborated as follows: reviewing and collecting the actual data and information for each parameter, providing the locations of available database, describing the status of commercial fisheries, describing the current state of knowledge of fisheries carrying capacity, describing the existing status and trends of mariculture, describing existing national laws and regulations on fisheries and mariculture, listing the gaps in data and information required for understanding change in the condition of fisheries, and submitting a report to describe the fisheries problems (YSFRI, 2006; NFRDI, 2006).

Appendix Table 1 (Annex III) shows agreed data formats at the RWG-F meeting and data submissions from both nations.

### 3.1.1 Description of fisheries

Most of marine living resources in the Yellow Sea and the East China Sea have their own migration patterns seasonally for spawning, hibernating, and feeding. In this region, there are about 300 fish species, 41 crustaceans and 20 cephalopods (National report of China, 2006).

Warm-temperate animals are more dominant than warm-water species among the fisheries resources. Migratory fish species mainly consist of both the warm-temperate and warm-water animals, showing a wide range of migration and distribution. Main target species in the Yellow Sea including the area of the East China Sea are listed in Table 1 together with local names in Chinese and Korean.

**China**: The economically important species in the Yellow Sea and the Bohai Sea are small yellow croaker (*Larimichthys polyactis*), largehead hairtail (*Trichiurus lepturus*) and fleshy prawn (*Fenneropenaeus chinensis*) etc. The dramatic change in fishery among the pelagic fishes was Japanese anchovy (*Engraulis japonicus*) in the Yellow Sea. Until the 1980s, there was no anchovy fishery, and in both 1997and 1998 its catch reached at more than 1 million MT, showing the highest landing from a single species capture and exceeding over Maximum Sustainable Yield (MSY). The fleshy prawn consists of three fishing seasons of autumn, winter/spring and spring seasons. Chinese shrimp fishery is mainly conducted in the autumn fishing season, accounting for 90% of the annual total catch. Having 300 years history in the Bohai Sea, acetes shrimp fishery plays an important role in Chinese marine fishery. Its production in the coastal waters of Zhejiang province was about 60-80% of the total marine shrimp catch in the Bohai Sea.

**Korea**: Rapid development of Korean fisheries occurred from the 1970s to the early 1980s. Total production was estimated to be worth about 4.82 billion USD in 1977, of which 26.2%, equivalent to about 1.26 billion USD came from the Yellow Sea catch. The catch in 1970 was about 244,000 MT and increased to 647,000 MT in 1987. After then, the annual catch in the Yellow Sea has kept a continuous downward trend. The Korean catch of capture fisheries in the Yellow Sea and the East China Sea comprised 34% of the annual total in 1971, 40% in 1987 and less than 30% in recent years (National report of Korea, 2006).

#### 3.1.1.1 Landings (or Catches)

The reported amount of catch record for the 10 commercially important fish species from China during 1986 to 2004 is given in Table 2 and Figs. 1 and 2, and in Table 3 and Figs 3 and 4 for Korea.

The annual total catch for the 10 commercial fish species during 1986-2004 showed that China has increased from about 296,000 MT in 1986 to 2,288,000 MT in 2004, especially keeping the catch level of more than 2 million MT since 1998 (Fig. 1). Korea has decreased from 128,000 MT in 1986 to 75,000 MT in 2004 (Fig. 3). The catch trends for each species are summarized below (Fig. 2 and Fig. 4).

**Small yellow croaker (***Larimichthys polyactis*)

**China:** Total catch of this species was only about 13.400 MT in 1986. The catch increased significantly every year, reaching 110,000 MT in 1995, but the 1996-1997 catches were decreased compared to the previous year's figure and then maintained a level of 155,000-160,000 MT, peaking at about 187,000 MT in 2004 (Table 2, Fig. 2). This phenomenon was mentioned by the national report of China that the fishing effort and fishing efficiency since 1957 have rapidly increased and was uncontrolled along with fishery development, leading to the small yellow croaker population subjected to over-fishing both inshore and offshore.

**Korea:** The catch for this species was recorded at less than 10,000 MT except for approximately 16,200 MT, 13,900 MT and 14,200 MT in 1991, 1992 and 1994, respectively. Long term trend of catch revealed an increasing pattern until the beginning of the 1990s, but a significant decreasing trend afterwards (Table 3, Fig. 4).

**Spanish mackerel** (*Scomberomorus niphonius*)

**China**: This species catch maintained less than 130,000 MT through the years of 1986-1995. Since 1996, the catch leveled off at an average value of about 250,000 MT from 1997 to 2004, and peaked at 292,000 MT in 1998 (Table 2, Fig. 2).

**Korea**: The highest catch was 1,860 MT in 1986 and then decreased to less than 1,000 MT for 11 years, 1992-2002, but recently was at 1,000 MT in 2003 and 2004 (Table 3, Fig. 4).

**<u>Anchovy</u>** (*Engraulis japonicus*)

**China**: Until 1996, anchovy catch steadily increased from 20,000 MT in 1989 and its figure reached nearly one million MT since 1997, consisting of the highest catch composition among all commercial fish species so far (Table 2, Fig. 2).

**Korea**: The catch has shown an increasing pattern year after year until 1999, at a level of about 50,000 MT. Afterward, it showed some fluctuation between 36,000 MT and 49,4000 MT (table 3, Fig. 4).

**<u>Chub mackerel</u> (***Scomber japonicus*)

**China**: The catch slowed its increase from 40,000 MT in 1986 to 76,000 MT in 1993. From 1994, yearly catch was recorded at a level between 130,000 MT and 165,000 MT (Table 2, Fig. 2).

**Korea**: This species was caught at very low levels, less than 7,000 MT throughout the study period with the exception of the catch of 12,600 MT in 1996 (Table 3, Fig. 4).

**<u>Largehead hairtail</u> (***Trichiurus lepturus*)

**China**: The steady upward trend was kept every year until 2004. The catch peaked at 300,000 MT in 2004, which was about 4 times that of the catch during 1986-1989 and 2.5 times during 1990-1993, respectively (Table 2, Fig. 2).

**Korea**: The catch trend showed a significant decreasing pattern from year to year since 1986. In 2002, it was about 2,900 MT and then showed some increase in its catch (Table 3, Fig. 4). The catch pattern between two nations revealed an opposite trend during the long term period.

**<u>Pacific herring</u>** (*Clupea pallasii*)

This fish species is not a target animal for both countries. This assumes that the species might be taken as by-catch, taking into account some years' catch records that showed much variation and/or there were no catches in recent years. However, the catch of this species from China during 1986-1991 was recorded between nearly 800 MT and 3,350 MT (Tables 2, 3).

**Sandlance** (*Ammodytes personatus*)

**China**: Until 2002, this fish was not utilized by China. From 2003, the catch record was at a very high level of 177,000 MT – 195,000 MT (Table 2, Fig. 2). China anticipates that this species will be a new target in Chinese fishery and also is in good condition (National report of China, 2006).

**Korea**: No annual trend existed but the catch was about 12,000 MT in 2000 (Table 3). In Korean capture fishery, this is not a target species but incidentally mixed in the fishing activities.

**Acetes** (*Acetes chinensis*) and (*A. japonicus*)

**China**: The catch has increased from 100,000 MT in 1993 to 294,000 MT in 2004. After 1997, it was recorded at a level of more than 250,000 MT (Table 2, Fig. 2).

**Korea**: Total amount of annual catch was less than 20,000 MT, peaking in 1993. There was an increased period for 8 years from 1986 to 1993 and then a decreased period for 12 years from 1993 to 2004. The 2004 catch was about 5,200 MT (Table 3, Fig. 4).

**Fleshy prawn** (*Fenneropenaeus chinensis*)

**China**: This species was caught at 18,000 MT in 1988, indicating a peaked catch but it decreased to 4,600 MT in 1995. Afterwards, the catch slowed the trend of increase at a level of less than 8,000 MT (Table 2, Fig. 2).

**Korea**: The catch of this species was recorded at between 1,000 MT and 1,500 MT during 1994-1997 (Table 3). It showed a trend of rapid decrease (Fig. 4).

**Squids** (*Todarodes pacificus*, *Loligo* spp. and *Sepia* spp.)

**China**: Annual catch of this species has shown a trend of decrease from 22,200 MT in 1986 to 10,000 MT in 1992, but it maintained an annual catch level between 32,000 MT and 39,000 MT during 1995-1999. In 2000, the catch peaked at about 73,000 MT and then decreased to about 27,000 MT and 30,000 MT in 2003 and 2004, respectively (Table 2, Fig. 2).

**Korea**: Yearly catch from 1986 to 2004 showed a significant decreasing pattern. The catch in 1986 was 30,000 MT and it decreased to 10,000 MT in 1992. Since 1993, the annual catch was recorded at less than 10,000 MT until 2004 (Table 3, Fig. 4).

3.1.1.2 Catch composition by species

**China**: A long-term catch composition is given in Fig 5 from the Yellow Sea and the Bohai Sea. In recent years, anchovy showed the highest proportion. During the 1950s-1960s, Spanish mackerel, largehead hairtail and acetes have taken a high portion but low catch levels.

**Korea**: Percentage species composition based on the catch (Table 3) for the 1980s, 1990s and 2000s is presented in Fig. 6. In the 1980s, the most dominant species was largehead hairtail which accounted for 41.5%, followed by 20.1%, 19.4% 10.1% and 3.8% for anchovy, squids, acetes and small yellow croaker, respectively. In the 1990s, anchovy occupied the highest proportion with 37.5% of the total catch, and largehead hairtail 23.8%, acetes 14.1%, small yellow croaker 9.2& and squids 8.5%. In the 2000s, the dominant species in catch composition was anchovy, accounting for 61.6%. Proportion of catch for each species was acetes 10.1%, squids 8.6% largehead hairtail 7.9% and small yellow croaker 4.6%.

3.1.1.3 Fishing efforts

The fishing efforts including number of boats, tonnage and KW units for both nations are given in Tables 4 and 5 for China and Korea, respectively.

**<u>Total tonnage and KW of vessels</u>**

**China**: The yearly number of powered vessels increased from 46,000 in 1986 to 81,000 vessels in 1991 and remained almost at 110,000 vessels until 2001. From 2002, it decreased from 98,000 vessels to 96,000 vessels in 2004. Total tonnage of powered vessels has shown an increasing trend from about 730,000 tons in 1986 to over one million tons in 1991. During 1991～1996, there had been a little fluctuation in the gross tonnage of 1.2 million tons, but its value from 1997 to 2002 increased to about 1.5 million tons. In recent years, both the 2003 and 2004 figures showed a slight downward trend. The figure of KW between 1986 and 2004 showed a year after year trend of increase from about 1.2 million KW to 3.1 million KW (Table 4).

On the other hand, annual number of non-powered vessels has kept a downward trend as whole, showing a peak of about 35,000 vessels in 1992. Total tonnage of vessels showed the same fluctuation with yearly total number of vessels, peaking at about 50,000 vessels in 1992 (Table 4). The figure for 1986 was 55,000 vessels.

**Korea**: Annual number of powered vessels increased from 24,000 in 1986 to about 30,000 in 1991 and then decreased to 23,000 in 1997. From 1998, it kept up at about 32,000～33,000 vessels until 2004. Total tonnage of vessels has leveled off almost at 160,000 tons and in recent years it showed a trend of decrease. Then, total tonnage was recorded at 131,000 tons in 2004. For the non-powered vessels, total number and tonnage revealed a trend of significant decrease from 6,500 to 1,400 vessels and about 10,000 tons to 1,100 tons throughout the whole years (Table 5).

**Tonnage per vessel**

**China**: Tons per powered vessel showed no big changes between years, remaining at a range between 10 and 16 tons/vessel. Non-powered vessels' values also kept a nearly constant level from 1.0 to 1.9 tons/vessel during the period (Table 4).

**Korea**: Yearly powered vessel value during 1986-1996 had a value of 5.2-6.15, and then slowly decreased from 6.2 in 1994 to 4.0 in 2004. The number of non-powered vessels decreased year after year between 1.5 in 1986 and 0.8 in 2004 (Table 5).

### 3.1.2 Biological and ecological data

#### 3.1.2.1 Growth parameters

The estimates of growth parameters for 10 commercial fish species resulted from both nations' research institutes are tabulated in Tables 6 and 7 for China and Korea, respectively.

When compared to the estimated values for each species, there existed a tremendous difference in the longevity of small yellow croaker (*Larimichthys polyactis*), *that is*, the estimate from China was 23 yr and 10 yr from Korea.

For Spanish mackerel (*Scomberomorus niphonius*), asymptotic length was 71㎝ from China and 123.3㎝ from Korea.

There is no available information on the asymptotic length of anchovy (*Engraulis japonicus*) from Korea, but longevity of this species showed different values with 4 yr and 1 yr from China and Korea, respectively (Tables 6 and 7).

Asymptotic lengths of chub mackerel (*Scomber japonicus*) from Korea data also differ between references. No information is available for Pacific herring (*Clupea pallasii*) from Korea.

Largehead hairtail (*Trichiurus lepturus*) are not much different for the two countries. Sandlance (*Ammodytes personatus*) were not studied for the growth parameter from both nations but length-weight relationship is given from China.

The parameters of acetes (*Acetes chinensis* and *Acetes japonicus*) are not available from China. Fleshy prawn (*Fenneropenaeus chinensis*) is estimated by female and male from Korea, and common squids (*Todarodes pacificus*) are available for both countries.

#### 3.1.2.2 Reproduction and spawning characteristics

Reproductive biology for the 10 commercial species studied from China and Korea are presented with information on fecundity, optimum water temperature and mean length at maturity and spawning season (Tables 8-1, 8-2). Mean lengths at maturity of small yellow croaker and Spanish mackerel had quite different values between the two nations. Small yellow croaker was 13.5 ㎝ from China and 19.1㎝ from Korea. Spanish mackerel was 35/42 ㎝ from China and 78 ㎝ from Korea.

#### 3.1.2.3 Migration and distribution

The national reports of China and Korea described patterns of migration and distribution for 6 commercial species together with seasonal movement routes, and more detailed explanations of them are given in the migration and distribution of commercial species in Section 3.2.2 (National report of China, 2006 and National report of Korea, 2006).

### 3.1.3 Bottom trawl survey

Trawl survey activities were conducted from both nations in June, 2000-2004 from China, and spring/winter seasons, 2003-2006 from Korea. The results derived from the surveys are summarized in the synthesis of data and information in Section 3.2.3 with the species composition, seasonal density distribution and ichthyoplankton survey.

### 3.1.4 Status and trends of mariculture

#### 3.1.4.1 Mariculture status

**China**: Mariculture in China has a very long history dating back to the Song Dynasty about 1,000 years ago (National report of China, 2006), cultivating a kind of seaweed called glueweed (*Gloiopeltis furcata*) in Jinmen near Xiamen province. Oyster cultivation must have existed in China for a long time, probably more than 1,000 years, and records from 400 years ago have been found. Cultivation of mollusks must have been in existence for a few hundred years. The gangyang or tank cultivation of fish and shrimp in the coastal region of Tiajin has a history of perhaps 2,000 years. In recent years, more and more species of seaweeds, mollusks, shrimp and fish have been introduced from foreign countries.

Its report voices that there have been cultivation eras: the seaweed era before the middle of 1990s, mollusks era from 1986 to present and in the near future, shrimp era will come soon.

**Korea**: According to the available documents, it was around 300 years ago when commercial aquaculture was first practiced in Korea. A culture of seaweed species, *Porphyra* sp. appeared in estuarine waters on the southern coasts of the peninsula. Pacific oyster (*Crassostrea gigas*) has also hundreds of aquaculture history. The science-based research activities were initiated since 1929 when Jinhae Inland Fisheries Research Institute of NFRDI was organized, focusing on freshwater finfish including common carp.

The aquaculture research activities for freshwater finfish contributed to the development of mariculture. NFRDI and Pukyong National University played a central role in mariculture development in Korea. Hatchery-based seed production was the primary element for recent aquaculture because advanced aquaculture technology was based on mass production from hatchery-based seeds. More than ten marine hatchery labs, which were re-organized as specialized research centers of NFRDI, have taken part in technical aspects of the hatchery-based seed production technology. Due to contribution of the efforts, commercial hatcheries have thrived successfully in Korea, providing fish and shellfish farmers with the seeds for aquaculture.

Aquaculture has been contributed to supply an important source of marine protein to Koreans. Because the capture fishing industry has peaked and is likely to decline as wild stocks are diminished, aquaculture will become a growing source of seafood products. In fact, a considerable percentage of all aquatic products consumed in Korea are coming from aquatic farms.

For some species, the production totally comes from aquaculture activities in the country. The aquaculture industry of Korea, however, has lots of problems (MOMAF, 2005). Outbreaks of diseases and harmful algal blooms (ex. red tide) in the farming grounds occur annually. However, efforts to get through the problems are continuous, using environmentally-sound aquaculture practices. An approach to molecular biology and genetics is of recent interest in the practice of modern aquaculture.

#### 3.1.4.2 Mariculture trends

**China**: Traditionally, freshwater culture dominated, but in recent years, the marine aquaculture has increased dramatically. This is partly due to the overexploitation of natural fish stocks in Chinese waters, which has forced many fishermen to change their profession to fish or shellfish farmers. Rapidly developed scallop culture with other mariculture industries in last decade have overcrowded almost every potential culture site in the shallow seas of China. In consequence, low growth rate, high mortality and increased costs are challenging the sustainable development of mariculture industry (National report of China, 2006). It is also expected that mariculture will continue expanding in China as an important source of seafood.

**Korea**: Mariculture production in the Yellow Sea coast of Korea reached 208 x $10^3$ MT or 22.7% of total national mariculture production in 2004. Of these, seaweeds consist of a considerable part of total marine aquaculture. The yield of seaweed is 145.9 x $10^3$ MT, or 70.1% of the total Yellow Sea mariculture production. The farmed production of finfish, crustaceans, and mollusks occupy 3.9%, 0.5% and 25.5% respectively. Of the marine farmed production, shellfish are of interest in the Yellow Sea coast of Korea (National report of Korea, 2006).

#### 3.1.4.3 Species groups

**Seaweed**

China: Scientific aquaculture in China started with kelp (*Laminaria japonica*) in 1952. Kelp cultivation was used at first by natural sporelings, and then palm ropes in the form of rafts were used for collecting spores. Production of Japanese kelp dry per annum was as much as about 801,000 tons as the greatest producer in the world. Shandong and Liaoning provinces are the main producing areas of kelp whose annual production accounts for more than 30%, an average of 400,000 tons, of the total.

Purple laver cultivation has been successful, producing some *Porphyra* by rock cleaning method for a few hundred years. In 1952, large scale cultivation was conducted with an improvement of the traditional Japanese pillar method. Main producing area is one of the Yellow Sea coastal provinces, Jiangsu, accounting for more than 80% of the total production, 10,000 MT per year, in China. Others cultivated are *Undaria pinnatifida* and *Hizikia fusiformis* of brown algae and *Gloiopeltis furcata*, *Gracilaria* spp., *Eucheuma gelatinae* and *Gelidium amansli* of red algae. In recent years, *Dunaliella salina* of green algae and *Spirulina platensis* of blue-green algae are cultivated. Now there are more than 20 species and groups of seaweeds under culture.

Korea: Seaweeds have a long history of aquaculture and have been important aquatic products in Korea. The seaweed production in YS coast reached 145.9 x $10^3$ MT in 2004 and occupied 70.1% of the total mariculture production in the west coast of Korea. The two species, laver *Porphyra* and sea mustard *Undaria* occupied 92.5% of the total seaweed production. Other minor cultured species are kelp *Laminaria*, fusiforme (*Hijikia fusiforme*), and green algae *Enteromopha*.

There are about 16 species of *Porphyra* growing along the coast of Korea. Common cultivated strains of *Porphyra* in Korea are *P. yezoensis, P. tenera* and *P. kuniedae*. The history of seaweed culture began with *Porphyra* in Korea. According to the oldest records on *Porphyra,* the algae were processed by chopping and drying as early as 1425. Another story, passed from generation to generation, tells that it was in 1623-1649 that *Porphyra* was cultivated around Taein Island when a fisherman found some floating bamboo twigs with *Porphyra* attached to them and began his own cultivation by planting bamboo twigs along the sea shore. This bamboo twig cultivation method was used until 1986 around Taein Island and its vicinity on the south coast. The method is no longer in use.

In Korea, there are two forms of *Undaria*, i.e., southern and northern types. Compared to the southern form, the northern form has a longer stripe with sporophylls arising from the lower region with a deeply divided blade. This morphological character has very important implications for the efficiency of *Undaria* processing. In the early stages of *Undaria* cultivation, the selection of morphologically dominant strains for artificial seeding was considered to be important. However, most farmers disregarded this fact after the success with mass production of *Undaria*. The influence of plant morphology is being seriously reviewed in order to encourage strong competition in *Undaria* cultivation and marketing. Technology for producing artificial *Undaria* seeding was first developed in 1967.

**Mollusks**

China: The first mollusk in cultivation was the mussel (*Mytilus galloprovincialis*) and production yielded about 210,000 MT. The local scallop (*Chlamys farreri*) and bay scallop (*Argopecten irradians*) which was introduced from America were cultivated at commercial level in the 1980s. In 1996, three species, *Argopecten irradians, Patinopecter yessoensis* and *Crassostrea gigas,* were denoted as new species. The production was about 910,000 tons in 2004, of which about 548,300 tons were from Shandong province.

Three species of oyster and scallop are cultured: *Crassostrea rivularis* of Guangdong in the South China Sea, *C. dalianwanensis* of North China and *Argopecten* spp. of Fujian and Zhejiang in the East China Sea in the Yellow Sea.

Korea: Production of shellfish in the coast of the Yellow Sea in 2004 reached 53 x $10^3$ MT, making up 27.2% of the national shellfish production. Two shellfish species, Pacific oyster and Manila clam have been major bivalves in the Yellow Sea mariculture industry. Production of these two species occupied 91.7% of the total YS shellfish production.

Oyster aquaculture has been a traditional practice and has taken considerable parts of total shellfish production in Korea. For the culture of Pacific oysters, *Crassostrea gigas* seeds are obtained both from wild collection and hatchery. Hatchery based seeds have been commercially available from the 1990s, and a numbers of oyster farms are using the hatchery-based seeds.

Farming grounds of Manila clam (*Ruditapes philippinarum*) in the Yellow Sea coast are normally selected based on sandy-silt or muddy-gravel bottoms from the inter-tidal zone to 2 meters in depth. Most of the farming for Manila clam is in Chungcheongnam-do, Jeollanam-do and Jeollabuk-do of the west coast of Korea. Almost all the seedlings for aquaculture have been caught from wild habitat in Taean, Boryeong, Dangjin and Hongseong in Chungcheongnam-do.

Recently, because of reduction in wild seedling resources at natural habitats in Korea, demands for import of juveniles from China and Democratic People's Republic of Korea are being increased. In addition to natural seedling catches, artificial hatchery-based spat producing techniques are already developed by NFRDI, but development of mass producing techniques in the field (for example in dike pond or tidal flat habitat) still remain as a problem to be solved.

**Crustaceans**

China: Shrimp farming developed very slowly before the middle 1970s because of little support and low profits. Pond culture is the principal form of shrimp mariculture. Annual production of cultured shrimp has jumped from 450 tons in 1978 to about 535,000 MT in 2004.

The most common cultivation species are *Penaeus vannamei, P. monndon, P. chiesis and P. japonica.* These four species are cultured in the Yellow Sea coastal provinces, Liaoning, Shandong, Hebei and Jiangsu, producing about 92,000 tons in 2004.

Korea: Crustacean culture in Korea is primarily of Penaeid shrimps.

Two Penaeid shrimps, fleshy prawn (*Fenneropenaeus chinensis*) and Kuruma prawn (*Penaeus japonicus*), have been cultured for decades in the western and southern coasts of the Korean peninsula. Shrimp farming began in the 1960s and the farming industry was developed in the 1980s. Farmed shrimp production has been rapidly increasing since the 1990s. More than 90% of shrimp farms are located in the western coast and the remainders are along the southern coast.

Two species, fleshy shrimp and Japanese kuruma shrimp had been cultured before the middle of 1990s, but kuruma shrimp had not been cultured since the introduction of WSSV (white spot syndrome virus) into Korea in 1993. Pacific white shrimp (*Litopenaeus vannamei*) was first introduced from U.S.A. in 2003.

NFRDI imported three hundred SPF (specific pathogen free) brood-stocks from Hawaii, U.S.A. in 2003, which succeeded with production of post-larvae and grew up to commercial size. For commercial purposes, some shrimp hatcheries began to import SPF brood-stock from 2004 and the potential of white shrimp farming is expected to rapidly increase in next few years.

**Fishes**

China: Fish mariculture has had a history of about a hundred years but it was primarily a rough cultivation method of enclosing the fry of the fish *Liz soiuy* in enclosures together with shrimp (*P. chinensis*) at the beginning. In 1980, the area under cultivation was about 16,700 ha with production of 2,600 tons, averaging 155 kg/ha.

The main production region is Guangdong with 35,000 ha, producing 28,000 tons, accounting for 84% of the total Chinese cultivation area in 1990. At beginning in 1958, experiments achieved with mugli and more recently with sea bream *Pagrosomus* and *Sparus*, flatfish *Paradichthys* and grouper *Epinephelus*. Besides, natural fry of Japanese eel has been caught and reared. In 2004, total production was about 582,600 MT.

Annual total production of marine and freshwater aquaculture together consisted of 30% of the total fishery production in 1980, 43.8% in 1985, 50.2% in 1988 and 47.6% in 2004.

Korea: The total farmed finfish production in the Yellow Sea coast reached 8,050 MT in 2004 and occupied comparatively small parts of total mariculture production in the west coast of Korea. Two marine finfish, olive flounder and black rockfish, dominate all the finfish species farmed in Korea. Production of these two species consists of 76.1% of total finfish production. Other minor farmed species are sea bass (*Lateolabrax japonicus*), mullet (*Mugil cephalus*), black sea bream (*Acanthopagrus schlegeli*) and parrot fish (*Oplegnathus faciatus*).

Olive flounder (*Paralichthys olivaceus*) is one of the most important marine species cultured in Korea. Flounder culture is totally based on the hatchery seeds, and is mostly practiced in the flow-through system of land-based facilities. Conditioning strain-good brood-stocks for seed production is one of the key issues in the flounder aquaculture. The flounder together with black rockfish has been a key marine finfish species cultured in this country since the late 1980s.

With an aid of the advanced aquaculture technology on this species, particularly on the conditioning technology of the brood-stocks in captivity, the production of the species is totally under control. However, some items, such as how to effectively control diseases and how to get better brood-stocks are on-going subjects which need continuous research. Although the aquaculture for the olive flounder started from the late 1980s, its commercial production was from the beginning of the 1990s. Soon after industrialized production, Korean production exceeded Japanese production and was maximized by 1997, thereafter showing a decreasing trend.

Black rockfish (*Sebastes schlegeli*) has been studied since 1986 by NFRDI for aquaculture purpose. Currently, its artificial seedling cultivation method has been established. The rockfish together with olive flounder are the leading species farmed in the west coast of Korea.

### 3.1.5 Socio-economics

#### 3.1.5.1 Vessels by fishery

**China**: The total number of fishing boats operated in the coastal waters in China showed a decrease trend in recent years while it slightly increased in the distant water fisheries (Table. 9). In contrary to the number of boats, Gross tonnage figures showed a bit of an upward trend as a whole. Number of vessels by province is given in Table 10. Fishing vessels are mainly from both in Shandong and Liaoning provinces, but showed a decline from about 43,300 in 2000 to 29,700 in 2004 and 33,800 in 2000 to 25,000 in 2004 in respective province. Gross tonnage maintained an increasing pattern in both provinces.

**Korea**: Both number of fishing boats and vessel's gross tonnage in the coastal and off-shore fisheries had a trend of slight decrease (Table 11-1). In province figures, the vessel's numbers are mainly registered in Jeonnam between 35,800 and 36,800 vessels during 2000～2004. In Jeonbuk, fishing boats showed a significant increase to 36,000 in 2004 from about 5,000 in 2000 (Table 11-2).

3.1.5.2 Fishermen

**China**: Fishermen engaging in fishing both in the sea and inland waters were 1.82 million in 2004 (Table 12), and most fishermen are from Shandong and Jiangsu provinces, followed by Liaoning and Hebei provinces.

**Korea**: Number of fishermen maintained a slight decrease from 140,000 in 2000 to 122,000 persons in 2004 (Table 13). Most fishermen are located in Jeonnam province, and this showed a declining trend.

3.1.5.3 Fisheries income

**China**: Total fishery production was 49 million MT in 2004 including capture of 17.0 million MT (14.5 million MT from coastal and distant waters, 2.4 million MT from freshwater) and aquaculture of 32.1 million MT (13.2 million MT from mariculture, 18.9 million MT from freshwaters), with a total of about 38 billion Yuan, equivalent to 4.75 billion USD (National report of China, 2006). Total annual income has steadily increased from 3.51 billion USD to 4.75 billion USD, comprising 35.2% (Table 14).

**Korea**: In 2004, total production was 2.52 million MT (1.08 million MT from coastal and off-shore waters, 0.92 million MT from shallow sea culture, and 0.50 million MT from distant waters). Net income per fishermen house in 2004 was estimated to be about 12,000 USD, indicating an 18.6% increase compared to the 2000 figure (Table 15).

3.1.5.4 Exports and imports of fishery products

**China**: Total quantity of trade with 150 countries was 5.4 million MT, valued at 10.2 billion USD in 2004. Table 16 gives the figures of total exports and imports from 2000 to 2004. There are increasing trends in recent years.

**Korea**: Exports of fishery products are shown with a decrease from 2000 to 2003 but slight increase in 2004. Annual imports have kept a year after year upward trend (Table 17).

3.1.5.5 Economic importance of fisheries (GDP contribution)

**China**: Contribution of fisheries to GDP was 3.14% in 2000 and 2.78% in 2004, showing a decreasing trend (Table 18).

**Korea**: GDP contribution of fisheries was within 0.3% and 0.4% per year (Table 19).

3.1.5.6 Fishery consumption per capita

**China**: Per capita consumption ranged from 10～13 kg throughout the years with little fluctuation (Table 20).

**Korea**: Consumption per capita increased from 36.8 kg in 2000 to 44.7 kg in 2003 (Table 21).

## 3.2 Synthesis of data and information

### 3.2.1 Description of fisheries

#### 3.2.1.1 Total landings (or catches)

The historical trend of total landings combined from Chinese and Korean fisheries data, and those of each nation for 10 commercial species in the Yellow Sea from 1986 to 2004 are given in Figs. 7 and 8 and in Table 22. The total landing has shown a rapid increasing trend every year from about 425,000 MT in 1986 to 1.9 million MT in 1997. Then, it remained at a level of 2.08 million MT during 1998～2002, increased to 240 million in 2003 and 2.36 million MT in 2004, maintaining a slow upward trend. The annual landings in this region are very much dependent on China's figures, with an average value of 92.6% of the total during the study period (Fig. 7).

Trends of commercial species are summarized below:

**Small yellow croaker** (*Larimichthys polyactis*)

Yearly catch of this species was increased from 16,000 MT in 1986 to about 85,000 MT in 1994. Since 1995, the catch level varied between about 100,000 MT and 110,000 MT until 1998. The catch showed a trend of increase from 146,000 MT in 1999 to 193,000 MT in 2004 as a whole (Table 22). The total annual catch of China accounted for 92.4% per annum (Fig. 8).

**Spanish mackerel** (*Scomberomorus niphonius*)

This species was caught at 56,700 MT in 1986 and increased to 178,500 MT in 1997. The catch was 292,000 MT in 1998 which was the highest level through the whole period. Then, it showed a slightly downward trend, recorded at about 275,000 MT in 2004 (Table 22). The Chinese catch of this species has a proportion of 99.4% of the total per year (Fig. 8).

**Anchovy** (*Engraulis japonicus*)

In 1997, its catch reached nearly at 1.04 million MT, which is about 37 times as compared to the 1986 catch. Afterwards, the species catch remained at a level of 1.02 and 1.10 till 2003, but the catches in 1999, 2000 and 2004 were less than 1.0 million MT, respectively (Table 22). The catch proportion of China averaged at 93.4% during the period (Fig. 8).

**Chub mackerel** (*Scomber japonicus*)

The catch peaked at 171,000 MT in 1995, indicating a continuously increase trend from 43,000 MT in 1986 even though the 1991 catch was decreased to about 40,000 MT. From 1996, it showed a slight decrease with a fluctuation between 133,000 MT and 161,000 MT (Table 22). The Chinese proportion of this species was 96.2% on average through the whole period (Fig. 8).

**Largehead hairtail** (*Trichiurus lepturus*)

The steady upward trend was maintained until 1995, reaching at 226,000 MT. In 1996 and 1997, there was a little decrease in the catches. The annual catch showed a slow increasing trend with a level of 222,000 MT and 240,000 MT from 1999 to 2003. The 2004 catch peaked at 312,500 MT (Table 22). The catch proportion was 86.2% from China and 13.8% from Korea (Fig, 8).

**Pacific herring** (*Clupea pallasii*)

This fish is not a target species of both nations (Fig. 8). The catch peaked at 3,360 MT in 1987 and at 4,600 MT in 1991. Then it decreased significantly to less than 600 MT until 2004 (Table 22). During 1986～1990, the annual catch was mainly from China with over 99.5 % of the total, but in 1991 about 76% of the total was from Korea.

**Sandlance** (*Ammodytes personatus*)

This species was not utilized until 2002 by China. In 2003, however, the catch was 197,000 MT and 177,000 MT in 2004. Korean catch was recorded sporadically but not at a commercial level (Table 22, Fig. 8).

**Acetes** (*Acetes* c*hinensis*) and (*A. japonicus*)

The catch trend showed an increase from 82,000 MT in 1986 to 304,000 MT in 1998, with a decrease to 79,000 MT in 1992. Since 1999, it decreased 244,000 MT in 2003, but increased to 299,000 MT in 2004 (Table 22). The catch portion was 93.2% from China and 6.8% from Korea on the average during the period (Fig. 8).

**Fleshy prawn** (*Fenneropenaeus chinensis*)

Yearly total catch varied between 10,000 MT and 18,500 MT during 1986～1992, showed a decreasing trend for a while. From 1993 till 2004, it remained at less than 10,000 MT (Table 22, Fig, 8).

**Squids** (*Todarodes pacificus*), *Loligo* spp. and *Sepia* spp.

The annual catch has shown a steady decrease from 52,600 MT in 1986 to 25,000 MT in1994. From 1995, its catch showed a slight increase until 2000, peaking at 76,400 MT through the whole period. Then, it decreased again at a level of 33,000～38,000 MT in 2003 and 2004 (Table 22, Fig. 8).

#### 3.2.1.2 Catch comparison between Powered and non-powered vessels

**China**: More than 95～98% of annual total catch was from the powered vessels and only about 5% from non-powered vessels in the Yellow Sea during 19 years from 1986 to 2004 (Fig. 9). The number of powered vessels stopped its increasing trend since 1997 but the annual catch stayed between 1.4 million and 1.5 million MT during 1997～2002, and decreased to less than 1.4 million MT in 2003 and 2004 (Fig. 9).

#### 3.2.1.3 Catch composition by commercial species

10 species compositions of total catch for China and Korea in the Yellow Sea are given in Table 23.

**China**: Percentage composition of 10 species in this region increased from about 20% in the 1980s to 37% in 1995. From 1996, the portion dropped to 18% both in 1998 and 1999 and then in the 2000s, it occupied over 40% every year.

Main target species in the yearly catch composition were largehead hairtail, acetes and Spanish mackerel with a proportion of total catch ranging from 3.0%～6.0%. Anchovy showed a higher portion between species composition in the years of 1994～1997 and 2001～2004 with a value of more than 13.0% and 17.0%, respectively. Small yellow croaker as commercially valuable species has a low proportion every year with a trend of increase.

**Korea**: The 10 species percentage composition every year remained between 28% and 36% (Table 23). Largehead hairtail showed the highest percentage portion during the first half of the 1980s, with values of 10.0～12.0% and then decreased significantly. Anchovy had a gradually increasing trend until 2003, showing the highest percentage of 25%. Acetes occupied a higher portion during the first half of the 1990s, with values of 4.0～6.0% (Table 23).

3.2.1.4 Fishing effort

**Powered and non-powered effort**: Total boats from China and Korea showed an increasing trend for 7 years from about 100,000 vessels in 1986 to 153,000 vessels in 1992, then it remained constant at 140,000～150,000 vessels until 2004. This trend mainly followed Chinese fishing effort, while Korean effort remained unchanged at about 30,000 vessels throughout the period (Table 24, Fig. 10). In contrary to this, gross tonnage showed a slow increasing trend according to Chinese yearly number of vessels, but Korean vessels showed no fluctuation across the years (Fig. 10).

**Powered vessel effort**: The trend showed an increasing pattern from 72,500 vessels in 1986 to 140,000 in 2000, then a bit of a downward trend to 2004 (Fig. 11). Gross tonnage of powered vessels showed the same picture with that of the total effort, which implies that total effort was entirely depended upon by powered vessels (Table 24, Fig. 11).

**Non-powered vessel effort**: Both number of vessels and gross tonnage from China and Korea have shown a continuous decreasing trend from year to year (Fig. 12). In 2004, the numbers of boats were about 10,000 vessels and gross tonnage was about 15,000 tons (Table 24).

**KW of powered effort**: Total KW has kept up a steady increasing trend from 1.9 million KW in 1986 to 7.1 million KW in 2002 and then leveled off at this value in 2003 and 2004 (Fig. 13). It should be pointed out that KW from Korea showed much higher values than that of China from 2001 up to 2004.

**Powered vessels vs. Non-powered vessels**: Figure 14 gives a comparison of powered vessels and non-powered vessels for both nations. As explained above, total number of non-powered vessels from both two nations indicated a gradually decreasing trend (Fig. 14).

3.2.1.5 Tonnage per vessel and KW per vessel

**Powered and non-powered vessels**: Tons per vessels from powered and non-powered vessels data combined from two nations' data showed nearly unchanged values, 8.3～9.5 tons/vessels during 1986～1996. From 1997, its value jumped to about 10.0 tons/vessels and remained at this level until 2004 (Fig. 15). Chinese values each year were much higher than those of Korean values. This figure indicated that tonnage per vessels from China had an increasing trend but Korea data remained nearly unchanged level during the study period (Table 24).

**Powered vessels**: Each year's tons/vessels value showed a parallel level at a value of 10.0 to 11.5 tons/vessels (Fig. 16). Non-powered vessels increased as a whole (Fig. 16).

**KW per boats**: The combined KW/boats values from the two nations showed a trend of increase slowly every year (Fig. 17). Chinese figure has kept an upward trend although the values during 1998～2000 were lower than the previous year, and also the 2004 value decreased. Korea's value was unchanged throughout the entire period (Fig. 17).

#### 3.2.1.6 Catch per unit of effort trends

Relative abundance values are used in many ways to estimate biomass of fisheries in questions and/or to carry out stock assessment as a basic tool in population dynamics. In this section, even though fishing efforts described above were not given validity in details whether they were actual fishing effort or only registered number of boats and gross tonnage (e.g., fishing effort of main target species and multi-gear used to capture the same animals etc.), CPUE values were calculated based on the fishing efforts in Table 24. These figures might be helpful to understand to some degrees, the current status of fisheries resources in the Yellow Sea.

The CPUE values for total number of powered and non-powered vessels, and the total gross tonnages and KW of powered vessels are shown in Tables 25, 26, 27 and Figs. 18, 19, 20. These data sets can be used for quantitative evaluations based on synthetic models (Schaefer, 1954; Fox, 1970) after sophisticated data handling.

The CPUEs of total boats including both fishing efforts from total number of powered and non-powered vessels were significantly increased from 3,900 kg in 1986 to 17,200 kg in 2004 (Table 25 and Fig. 18). The CPUE from total gross tonnage also has kept the same trend with that of total number of boats (Table 26 and Fig. 19). When fishing efforts of powered vessels were taken as a unit effort, the CPUE trends were given for the CPUE/number of boats, the CPUE/tonnage and CPUE/KW in Fig. 20 and Table 27. Those three CPUEs showed the same patterns with an upward trend from 1992 to 1998. Recent values from 2001 to 2004 remained nearly unchanged (Fig. 20, Table 27).

### 3.2.2 Biological and ecological data

#### 3.2.2.1 Growth parameters

Growth patterns, length-weight relationship and spawning seasons for the 10 commercial species estimated from both nations' research institutes are briefed in Table 28. As pointed out in the comparison of this data set from review of the national reports, the growth figures of small yellow croaker (*Larimichthys polyactis*) from the two nations differed tremendously, especially its life span of which estimate from China was 23 yr and 10 yr from Korea. Based on the growth equations, calculated lengths at age are given in Table 29.

The values calculated from the equations are 11.4 ㎝ and 7.1 ㎝ from China and Korea for 0 year old, 20.0 ㎝ and 25.8 ㎝ for age 3yr, 25.2 ㎝ and 31.8 ㎝ for age 6yr, 29.1 ㎝ and 34.1 ㎝ for age 10yr. From Chinese information, length at age 15yr was estimated to be 34.6 ㎝ and 34.7 ㎝ for age 20yr, reaching at the asymptotic size. These two different figures may seriously cause inaccurate estimations of such population parameters as instantaneous natural mortality rate (M) and total mortality (Z) as well as in analytical stock assessments including VPA (virtual population analysis or cohort analysis) (Pope, 1972).

Asymptotic length of Spanish mackerel (*Scomberomous niphonius*) showed a large difference between the two nations' estimates, 71 ㎝ from China and 123.3 ㎝ from Korea. Calculated values from both equations are given in Table 30. Comparisons from the two estimates were: 22.0 ㎝ and 42.2 ㎝ from China and Korea for age 0yr, 61.0 ㎝ and 78.3 ㎝ for age 3yr, 67.5 ㎝ and 92.9 ㎝ for age 5yr, and 70.3 ㎝ and 106.4 ㎝ for age 8yr from China and Korea, respectively. This phenomenon will also give a serious bias when performing stock evaluation study for this species, especially for analytical stock assessment (Beverton and Holt, 1957).

Others are also summarized with information gaps (Table 28).

#### 3.2.2.2 Reproduction and spawning characteristics

Reproductive and spawning biology for 10 species studied from the two national reports are compared in Table 31. Fecundity of the same species from the two institutes showed a wide range of values but not much different. The minimum sizes at maturity for both small yellow croaker and Spanish mackerel differed from the two nations. That of yellow croaker was 13.5 ㎝ from China and 19.1 ㎝ from Korea. Spanish mackerel was 34/42 ㎝ from China and 78 ㎝ from Korea. These figures will give different recruitment patterns to the stocks (Ricker 1948).

3.2.2.3 Migration and distribution of commercial species

General patterns of migration routes and distribution for the 10 commercial fish species are presented in the national reports of China and Korea. For more detailed information related to movements of these species, it will be of help to have data on statistical area by seasonally rectangular distribution, *that is*, 0.5 x 0.5 square miles. Tagging is known as very useful tools to estimate migration route and range of distribution.

Migration and distribution patterns for each species from the two nations are summarized below:

**Small yellow croaker** (*Larimichthys polyactis*)

**China**: Small yellow croaker is distributed in the Bohai Sea, the Yellow Sea and the East China Sea. Three geographical stocks are recognized as the northern stock, Lüsi stock and the East China stock.

The northern stock seasonally migrates between the central southern Yellow Sea during winter and northern part of the Yellow Sea and the Bohai Sea from spring to autumn (Fig. 21-1).

The Lüsi stock is the bigger one and is distributed in the southern Yellow Sea. It migrates short distances mainly between shallow and deep water in the southern Yellow Sea.

This species, in general, starts toward the spawning migration ground from the wintering ground in March and then arrives to spawn in the very shallow coastal waters from April to May in the Yellow Sea and Bohai Sea.

**Korea**: This species, spread widely in the Yellow Sea and the East China Sea, can be divided into a number of subpopulations by the migration routes. One of them, which called “Korean subpopulation” starts to approach the Korean coast in spring, and migrates northward along the Korean western coast, and then spawns mainly near

Chungcheongnam-do or Hwanghae-do provinces from April to June, after which it migrates offshore, and back to the wintering area (Fig. 21-2).

**Spanish mackerel** (*Scomberomorus niphonius*)

**China**: The Bohai Sea, the Yellow Sea and the East China Sea are major areas for its dense schools. The two wintering stocks exist in the Yellow Sea and offshore in the East China Sea. After spawning, the distribution of this stock is strongly influenced by the water temperature and migrates southwards with decreasing temperatures. Until November, the main population is distributed in the central to south of the Yellow Sea, and starts returning to the wintering ground in December (Fig, 22-1).

**Korea**: The species stays near Jeju Island, where it is affected by the warm current, and during winter time, starts to swim to the coastal areas for spawning in spring, spawns in muddy bottoms in the relatively shallow coastal areas or in the bays in the Korean coast from May to July, and then starts to migrate back to the wintering ground in autumn (Fig. 22-2).

**Anchovy** (*Engraulis japonicus*)

**China**: This stock is an inshore small pelagic species and widely distributed from the Bohai Sea to the East China Sea. In November and December, the densest area of distribution is at the northern and central parts of the Yellow Sea. During winter time, this species migrates into the southeast Yellow Sea and the north East China Sea. With increase in temperature, it moves to the shallow coastal water for spawning (Fig. 23-1).

**Korea**: This species is a small pelagic species distributed widely in the Yellow Sea, the East China Sea and the East Sea/Sea of Japan. The Yellow Sea population seasonally migrates according to changes of surface water temperature. This fish migrates toward the coastal area along the Korean peninsula in spring and spawns mainly at the mouth of the Keum River from June to August, and in autumn migrates back to the wintering ground in the southern part of the Yellow Sea (Fig. 23-2).

**Chub mackerel** (*Scomber japonicus*)

**China**: As a warm water fish, it has a wide range of migration routes (Fig. 24-1). It is known that there are two wintering grounds, one is the area southeast of Jeju-do and another is the central to the east part of the East China Sea.

**Korea**: Chub mackerel has a wide migration route in the Yellow Sea. The species in the Yellow Sea can be largely divided into two subpopulations based on their wintering grounds and migration routes; one called the "East China Sea population" stays over winter in the northern part of the East China Sea. The other one called "Jeju Island offshore population" over-winters in the south-eastern area of Jeju Island offshore. In spring, they migrate up to the mid-part of the Yellow Sea and swim back to the wintering and spawning grounds in the autumn. They spawn from March to April in the East China Sea, and from April to May in Jeju Island (Fig. 24-2).

**Largehead hairtail** (*Trichiurus lepturus*)

**China:** This species consists of two major populations, i.e., the "Bohai and the Yellow Sea population" and the "East China Sea population" (Fig. 25-1). There are also some local populations in the South China Sea in the shallow waters of Fujian province and Taiwan Strait.

**Korea**: The species distributed in the Yellow Sea can be divided into two subpopulations according to wintering areas and migration routes; one called the "Northern East China Sea population" spends winter in the northern part of the East China Sea as the name shows, and the other one called the "Yellow Sea population" over-winters in the west-southern area of Jeju Island adjacent waters. Both subpopulations migrate to coasts in the Yellow Sea and the East China Sea in spring to spawn and nurse from May to August, and return to the wintering grounds in the fall (Fig. 25-2).

**Pacific herring** (*Clupea pallasii*)

**China**: Pacific herring in the Yellow Sea is a local stock that only inhabits the central to northern parts of the Yellow Sea (Fig. 26-1). The Yellow Sea stock is known with small quantity by survey. The wintering ground is in the central deep water.

**Korea**: This species is known to be divided in two subpopulations in the Korean waters; one is the “East Sea subpopulation” and the other is the “Yellow Sea subpopulation.” The Yellow Sea stock inhabits the cold water mass all year round in the Yellow Sea (Figure unavailable).

**Sandlance** (*Ammodytes personatus*)

**China**: This fish is a cold-temperature water, small-sized demersal species, distributing mainly in the area of the northern part of the Yellow Sea.

**Korea**: This species is not well known in Korea, so it is not possible to describe the migration pattern. It is caught in coastal areas of Chungnam-do province and Baik-lyeong Island in spring.

**Acetes** (*Acetes chinensis* and *A. japonicus*)

**China**: It is the most important species in catch by fixed nets in China. This species is distributed in the South/East China Seas, the Yellow and Bohai Seas.

**Korea**: These species are a kind of sedentary species. They migrate in or off shore with the change of season. They are distributed along the west coast of Korea.

**Fleshy prawn** (*Fenneropenaeus chinensis*)

**China**: This species is mainly distributed in the Yellow Sea and the Bohai Sea. There are two geographic populations. One is located in the west coastal waters of the Korean peninsular; the other one can be found both in the Chinese coastal waters of the Yellow Sea and the Bohai Sea (Figure unavailable).

**Korea**: This species distributes mainly in sandy or muddy bottoms in the Yellow Sea and Bohai Sea. This population can be divided into two subpopulations based on their breeding areas and migration routes. One population can be found in the western coast of the Yellow Sea, which hatches in the coast of the Bohai Sea and the Yellow Sea. The other population found in the eastern coast of the Yellow Sea, hatches in the Korean western coast. In spring, the Korean stock starts to migrate from the southern part of the Yellow Sea, their wintering ground, to the west coast of Korea, and spawns mainly in the coast of Chungcheongnam-do province from April to June, and then dies. In autumn, the new recruits migrate to the wintering ground (Fig.26-3).

**Pacific squid** (*Todarodes pacificus*)

**China**: Data are not available.

**Korea:** Pacific squid in Korean adjacent waters are divided into three stocks based on their birth seasons; one of them called "stock hatched in autumn from October to December," the second one "hatched in winter from December to March," and the third one "hatched in spring from May to August." Their spawning grounds are in the East/Japan Sea or the East China Sea, but not identified exactly because of the lack of information (Fig. 26-4).

3.2.3 Bottom trawl survey

China carried out its bottom trawl survey in June 2000 and this survey has continued until June 2004. Fig. 27 presents the survey stations of China's bottom trawl. Korea started its seasonal activities in spring and winter, 2003. Every year's survey research has been performed as in the same period mentioned above.

Research cruises' results obtained from bottom trawl survey for China and Korea are combined in Table 32. Details are summarized below.

3.2.3.1 Species composition

**China**: Trawl survey was performed every June from 2000 to 2004 (Table 32). In June 2000, the most dominant species from the survey was Japanese anchovy with 48.0% of the total, following by small yellow croaker 11.1%, largehead hairtail 10.4%, *Crangon affinis* 7.3%, *Enedrias fangi* 4.6% of the total.

In June 2001, there was a change in species composition compared to the 2000 figure. Japanese anchovy was 21.6%, Pomfret 11.6%, small yellow croaker 8.4%, *Metapenaeopsis dalei* 8.2%, *Setipinna taty* 7.1%, *Lophius litulon* 6.8%, *Eupleurogrammus muticus* 5.0% of the total.

In June 2002, *Enedrias fangi* consisted of 21.6% of the total, *Setipinna taty* 11.6%, *Metapenaeopsis dalei* 8.4%, fomfret 8.2%, *Eupleurogrammus muticus* 7.1% and *Lophius litulon* 6.8%.

In June 2003, Japanese anchovy occupied 30.7% of the total catch, *Metapenaeopsis dalei* 16.5%, *Setipinna taty* 11.4%, *Charybdis bimaculata* 7.6%, *Crangon affinis* 5.1% and *Saurida elongate* 4.7%.

In June 2004, the composition was *Metapenaeopsis dalei* 33.1%, *Crangon affinis* 15.7%, Japanese anchovy 7.7%, *Lophius litulon* 7.1% and *Palaemon gravieri* 6.2%.

**Korea**: Table 33 showed seasonal species composition of catches from bottom trawl survey from 2003 to 2005. *Lateolabrax japonicus* was the most dominant species comprising 29.0% of total catch in 2003.

In spring 2003, *Lophius litulon* was the most dominant species, comprising 17.3% of total catch, followed by *Hemitripterius villosus* (16.6%), *Zoarces gilli* (8.0%), *Gadus macrocephalus* (6.9%), and the other species (less than 5%). In the winter, *Lateolabrax japonicus* was the most dominant species comprising 38.7% of total catch. It was followed by *Sebastes schlegeli* (21.8%), *Loligo beka* (9.8%), *Liparis tanakai* (3.6%), and the other species (less than 3%). These above three species constituted approximately 70% of the total catch.

In 2004, *Lophius litulon* was the most dominant species, comprising 37.6% and 28.9% of the total catch in spring and winter, respectively. In spring, the second dominant species was *Hemitripterius villosus*, comprising 10.6% of the total catch. It was followed by *Hexagrammos otakii* (4.9%), *Cragon affinis* (4.9%), *Squalus megalops* (4.3%), and the other species (less than 4%). These above six species constituted about 70% of the total catch. *Collichthys niveatus* was the second dominant species in winter, comprising 11.8% of the total catch. It was followed by *Liparis tanakai* (9.9%), *Loligo beka* (7.3%), *Sebastes schlegeli* (5.7%), and the other species (less than 5%).

In 2005, *Lophius litulon* was the most dominant species, comprising 18.4% and 31.6% of the total catch in spring and winter, respectively. *Cragon affinis* was ranked as second dominant species from both seasons comprising 14.4% (spring) and 7.2% (winter) of the total catch. In spring, the third dominant species was *Sebastes schlegeli*, comprising 7.2% of the total catch. It was followed by *Gadus macrocephalus* (6.6%), *Squalus megalops* (5.8%), *Ammodytes personatus* (5.1%), and the other species (less than 5%). In winter, *Paralichthys olivaceus* was ranked as third dominant species, comprising 6.7% of the total catch. It was followed by *Loligo beka* (6.0%), *Collichthys niveatus* (5.4%), *Oregonia gracilis* (5.3%), and the other species (less than 5%).

3.2.3.2 Seasonal density distribution of species

Table 34 gives data on density values of species from China and Korea.

**China**: In spring 2000, the densest species was Japanese anchovy of 13,365g/trawl/h on an average, followed by small yellow croaker (3,073g/ trawl/h), largehead hairtail (2,888g/trawl/h), *Cragon affinis* (2,034g/trawl/h), *Enedrias fangi* (1,290 g/trawl/h).

In spring 2001, Japanese anchovy was the dominant dense species with 4,465 g/trawl/h and pomfret 889g/trawl/h, small yellow croaker 847g/trawl/h, *Metapenaeopsis dalei* 667g/trawl/h.

In 2002, *Enedrias fangi* consisted of 1,413g/ trawl/h, *Setipinna taty* 757g/ trawl/h, *Metapenaeopsis dalei* 553g/trawl/h and pomfret was 538g/trawl/h.

In 2003, Japanese anchovy was the densest species of 7,092g/trawl/h, followed by *Metapenaeopsis dalei* (3,809g/trawl/h), *Setipinna taty* (2,626g/ trawl/h), *Charybdis bimaculata* (1,752g/trawl/h), *Crangon affinis* (1,165g/ trawl/h), *Saurida* elongate (1,093g/trawl/h).

In spring 2004, *Metapenaeopsis dalei* showed the highest density of 4,311g/tral/h, and *Crangon affinis* 2,038g/trawl/h, Japanese anchovy 1,005g/ trawl/h, *Lophius litulon* 923g/ trawl/h and *Palaemon gravieri* 810g/trawl/h (Table 34).

**Korea**: Table 34 shows seasonal densities of major species caught by trawl survey from 2003 to 2005.

In 2003, *Lateolabrax japonicus* showed the highest mean density of 226.4㎏/㎢, which occurred in only one station in winter. The mean density of *Sebastes schelegeli* was 133.3 ㎏/㎢, and ranged from 4.6 to 2,603.3㎏/㎢. *Loligo beka* was caught at 6 stations in spring and winter, and mean density was 58.8 ㎏/㎢. The species which showed the highest mean density of 23.8 ㎏/㎢ among the crustaceans was *Oregonia garacilis.* It was widely distributed and then caught at more than 8 stations in spring/winter seasons. *Lophius litulon* and *Hemitripterus villosus* showed high mean densities of 47.9㎏/㎢ and 42.1㎏/㎢, respectively. *Liparis tanakai* and *Gadus macrocephalus* were major cold water species showing comparatively high mean densities with 23.8㎏/㎢ and 16.5 ㎏/㎢, respectively. *Liparis tanakai* showed higher mean density of 42.3 ㎏/㎢ in winter, but *Gadus macrocephalus* was higher that in spring.

In 2004, *Lophius litulon* showed the highest mean density, 134.4 ㎏/㎢ ranged from 8.7㎏/㎢ to 694.8 ㎏/㎢. It was widely distributed and the density difference between two seasons was insignificant. Mean density of *Collichthys niveatus* was 36.0 ㎏/㎢, ranging 0.5㎏/㎢~997.8 ㎏/㎢. It showed higher density value in winter (65.3 ㎏/㎢) than in spring (3.1 ㎏/㎢). This was followed by *Sebastes schelegeli* having a mean density of 32.2 ㎏/㎢, ranged 1.1~515.4 ㎏/㎢. The mean density of *Hemitripterus villosus* was 30.6 ㎏/㎢ and mean value (43.9 ㎏/㎢) of spring season was more than two times higher than that of winter season. Mean densities of *Liparis tanakai* and *Loligo beka* were 30.0㎏/㎢ and 28.7㎏/㎢, respectively. Higher values appeared in winter. *Cragon affinis* was the species that showed the highest mean density of 21.3 ㎏/㎢ among the crustaceans. It was widely distributed through two seasons and seasonal difference in densities was insignificant. *Oregonia gracilis* was another widely distributed crustacean species, and its mean density was comparatively high (21㎏/㎢). *Hexagrammos otakii* and *Cleisthenes pinetorum* were ranked among species showing high density.

In 2005, *Lophius litulon* was the most abundant species as the same in 2004. Its mean density was 134㎏/㎢, ranging from 3.7㎏/㎢ to 988.1㎏/㎢. Its winter value was slightly higher than spring's. *Cragon affinis* ranked second in mean density and its mean density was 65.1㎏/㎢. It was caught at all stations through two seasons. The mean density of *Collichthys niveatus* was 28.9㎏/㎢. It was more widely distributed in winter than in spring, but its mean density during winter was lower than that of spring. The distribution of *Gadus macrocephalus* was restricted to the cold water mass. This species was caught at 8 and 6 stations in spring and winter seasons, respectively. Its mean density was 27.5㎏/㎢, ranging from 2.1㎏/㎢ to 198.6㎏/㎢. *Oregonia gracilis* showed mean density of 26.3 ㎏/㎢ similar to those of 2003 and 2004. *Sebastes schlegeli, Loligo beka and Hemitripterus villosus* showed comparatively high mean densities having values of 24.7㎏/㎢, 21.3㎏/㎢ and 20.3㎏/㎢, respectively. *Aqualus brevirostris* was caught at only two stations in spring and its mean density was 19.6㎏/㎢. *Ammodytes personatus* showed mean density of 18.9㎏/㎢, ranged from 1.2㎏/㎢ to 642.1㎏/㎢. Its density during spring was considerably higher than that of winter.

#### 3.2.3.3 Seasonal number of fish larvae and eggs by ichthyoplankton survey

**China**: Ichthyoplankton survey was carried out in June from 2002~2004 (Table 35). Through the survey periods, *Engraulis japonicus* larvae and eggs were only collected from the sampling activities but in 2004, a few *Stolephorus commersonii* eggs were collected.

**Korea**: Survey data were collected in May 2003~2005 in the off-shore of west coast of Korea. Table 36 shows individual number (inds/1,000 ㎥) of fish larvae and eggs caught by ichthyoplankton net from 2003 to 2005.

In 2003, 3 species of fish larvae and one species of fish eggs were identified. *Sebastes schelegeli* showed mean density of 4.6 inds/1,000㎥, ranging from 4.9~24.0 inds/1,000㎥ at the 3 stations. *Engraulis japonicus* was caught at only 1 station with density of 7.5 inds/1,000㎥. Unidentified fish egg showed the highest mean density of 112.3 inds/1,000㎥.

In 2004, 2 species of fish larvae, *Cleisthenes pinetorum herzensteini* and *Sebastes schelegeli*, were identified. Densities of these species were very low. Eggs of *Engraulis japonicus* showed mean density of 0.6 inds/1,000㎥, and ranged from 0.9~12.0 inds/1,000㎥ at the 4 stations.

In 2005, 6 species of fish larvae were identified. Among them, *Engraulis japonicus* showed the highest mean density of 4.9 inds/1,000 ㎥, and ranged from 9.9~37.0 inds/1,000㎥ at the 3 stations. *Sebastes schelegeli* caught at the 6 stations and was the most widely distributed species. The others, *Sebastes vulpes, Liparis* sp., *Limanda herzenstein* and *Lophius litulon*, were caught at only 1 station, and showed low densities, less than 1 inds/1,000. Mean density of eggs of *Engraulis japonicus* was 3.8 inds/1,000㎥, ranging from 62.7~78.6 inds/1,000㎥ at the 3 stations.

### 3.2.4 Status and trends of mariculture

The species names related to farmed animals and seaweeds between China and Korea are explained together with scientific and English names in Table 37.

#### 3.2.4.1 Farmed production trends

Overview of aquaculture farmed production

Yearly farmed production figures from China and Korea are given in Table 38 and the trends in Figs. 28 and 29. The production jumped to about 17.5 million MT in 1996 from 2.1million MT in 1995. Then, it showed a continuous trend of increase year after year, reaching at over 33.0 million MT in 2004 (Table 38, Fig. 28). This upward trend resulted from China's production, accounting for an average of 96.4% of the total during the whole period. Korea contributes a proportion of 3.6% between the two nations. By species groups, finfish, crustacean, shellfish and seaweed have revealed the same pattern as in the total production (Fig. 29). Proportion of species groups between two nations was: 99.7% from China and 0.3% from Korea for finfish, 99.8% and 0.2% for crustacean, 96.5% and 3.5% for shellfish and 68.1% from China and 31.9% from Korea for seaweed (Table 38). By species groups figure that data from the two nations were combined, finfish has the highest portion with a value of 55.8% on average, followed by shellfish 33.2%, seaweed 6.9%, crustacean 3.5% and others 0.6%.

Percentage composition for species groups for China and Korea differed considerably (Table 39). In China, finfish showed the highest proportion with a decreasing trend from year to year. Shellfish consisted more than 30% of the total. In Korea, seaweed accounted for about 60% per year on average throughout the study period, followed by shellfish with more than 30% every year.

Marine farmed organism's production

Total farmed production trend: Total production pooled from two nations in the Yellow Sea and the nation's whole figure during 1995～2004 is presented in Table 40 and Fig. 30 for each species.

Seawater farmed production indicted a swift year to year increase from 1.23 million MT in 1986 to 14.1 million MT in 2004. This was attributed mainly to increase of shellfish from China, an average of 75% of the total. Freshwater production maintained the highest portion with a slightly increasing trend (Table 40, Fig. 30).

The proportions of the farmed production in the Yellow Sea to those of total seawater and total aquatic farmed production by species groups show that high proportions of the Yellow Sea were from both shellfish and seaweed with values between 40% and 50% of the seawater and freshwater, respectively (Table 40). The proportion of the Yellow Sea to the seawater remained constant, having an estimate of 45% through the years from 1997 to 2004, and the proportion from freshwater was about 35% every year (Fig. 30). In the Yellow Sea, the total production shows a trend of increase from 400,000 MT in 1986 to 6.25 million MT in 2004. This was also from shellfish of China with about 75% of the total in this region (Table 41, Fig. 31).

Major farmed species: Yearly production of economically important cultured species from China and Korea are given in Table 42. In the finfish species group, the major species in China were sea bass (*Lateolabrax latus*), flounder (*Paralichthys olivaceus*), black sea bream (*Acanthopagru sschlegelii*), and red drum (*Sciaenops ocellatus*). In Korea, flounder (*Paralichthys olivaceus*) was the dominant species showing an increasing trend in the yearly production. In crustaceans, *Fenneropenaeus chinensis* was a common species in both nations. For the shellfish species groups, *Crassostrea gigas* showed much higher production than other species in both nations. This species' production rate in China has kept an increase year after year at a level of 3.75 million MT in 2004, but in Korea less than about 240,000 MT in 2004 as a peak production. The yearly production of this species from China was about 15 times that of Korea. I*Cyclina sinensis* from China showed a high level of production at 2.8 millon TM in 2004, keeping a steady upward trend. In seaweed, China's dominant species of *Laminaria japonica* produced more than 800,000 Mt in 2002～2004. In Korea, *Undaria pinnatifida* and *Porphyra* spp were the main cultured species with a decrease to about 200,000 MT in recent years (Table 42).

Marine farmed production by province: The production for species groups in each of the 5 provinces located around the Yellow Sea from China and Korea in 2004 are summarized in Table 43. The total production in 2004 was about 6.16 million MT that accounted for 43.7% of total seawater production and 18.6% of the total from seawater and freshwater. In this year, the production from 5 provinces of China accounted for 96.6%. Shandong province showed the highest production with 55.9% of the total and shellfish taking 55.7% of the species total production. In Korea, seaweed production from 5 provinces was dominant with 70.1% of the year's total and Jeonnam province contributing 67.5% for this species (Table 43).

#### 3.2.4.2 Aquaculture area

Total aquaculture area

Aquaculture area used every year in China and Korea increased significantly from 461,500 ha in 1986 to 1,106,000 ha in 2004 (Table 44 and Fig. 32). The area in China rapidly climbed at a level of 1.05 million ha in 2004 from 416,000 ha in 1986 which was nearly doubled. Korea increased from 46,000 ha in 1986 to 56,000 ha in 2004. By species groups, shellfish area from both countries occupied more than 65% every year, followed by crustacean area, seaweed and finfish areas. The aquaculture area from China was about 95% of the total figure (Fig. 32).

Marine farmed species area

The areas of marine farmed species based on the data combined from China and Korea for 10 years are presented in Table 45. The total area has indicated a trend of increase from 359,000 ha in 1986 to 760,000 ha in 2004 (Fig. 33). Percentage portion of species groups to the total was: shellfish area 60.5%, crustacean 22.0%, seaweed 8.4% and finfish 3.5%.

Interaction between marine farmed production and farmed area

In the Yellow Sea, yearly production totally depended on the shellfish production, which accounted for an average of 75% of the total during the whole period. Both total production and farmed area of shellfish have increased gradually. Total production per area increased 7.2 MT/ha in 1996 to 10.4 Mt/ha in 2000 and it decreased to 8.2 MT/ha in 2004. For shellfish, its production/area peaked at 14.7 MT/ha in 1997 and revealed a decreasing trend from 14.1 MT/ha in 2000 to 10.5 MT/ha in 2004. Annual production per area of seaweed showed a nearly constant value of 21 MT/ha during 1996～1999. Since then, its values decreased from 22.0 MT/ha in 2000 to 17.1 MT/ha in 2004. This may suggest that production per unit area could not be expected to increase even if farmed area in this region would expand in future.

Aquaculture habitats

The areas for aquaculture methods by species groups from 5 provinces of Korea are available in Tables 46 and 47. The total area showed a trend of increase from the 2000s, 41,400 ha in 1999 to 55,700 ha in 2004 (Table 46, Fig. 34). This was mainly from increase of bottom culture in recent years. The main habitats were: pond culture for finfish and crustacean, floating net for seaweed and bottom culture for collective farms (Table 46). Table 47 describes the land used by species groups in Korea. Land for seaweed has the highest portion with an average value of 177,000 ha for 10 year from 1995 to 2004.

### 3.2.5 Socio-economics

#### 3.2.5.1 Vessels by fishery

The total number of vessels and gross tonnage including powered and non-powered vessels by off-shore and coastal fishery as well as distant waters fishery are tabulated for each nation during 2000～2004 (Table 48).

**Total number of vessels**: China showed a trend of steady decrease from about 294,100 boats in 2000 to 241,300 boats in 2004. This was caused by decrease of powered vessels throughout the period and the proportion of powered vessels took over 91.0% every year. The number of non-powered vessels stayed between 20,400 and 24,300 vessels.

Korea has maintained a much lower number of vessels in both total powered and non-powered boats than those of China. The numbers have remained between about 91,600 and 95,900 vessels with a slowly decreasing trend, but showed the proportion of more than 92.0% by powered vessels (Table 48).

**Gross tonnage**: China's gross tonnage decreased from 5.42 million tons in 2000 to 5.10～5.16 million tons in 2001～2002, but increased to 5.66 million tons in 2003 and 5.60 million tons in 2004. This trend was also mimicked by the powered vessels (Table 48). Korea showed a trend of continuous decrease from 923,000 tons in 2000 to 725,000 tons in 2004. This was totally depended on the trend of powered vessels.

**Vessel composition by fishery**: Coastal vessels of both nations every year took the proportion of over 99.0% of the total. There are about 2,000 distant waters vessels in China and about 500 boats in Korea in recent years (Table 48).

#### 3.2.5.2 Vessels by province

Table 49 presents the number of vessels by 5 provinces located near coastal areas of the Yellow Sea from China and Korea during 2000～2004. In China, all 5 provinces have shown a decreasing trend in number of vessels. Among the provinces, Shandong province showed the largest proportion in the number of vessels registered, followed by Liaoning and Jiangsu. In Korea, Jeonnam province occupied the highest portion among the 5 provinces, and in 2004 Jeonbuk province showed a significant increase in the number of vessels (Table 49).

#### 3.2.5.3 Fisherman by province

Table 50 shows the total number of fishermen for 5 provinces from China and Korea. Total fishermen engaged in fisheries industry in the Yellow Sea from both nations was about 2 million, but in recent years there has been a slight decrease in persons. In China, fishermen increased to 1.87 million in 2003 compared to the previous year and then decreased to 1.82 million persons. Korea continued its decreasing trend.

#### 3.2.5.4 Fisheries income

Both nations' fisheries incomes generally kept an upward trend and the 2004 incomes were higher than in other years (Table 51).

#### 3.2.5.5 Exports and imports of fishery products

China's exports increased from 1,534,000 MT in 2000 to 2,421,000 MT in 2004, but Korea showed a trend of decrease (Table 52). Imports of China slowly decreased, but increased in 2004, and Korea showed a year after year increasing trend.

#### 3.2.5.6 Economic importance of fisheries (GDP contribution)

Both counties maintained a steady increase in GDP but in fisheries sector, China increased and Korea rather decreased (Table 53). GDP contribution of China was much higher than that of Korea.

#### 3.2.5.7 Fishery consumption per capita

Per capita consumption of fishery showed that Korea side was about 3.2-4.8 times that of China, depending on years (Table 54).

### 3.2.6 Analysis of national laws and regulations on fisheries and mariculture

#### 3.2.6.1 The People‘s Republic of China

Major laws and regulations related to fisheries

- Fishery act

This Act was promulgated, enforced in 1986 as a legal provision. Based on the Act, the central and provincial governments have issued various laws and regulations consisting of more than 500 documents.

On December 1, 2000, a revised Chinese Fishery Act went into effect, imposing strong punishment for illegal fishing and establishing a legal foundation for a quota management system.

There were about 30,000 fisheries inspectors and 1,500 enforcement vessels including marine enforcement vessels in 2003.

- Marine Environmental Protection Act

The Act went into effect in April, 2000 for protection and improvement of environment, marine resources, pollution damage, ecological balance, human health, and sustainable development in economic and society. The chapter of marine ecological protection is highly related to fishery resources.

- Breeding and Protection Act of Fishery Resources

In 1957, a draft Act was promulgated as a regulation and first trial to identify fishery resources for protection. In 1979, this Act was issued in which 26 marine fishes, 7 shrimps and crabs, 14 mollusks, 6 algae and 10 mammals were listed as protected species. More detailed protection rules were stipulated by each province.

- Conservation regulation of living resources in the Bohai Sea

On May 1, 2004, this law went into effect to protect, enhance and rationally use living marine resources, as well as to protect the ecological environment in the Bohai Sea. In 1991, it was replaced with the regulation of fisheries resources breeding and conservation, which set down the minimum landing size, minimum mesh size and closing season for each fishing gear.

- Regulation on administration and management of aquatic seedling production

  In December, 1996, the regulation was issued, and amended and reissued on December 8, 2000. The main aspects are: 1) regulation on the examination and approval of native and excellent breeds, 2) standard on the examination and approval of native and excellent breeds, 3) brief introduction of species approved by the examination and approval committee of the nation, 4) regulation on checking and accepting of the breeding factory, 5) regulation on the administration of producing procedure and regulation on the administration of the project of breeding factory construction.

Fisheries management measures

- Fishing effort control

| | |
|---|---|
| In 1981 | identification of fishery problems and overcapacity |
| In 1983 | measures to stop increased catches, and strict control over increase of fishing boats. |
| In 1987 | control effort limiting aggregate horsepower by fishing zone. |
| In 1997 | fishing permits reissued in all coastal provinces and cities. |
| In 1999 | new fishery structural adjustment guidelines for strict control of fishing effort and catch reduction. |

Measures designed to reduce effort include: 1) stop on permission to build new fishing vessels except for distant fishing purposes, 2) comprehensive clear up of illegal boats, 3) prohibition on the introduction of foreign boats to fish in the Chinese EEZ, 4) gradual establishment of a mandated vessel retirement system and, 5) strict prohibition for non-fishing laborers to take jobs in marine fisheries.

Currently three official documents are required for engaging in fishing activities along the Chinese coast: 1) fishing vessel inspection document, 2) fishing vessel registration document and, 3) fishing permit.

Other measures: 270 million CNY each year during 2002-2004 have been arranged for subsidizing scrapping old fishing boats and for encouraging fishermen to change their jobs. As a result, about 8,000 marine fishing boats were decommissioned, and 40,000 fishermen were transferred to other sectors until November, 2004.

A fishing ban in the Yellow Sea, Bohai Sea and East China Sea has been implemented for 2～3 months in summer since 1995 and similar measures along the continental shelf of the South China Sea are used.

- Output control

A zero growth policy in total marine catches was imposed by the government on the basis of the catch level in 1999 as the maximum production. This policy continued in the year 2000 and thereafter.

- Mariculture

Firstly, current legislation and regulations are: standards for aquaculture production, the code for aquaculture operations, quality standards for fish products, environmental standards for fisheries including water quality standards and standards for rearing techniques.

Secondly, aquaculture system and technologies should be developed in accordance with accepted ecological standards.

Thirdly, a licensing system for the discharge of sewage drain into fishery environments should be implemented where sewage could only be released after approval by the fishery environment monitoring department. Financial charges would be collected from the sources of discharging sewage and be used as a management fee to assist in: production management, technical renovation, treatment of wastes and drainage waters, and cleaning of pollution to protect or recover fishery environments.

3.2.6.2 The Republic of Korea

<u>Fishery structure control</u>

- Off-shore, coastal fishery structure control

The main contents of off-shore and coastal fishery structure reorganization policy are as follows: 1) reorganizing type of off-shore and coastal fishery, 2) control of off-shore and coastal fishing waters, 3) maintenance of continual usable fishing intensity, 4) maintenance of proper vessel number, 5) building of fishery management system scientifically and, 6) development and diffusion of fishing implements and systematic support to fishermen.

- Rebuilding of fishery resources

The government has employed a new management system to enhance commercially important fish resources with participation by fishermen since February 2001. At present, there are a total of 122 nationwide self-management fishery communities along the coastal area.

- Output control

In 1999, the TAC[1] system was started with some commercial species such as chub mackerel, horse mackerel, sardine in the west sea of Korea. Now, it was expanded to 10 species around Korean waters.

Status and revision of fisheries law

- Revision of fisheries sub-ordinate laws

Details of the preservation ordinance of fisheries resources (Presidential decree 18095, on August 27, 2000) include: 1) limit the use of double gillnet in Ulleung Island and Dokdo island waters, 2) standards of net-knot size in coastal fishery and inland waters, 3) capturing and picking Chinese mitten crab and lenok during the forbidden period, and 4) TAC resources management through systematic selling and reporting.

Other revisions are: Enforcement of ordinance of fisheries law – Presidential decree No. 18121, on November 4, 2003, and Rule of fisheries license and declaration – Marine Affairs and Fisheries (MOMAF) decree No. 247, on May 29, 2003.

[1] Total Allowable Catch (TAC)

- Status of raising fishery cultivating law

Enforcement ordinance of raising fishery cultivating law (Presidential decree No. 18052) was promulgated on July 15, 2003, where the minister of MOMAF and provincial governors can decide the methods and contents of basic investigation for Raising Fisheries Development Plan.

The rule of raising fishery cultivating law (MOMAF decree No. 251, on July 15, 2003) was enacted to decide methods and procedures of fishery developing areas.

# 4 INFORMATION GAPS

## 4.1 China

The gaps in data and information mentioned through the national report of China are described below:

a. No available data on catch statistics by area and species.

b. Lack of English-written publications and information.

c. Most mariculture data and information are based on the provincial level. So, it would be useful to access the data easily if they could be managed under an independent government level

d. No detailed data on habitat as mariculture methods.

e. No available statistical data on mariculture licenses by habitat so far.

## 4.2 Korea

a. No available data on catch statistics by area and species.

b. Little data available on area of collective farms during 1995-2000 but available data from 2001 to 2004.

c. Data on area for culture method of shellfish only available in 2004.

d. The number of farm area from legally permitted farms does not include illegal farms (when added, is about 10% increase in total area).

### 4.3 Lacks of data and information from two nations

It was pointed out that the following types of data and information are essential to understand the current status of commercially exploited stocks in the Yellow Sea as well as to carry out future research works.

a. A need for basic statistics and effort data by different fishing methods for standardization of fishing effort that should be used for quantitative assessment to understand current exploitation level of marine resources.

b. Recording on logbook for landings or catches with information on amount of dumping and/or discards at sea.

**c.** Estimations of relative abundance index (ex. CPUE, density etc.) from fishery independent research.

**d.** Distribution area and range of commercial species that migrate or cross the boundary between two nations for TDA analysis.

  Statistical area distribution by rectangular method (0.5x0.5 miles) for each species

  Establishment of long-term database available for retrieval use

e. Size composition data or if possible age-length key data for cohort analysis

f. Submission of all data from both nations according to agreed data formats, especially for mariculture data.

g. Research works of joint cruises from China and Korea in the Yellow Sea.

# 5 REGIONAL FISHERIES AND MARICULTURE ISSUES

Critical elements causing environmental changes in the Yellow Sea, based on the national reports as well as on the data and information synthesis provided in this report, are summarized below:

## 5.1 National issues

### 5.1.1 China

a. Over-exploitation of target species and climate change has caused a shifting in dominant species with the food-web shifting downwards.

b. Insufficient monitoring and lack of scientific-based knowledge on status of stocks.

c. Insufficient management and control of fisheries activities

d. Intensive use of natural coastal habitats and ecosystems for mariculture, exceeding the carrying capacity and causing environmental degradation, disease outbreaks and reduced growth rates.

e. Poor regional coordination, communication and collaboration between fishermen and government.

f. Insufficient information and environmental impact assessments for ecosystem-based management.

### 5.1.2 Korea

a. Local production of farmed animals and seaweeds is not included in total farmed figure when they are sold directly. It is estimated that such production comprises an additional 10～30% to the total, depending upon the species.

b. Data on aquaculture area only include licensed farms until 1997, but from 1998 the annual aquaculture areas include all from the licensed, permitted and notified farms.

c. Data on area of culture method include only licensed farms before 1998 and during the period 1998～2004 the data on culture method include all from licensed, permitted or notified farms.

## 5.2 Major issues from synthesis of data and information from two nations

### 5.2.1 Fisheries

**Heavy exploitation of capture fisheries**: Most of the commercial fisheries resources seem to be heavily exploited due to intense Chinese fishing activities, showing a significant increase in catch since the late 1990s despite of a zero growth policy in marine total catch referenced to the 1999 catch level. It is anticipated, therefore, that sustainable yield can not be achieved in the future at the current level of catch from capture fisheries in this region. It is not possible, however, to arrive at any conclusions on the status of commercial important stocks on the basis of the currently available data. Such information is required to perform fish stock assessments by the two nations' institutes for a reasonable level of managements to be achieved.

**Fishing effort**: The total registered number of powered fishing vessels has been kept on a somewhat constant level since the 1990s, but trends in gross tonnages and KW (kilowatt) showed increases during the study period. This implies that the fishing power and/or fishing efficiency have significantly improved taking into account recent catch levels. It is assumed, on the other hand, that fishing pressures on marine living resources have increased since the1980s.

**Catch per unit of effort (CPUE)**: CPUE values as a relative abundance index were calculated for 10 commercial species using fishing effort information including the total number of vessels, gross tonnages and KW. It is clear that the estimated values do not reflect the real abundances of each fish stock. The fishing effort data used for calculating the CPUE values was not the actual fishing efforts, but the total number of registered boats, tonnages and KW. The relative abundance index obtained from the total catch and fishing effort could not be used for quantitative assessments. This makes it difficult to understand how the aquatic population reacts to a given level of fishing effort. In fact, the long-term CPUE trends showed a continuously increasing figure. Accordingly, it identifies the important data requirements for stock evaluation that can provide reliable CPUE values for fish stocks and enable the formulation of rational fisheries management advice on the basis of synthetic models.

5.2.2 Biological and ecological data

**Growth parameters**: The comparison of the biological aspects of commercial species, based on the two nations' research, reveals that the estimated growth figures showed considerable differences: for small yellow croaker, longevity (or maximum age) were disparate, being 23 years for China and 10 years for Korea, and for Spanish mackerel, asymptotic lengths were 71 ㎝ for China and 123.3 ㎝ for Korea. Some differences also existed in the growth parameters of other species. This situation causes discrepancies in such population characteristics as instantaneous natural mortality (M) and instantaneous total mortality (Z) as well as in analytical stock assessments including VPA (virtual population analysis) and yield-per-recruit study. It is recommended that a study group or working group be established to perform a cooperative research effort to improve the age estimation techniques used by the two nations' institutes.

**Reproduction and spawning characteristics**: The fecundity of commercial species showed a wide range of values, but did not result in markedly different outcomes for the same species from the two nations. However, the minimum sizes at maturity of small yellow croaker and Spanish mackerel have large differences between the two nations. These will result in the prediction of differing recruitment pattern in the same stocks. There is no information on recruitment patterns, so a study is needed for developing an index of recruitment for commercially important fish species.

**Migration and distribution of commercial species**: General patterns of migration routes and distributions of commercial species are described using only the data from the two nations' institutes. More detailed descriptions would require data on statistical fishing locations by season and rectangular sea blocks distribution (e.g., 0.5x0.5 square miles). It is well known, in general, that tagging experiments will be of help in understanding actual migration routes and ranges in the seasonal distributions of marine animals.

**Bottom trawls survey**: Research cruise surveys were conducted every June in the years 2000～2004 in China and spring and winter in the years 2003～2005 in Korea. The data and information from these research activities are very limited and can not be well correlated with syntheses because of spatial-temporal differences among the various surveys. It is recommended that research investigations based on joint cruises between the two national institutes be used in the future.

### 5.2.3 Mariculture

**Aquaculture farmed production**: Farmed aquaculture production showed a continuously increasing trend and reached 33 million MT in 2004. This resulted mainly from Chinese production that accounted for 96.4% of the total during the period 1995～2004. Based on these figures, there was a substantial change in the production of China between 1995 and 1996, from about 1.1 million MT in 1995 to 16.6 million MT in 1996 (by about 16 times compared to the previous year). This period explains a turning point in Chinese aquaculture farmed production.

**Marine farmed production**: Seawater farmed production in the Yellow Sea maintained an increasing trend similar to that of aquaculture production, recording a production of 6.2 million MT in 2004. Significant increases in production from 402,000 MT in 1995 to 2.9 million MT in 1996 (i.e., by a factor of 7) occurred mainly as a result of increased Chinese mariculture. This rapid growth in mariculture warrants explanation.

**Aquaculture area**: The total aquaculture area in the Yellow Sea used by the two countries increased significantly from 462,000 ha in 1986 to 1.1 million ha in 2004, with China accounting for approximately 95% of the total increase. In terms of the marine farmed area, the total area showed a continuous increase from 359,000 ha in 1986 to 760,000 ha in 2004. This would appear to imply that there has been significantly increased impact on marine environments as a result of the growth in mariculture facilities in the coastal areas of the region.

**Interaction between marine farmed production and marine farmed area**: In the Yellow Sea, yearly production depended heavily on the shellfish production, which accounted for an average of 75% of the total during the entire period. Both the total production of shellfish and the associated farmed area for shellfish production have increased gradually, although the production per unit area reveals a decreasing trend from 14.1 MT/ha in 2000 to 10.5 MT/ha in 2004. For seaweed, annual production per area also showed a downward trend from 22.0 MT/ha in 2000 to 17.1 MT/ha in 2004. This suggests that production per unit area could not be expected to increase even if farmed area in this region was expanded in the future.

#### 5.2.4 Socio-economics

Some data and information related to the fisheries socio-economic aspects of fisheries made available by the two nations are contained in this report. However, only general descriptions have been provided without the detailed analyses required for long-term data interpretation. There is a need, on the one hand, to collect long-term data on fisheries economics. On the other hand, there is a need to include expertise on economic data analysis in future studies.

### 5.3 Establishing a regional fisheries database

It is recommended that a database be established, not only for historical fisheries data and information but also for future cooperative research studies in the Yellow Sea between the two nation's institutes, which can be expanded to include other nations in this area. Such a database would be of great assistance to scientific activities for collecting and retrieving research data and for monitoring the status of fisheries resources.

## 6 CONTRIBUTIONS FOR FISHERIES CHAPTER OF TDA

Based on the synthesis of data and information from the national reports of China and Korea, brief statements of major issues on fisheries and mariculture (see Section 5) that could be incorporated in the TDA are provided below:

### 6.1 Fisheries

#### 6.1.1 Description of fisheries

- Evaluation of current exploitation level for 10 commercially important species between two nations.
- Analysis of fishing efforts for total number of vessels, tonnage and KW of powered and non powered vessels.
- Comparison of catch compositions of commercial species for two nations.
- Review of CPUE trends for stock assessment.

#### 6.1.2 Biological/ecological data and information

- Differences of growth patterns, reproduction and spawning pattern from two nations
- Estimation of migration route and distribution of commercial species

6.1.3 Bottom trawl survey

- Seasonal major species compositions and density distributions, and fish larvae and eggs

## 6.2 Mariculture

- Long term aquaculture production trends

  Comparisons of production nationwide and production of Yellow Sea
- Historical aspects of aquaculture areas and habitats (methods) used for two nations
- Recent marine farmed production by province in the Yellow Sea of two nations

## 6.3 Socio-Economics

- Vessels trend by fishery and by province, fisherman engaged for each province and incomes
- Trends of exports and imports of fishery products
- Contribution of economic importance of fisheries (GDP)
- Yearly fishery consumption per capita

## 6.4 Analysis of national laws and regulation on fisheries and mariculture

- Chain: Major laws and regulations related to fisheries and mariculture management, and environment protection etc.
- Korea: Off-shore and coastal fishery structure control, rebuilding of fishery and status of raising fishery cultivating laws etc.

## 7 PERSONS/INSTITUTIONS VISITED OR INTERVIEW

The consultant have visited the following institutes and also contacted scientists/persons to carry out the consultancy duty:

China

Yellow Sea Fisheries Research Institute

Dr. Jin Xiangshi

Dr. Fang Jian Guang

Korea

West Sea Fisheries Research Institute of NFRDI

- Dr. Yeon In Ja
- Dr. Im Yang Jae
- Dr. Jang In Kwon

National Fisheries Research and Development Institute (NFRDI)

- Dr. Kim Jin Yeong

Korea Institute of Marine Science and Technology Promotion (KIMST)

- Dr. Kuan Moon Sang

National Federation of Fisheries Cooperation (NFFC)

- Dr. Kim Yeong Ku

Ministry of Maritime Affairs and Fisheries (MOMAF)

- Mr. Yang Dong Yeop

## 8 WEBSITES RELATED TO FISHERIES DATA AND INFORMATION

### 8.1 China:

http://www.cafs.ac.cn/

http://www.china-fishery.net/

http://www.china-fish.com/

http://www.nmdis.gov.cn/

http://www.agri.gov.cn/

http://www.fishery.com.cn/

http://www.china-fisheries.org/

### 8.2 Korea:

http://www.momaf.go.kr/

http://www.kosis.nso.go.kr/

http://www.infofishnet.co.kr/

http://www.fs.fips.go.kr/

http://www.bok.or.kr/

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UNDP/GEF, 2005. The second regional working group meeting report for the fisheries component of the UNDP/GEF Yellow Sea Project, 12p. and annex III 25p.

Yellow Sea Fisheries Research Institute. 2006. Report of data and information collection from China, National report of China, 56p.

West Sea Fisheries Research Institute. 2006. Reducing environmental stress in the YSLME: Data/information collection – fisheries component, 96p.

**AGREED DATA FORMATS AND SUBMISSIONS**

| Classification | China | Korea | Remark |
|---|---|---|---|
| **1. Fisheries production** | | | Annex III pages |
| **<u>Capture fishery</u>** | | | |
| 1.1 Total catch by commercially important species<br>- 10 species<br>- Duration: 19yrs, 1986-2004 | 1986-2004 for 10 species | 1986-2004 for 10 species | Page 2 |
| 1.1 Tonnage and KW of boats<br>- Powered vessel: no., tons,<br>- KW<br>- Non-powered vessel: no., tons | 1986-2004 | 1986-2004 | Page 3 |
| 1.3 Commercially important species composition of total catch<br>- Percentage species composition based on the item 1.1 | 1986-2004 | 1986-2004 | Page 4 |
| **<u>Biological data</u>** | | | |
| 1.4 Growth parameters by species | 8 species | 8 species | Page 5 |
| 1.5 Reproduction and sampling characteristics by species | 10 species | 8 species | Page 6 |
| **<u>Bottom trawl survey</u>** | | | |
| 1.6 Seasonal species composition<br>- Spring, winter catch & % | 2000-2004 June | 2003-2006 spring,winter | Page 7 |
| 1.7 Seasonal density distribution | 2000-2004 Spring | 2003-2006 spring,winter | Page 8 |

| | | | |
|---|---|---|---|
| by species | | | |
| **<u>Ichthyoplankton survey</u>** | 2002 (June) | 2003-2006 | Page 9 |
| 1.8 Seasonal number of fish larvae and eggs | Larvae & eggs | Larvae,egg | |
| **2. Mariculture production** | 2004 | 1995-2004 | Page 10 |
| 2.1 Total production of marine farmed organisms in (  ) year | 5 province | 5 provinces | |
| - Finfish, crustaceans, shellfish and seaweeds, others by province | 1995-2004 | 1995-2004 | Page 12 |
| 2.2 Chang in total production of marine farmed organisms from (  ) to (  ) year | | | |
| - Finfish, crustaceans, shellfish and seaweeds, others | 1995-2004 | 1995-2004 | Page 15 |
| 2.3 Change in total production of major marine farmed species from (  ) to (  ) year | | | |
| - Finfish, crustaceans, shellfish and seaweeds | 1995-2004 | 1995-2004 | Page 16 |
| 2.4 Overview of marine farmed production for last 10 years | | | |
| - Finfish, crustaceans, shellfish and seaweeds, others | | | |
| 2.5 Production ratio of marine farmed organisms (kinds) for last 10 years | 1995-2004 | 1995-2004 | Page 16 |
| - Finfish, crustaceans, shellfish and seaweeds | 2004 | 1995-2004 | Page 17 |
| - Total farmed production by province in 2004 | 2004 | 1995-2004 | Page 17 |
| 2.6 Aquaculture licenses and | | area(ha) | |

| | | | |
|---|---|---|---|
| area of marine farmed species | area(ha) only | only | |
| for ( ) year | | | |
| - No., number of licenses: ha, | | | |
| farmed area | | | |
| - Finfish, crustaceans, shellfish | | | |
| and seaweeds, polyculture | | 1995-2004 | |
| and collective farms | 1995-2004 | area (ha) | Page 18 |
| 2.7 Aquaculture licenses and | area(ha) only | only | |
| area of marine farmed species | | | |
| for last 10 years | | | |
| - Fish, crustaceans, shellfish | | | |
| and seaweed, polyculture, | | 1995-2004 | |
| collective farms and others by | No data | for 5 | Page 21 |
| organism | available | provinces | |
| 2.8 Overview of aquaculture | | | |
| methods for ( ) year | | | |
| - No., number of licenses: ha, | | | |
| farmed area | | | |
| - Fish, crustacean, shellfish and | | | |
| seaweed, polyculture, | | 2000-2004 | |
| collective farms and others by | 2000-2004 | | Page 23 |
| habitat | | | |
| **3. Socio-Economics data and information** | | | |
| 3.1 Vessels by fishery | | | |
| - Total number of powered | | | |
| vessel and non-powered | | | |
| vessel | | | |
| - GT of powered vessel and | | 2000-2004 | |

| | | | |
|---|---|---|---|
| non-powered vessel | | for 5 | |
| - Distant waters fisheries: | 2000-2004 | provinces | Page 23 |
| number and GT | 5 provinces | 2000-2004 | |
| -Offshore and coastal fisheries: | | | |
| number and GT | 2000-2004 | 2000-2004 | Page 24 |
| 3.2 Vessels by province | | | |
| - Vessels by province: number | 2000-2004 | | Page 24 |
| and GT | | 2000-2003 | |
| 3.3 Number of fisherman by | | | |
| province | 2000-2004 | | Page 24 |
| - No. of persons by province | | 2000-2004 | |
| 3.4 Fisheries income | | | |
| - Income by country and year | 2000-2004 | 2000-2004 | Page 24 |
| (USD) | | | |
| 3.5 Fisheries consumption per | 2000-2004 | 2000-2004 | Page 25 |
| capita (kg) by year | | | |
| 3.6 Exports of fishery products | 2000-2004 | 2000-2004 | Page 25 |
| by year | | | |
| 3.7 Imports of fishery products | 2000-2004 | | Page 25 |
| by year | | | |
| 3.8 Economic importance of | | | |
| fisheries (GDP contribution) | | | |
| - GDP fisheries by year | | | |
| - GDP contribution by year | | | |