

Appendix I

China P.R.1: A Review of National Aquaculture Development²

**Wang Yianliang Deputy Director General,
Bureau of Fisheries, Ministry of Agriculture,
Beijing, China P.R.**

Wang, Y. 2001. China P.R.: a review of national aquaculture development. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 307-316. NACA, Bangkok and FAO, Rome.

ABSTRACT: China's aquaculture production exceeds its fish capture landings. When China adopted the reform and opening-up policies, fisheries began to take off rapidly. By the 1980s, fisheries were playing an important role in food security and became one of the most vital support industries and economic activities in rural development. Technical innovations, especially mass seed production of aquatic organisms, design and construction of commercial fish bases, expansion of coastal aquaculture and sea-farming, and intensive and high-yield aquaculture technologies stimulated a rapid increase in production; it rose from 1.68 million mt in 1980 to 21.82 mt in 1998. Improvements have been attained with expansion, increase in yield per unit area, improvement of support and production facilities, more investments in aquaculture research and development, and provision of better services to farmers. Constraints, however, are becoming more pronounced - these include increasing cost of production and biological problems, including genetic degradation of farmed species and diseases. The environmental problems have also exposed the shortcomings of the regulatory and institutional systems for fisheries. China feeds 22 percent of the world's population but has only 7 percent of the earth's arable land, which is devoted mostly to grain production. Thus the substantial production from fisheries, especially aquaculture and enhanced fisheries, has made a significant contribution to improving the food intake and nutrition of the people. Aquaculture has also created much rural employment. Between 1980 and 1998, the additional number of people employed in the fisheries sector was 10 million; the average new entry or job creation is half a million people a year, with 70 percent going into aquaculture. To meet the demands of another 100 million people that are expected to be

added to the population in the next 20 years, the fisheries development plan aims to promote the transformation of the fisheries economic system to fit the basic requirements of a market economy, and to promote science, education and sustainable fisheries development. The goal is to increase aquaculture contribution to improve the welfare of farmers and develop the rural economy.

KEY WORDS: Aquaculture Development, China, Fisheries, Planning, Fish Farming

307

Introduction

From 1978, when China adopted reform and open policies, fisheries were placed in the rapid development track. Fisheries have played an increasingly important role in food security, especially after the late 1980s, to become one of the most vital support industries and an increasing centre of economic activity within agriculture and the rural economy. In the past 20 years, aquaculture has developed through the popularization of different operating systems, by means of designing and constructing commercial fish bases³, and by extending large-scale intensive and high-yield aquaculture technologies. These actions have led to aquaculture production rising sharply from 1.68 million mt in 1980 to nearly 21 million mt in 1997, an APR [Average Percent Rate] of 16.7 percent over this seventeen-year period. Alongside this production systems evolution and the associated increase in fish consumption, problems of regional and structural over-production, the reduction of comparative benefits and the degradation of the fisheries environment have been inhibiting factors for the further development of fisheries and aquaculture. In order to meet the demand for fish and fishery products in the new millennium based on the forecasted increase in population of 100 million people in the next 20 years, a general plan has been made for fisheries and aquaculture development in China. The plan is comprised of the following key elements:

- * To promote the transformation of the economic system of fisheries, including the pattern of economic enlargement, by applying the basic requirements of the socialist market economy;
- * Implementing the strategies of promoting fisheries through science and education and the sustainable development of fisheries;
- * To realize the optimum composition of the different elements of fisheries production, including farming of high-valued species, intensification of pond-culture operations and industrialized

development, by actively readjusting and optimizing the industrial structure and the production components;

* By treating seed production as the base, and aquatic product quality and sustainable fisheries development as the key content; and

* Industrialization of the sector as the goal, to promote the rapid development of sustainable fisheries and aquaculture in a coordinated and regulated manner in the 21st Century so as to promote agriculture and the rural economy and provide a greater contribution to the improved livelihood of the rural population.

Review of the achievements and development trends

Summary of aquaculture developments

During the past 20 years, the remarkable characteristic of Chinese fisheries and aquaculture development has been that the structure of production has changed, particularly when measured alongside the rapid increases seen in production volumes. The readjustment and optimization of the structure that exploits resources has been considered to be the most important factor for both the sustainable and rapid development of fisheries.

For a long time, capture fishery occupied the dominant position within traditional fisheries in China, providing 71 percent of total production up until 1978. The irrational pattern of increasing production by exploiting natural resources (mainly marine fisheries resources) had caused the degradation of fisheries resources, seriously limiting the potential for the sustainable development of the fisheries sector. Following China's reform and opening-up to the outside world, the government adopted the policy to give first priority to aquaculture development in its overall fisheries development strategy, which resulted in the significant increase of aquaculture yield and its share in fisheries production.

In the past 20 years, vast areas of inland water bodies, shallow seas, mudflats and low-lying lands have been utilized effectively for aquaculture. The geographical distribution of aquaculture farming practice in the country also extended from the coast and the delta of the Yangtze and Pearl rivers, where fish farming has been practised for centuries, to the areas with no aquaculture tradition, particularly the three northern areas (i.e. North, Northeast and Northwest China). By 1998, the total area devoted to aquaculture production in China had reached 6 085 000 ha, about twice that for 1980. In the same year, aquaculture production attained 21 820 000 mt⁴, 12 times that

for 1980, an expansion reflecting an APR of some 32 percent, a measure of growth that confirms aquaculture to have been responsible for the major part of the increment of fishery production during this period.

308

Amongst the major fish producing countries of the world, China is the only one whose aquaculture harvest exceeds that of capture fisheries. In 1998, the share of aquaculture in total fishery production was 56 percent as compared to 26 percent in 1978. The rapid increase in aquaculture production also significantly increased its contribution to animal protein production; the percentage of aquaculture products in the total animal products, including meat, poultry, eggs, milk etc. reached 32 percent in 1998 against 20 percent in 1985. At the same time, the diversity of aquaculture products has shown a clear trend towards providing a wide range of products of high quality. The main aquaculture species used for production have developed from a few (four major Chinese carps, molluscs and seaweed) to several dozen commercially important culture species that include fish, shrimps, crabs, seaweed and molluscs for freshwater, brackish and marine environments. Aquaculture production increasingly includes desirable high-value species that now provide a significant portion of the total output.

For a long time, the per capita consumption of aquatic products in China was lower than the world's average. During the period examined, the considerable increase in the availability of aquatic products has contributed to rising annual consumption figures, and by 1998, the consumption has reached 31.3 kg per capita, a figure that is 10 kg higher than the world's average. The target of resolving the problem of fish shortage in China was reached on time. In China today, the aquatic products in the market are not only available in adequate supplies, but they are also rich in variety, of high quality and have a stable price.

Aquatic products are an indispensable food for the people, and it is often said that China feeds 22 percent of the world's population but possesses only 7 percent of the world's arable land which, in China, is devoted mostly to grain production. In fact, the large quantities of aquatic products harvested from the seas and inland waters also make great contributions to improving the human diet and, consequently, the health of the population.

China produces annually more than 20 million mt of aquaculture products, most of which contain high-quality fish protein, a situation that also reflects the important fact that aquaculture is an effective industry that utilizes lands that are not suitable for crop production and converts feed with a higher conversion rate than those of terrestrial animals.

It is an activity that lessens the contradiction of having a large population but little land, easing the pressure of population increase and the concomitant demand for grain and meat. These observations embody the great contribution of Chinese aquaculture production to food security in China and the world.

The past two decades have shown aquaculture to be the most rapidly developing sector within agriculture, not only in terms of production, but also in the creation of jobs in the rural areas. In 1998, the total fisheries production value reached 161.7 billion Chinese Yuan⁵, which was about 75 times that for 1980 (2.1 billion Yuan). The increasing importance of this economic value is demonstrated by the observation that, in 1980, fisheries represented 1.5 percent of the total combined value of fisheries and agriculture, a figure that rose to 12 percent by 1998. In terms of employment within the fisheries sector, the labour force is now estimated to be some 10 million people, a figure that is rising by around 500 000 per year. Of these totals, it is calculated that 70 percent are engaged in aquaculture.

The aforementioned details demonstrate that aquaculture development has made itself an important sector within the rural economy in China. The scope is growing continuously for the development of a series of related industries, business and services, such as storage, processing, transportation, fish feed manufacture and marketing, which are subsectors driven by the development of aquaculture. The sector as a whole has been playing an active role in facilitating the optimization of the restructuring and performance of the rural economy.

Utilization of resources by fisheries and aquaculture

The integrated management and utilization of natural aquatic resources has not only widened the scope of aquaculture but has also allowed steady increases in production. In the first instance, the surface and rate of use of water areas increased. China has 17 470 000 ha of inland water surface, of which some 2 980 000 ha (17 percent) were utilized for aquaculture in 1980. The figure jumped to 5 080 600 ha in 1998 (30 percent). The total area devoted to

mariculture increased from 133 000 ha in 1980 to 1 004 400 ha by 1998, nearly an eight-fold rise.

309

Secondly, not only has the aquaculture capacity improved, but the yield per unit area has also increased. Alongside the continuous improvements made in infrastructure, production facilities and technology extension, aquaculture's capacity has risen continuously. In 1980, the average annual yield in inland waters was 315 kg/ha; it has risen to 2 400 hg/ha by 2000, close to a seven-fold increase.

Mariculture is continuing to develop away from the simpler mollusc and seaweed cultures towards diversified systems of intensive culture of multi-species. The number of species used within mariculture has now reached several dozen and includes major commercial marine animals and plants, such as fish, shrimp, molluscs, seaweed and sea cucumber.

Aquaculture techniques include rafts employed for culture of kelp, *Undaria*, laver, scallops, oysters, abalone, mussels etc. in the shallow sea; net cages for a variety of marine finfish; ponds for the culture of shrimp, fish, crabs and molluscs; mudflats utilized for culture of clams, ark shells, razor shells and oysters; and enclosed indoor facilities (e.g. raceways and tanks) for rearing high-value species such as mock halibut, flounder, abalone and sea cucumber. Aquaculture systems are designed for multispecies mixed cultures, as well as for monospecies culture.

At present, a multi-patterned and three-dimensional mariculture industry is developing dynamically in the shallow seas and in the mudflats, adapting to local conditions in an appropriate manner. The third consideration is that the labour force input and employment have increased. Aquaculture is seen to give better benefits and wider opportunities for market development and thus attracts a large number of agricultural labour. It has been observed that the economic returns of a one-hectare pond are equivalent to that from two hectares of cotton or three to four hectares of paddy field. The fisheries labour force, including aquaculture, increased from 2 950 000 in 1980 to 12 374 800 in 1998, and the average per capita income of fishermen rose from 171 Yuan to 4 323 Yuan during the same period.

Fourthly, the contribution from science and technology has increased the level of skills of workers in the sector. The capacity of workers in

the sector to apply the scientific approach to fish farming has been vastly improved through technological research, demonstrations, extension and training courses.

Tremendous efforts have been made to provide on-farm technical support and extension services by fishery research institutes and technology extension stations at the provincial, prefecture, county and village levels. With the intensification of production systems and diversification of species, the contribution of science and technology has become a vital factor in aquaculture development. A comprehensive survey and tests carried out nation-wide came up with the estimate that some 48 percent of production increase was attributed to scientific and technological advancement.

Finally, aquaculture facilities have been enhanced and the investment in infrastructure increased. The rate of return on investment in aquaculture is high and continues to have good prospects. At the same time that the government invested considerable funds to construct 10 large commercial fish production bases for fish production, 500 000 ha of fishponds for intensive culture were built. This effort was realized using loans from the World Bank (WB), local government investment and labour input as the contribution of the people.

In order to guarantee the smooth implementation of the strategy of "promoting fisheries by science and technology", both central and local governments have invested a tremendous amount of funds to establish a national aquaculture technical training and extension network consisting of extension stations at the central, provincial, prefecture, county and village levels. This extension system includes 37 stations at the provincial level, 206 at the prefecture level, 116 at the county level and 1 155 at the village level. Each station is equipped with appropriate instruments and training facilities. Furthermore, an original system has been established for promoting fine (i.e. high-value) species, which includes 25 specialized farms at the state level to maintain broodstock, combined with a fishery administration and environmental monitoring and protection system.

Analysis of the main experiences and lessons learnt

The important experiences in aquaculture development, described for China, include the following:

Application of the fisheries development principle of “taking aquaculture as the key”

As China is rich in water resources and areas such as mudflats, the government proposed a core readjustment principle containing three keys – “utilize the resource rationally, make great efforts to develop aquaculture, and focus on improving quality”. Through this approach, the government assured that aquaculture development became the key means to increase the supply of aquatic products. In 1985, the establishment of the fisheries development principle - “take aquaculture as the key, let aquaculture, fishing and processing develop together, make different emphases according to local conditions” – enabled the fisheries sector to enter the rapid development phase, which was principally dependent on aquaculture expansion, forming a unique fisheries development pattern having Chinese characteristics.

Formulation of fisheries policies for development within the economic structure of the socialist market in China

The reformed and open environment in China has provided easier conditions for the development of fisheries, a circumstance that included two main policies. The first was the liberalization of right for land use and farm management. An aquaculture farm management system was adopted based on the household responsibility system as the key element, combined with a diversified operating system. In order to encourage the people to reclaim and exploit low-lying or saline-alkali land suited for aquaculture, the local governments actively established preferential policies and provided support and privileged fiscal and investment measures. These were extremely successful, arousing enthusiasm for involvement in developing aquaculture both within the population and industry. The second policy was the liberalization of price control by government, which allowed the price of fish products to adjust to the market, permitting the full range of advantages of unified production and sales. All policies have given a great impetus to the development of aquaculture in the country.

Adjustment of the cultured species profile and the reform of market-oriented aquaculture

In order to ensure the effective supply of fish products and increase the benefits from aquaculture, the local governments have paid considerable attention to popularizing the use of fine species for both

stock enhancement and aquaculture purposes, thus diversifying and optimizing aquaculture species use. This has enabled inland aquaculture to break out of the traditional pattern of rearing the four principal domestic species (silver carp, grass carp, common carp and bighead carp). Large-scale freshwater production has now been achieved for well-known high-grade species such as eels, crabs, softshell turtles and freshwater prawns. In mariculture, increased production has been seen for shrimps and prawns, marine fish species, scallops and other high-quality species. The core "single species" activities, such as kelp and mussels, have adopted a multispecies approach where a combination of fish, shrimp, molluscs and seaweed are reared.

To be able to assure a constant, year-round supply of fresh and live fish, aquaculture methodology was also reformed, including the policy of "take turns in fishing and stocking, catch the bigger and leave the smaller". This approach lessened seasonal peaks and troughs concerning supplies, thus improving the market situation and reducing overstocking as well as fluctuating prices. It is evident that aquaculture outputs and benefits have been improved with these reforms and operational changes.

Extending aquaculture technology and improving quality

Fisheries administrations have improved overall quality in aquaculture through the popularization of many kinds of advanced and suitable techniques. For example, the development and extension of artificial breeding and feeding techniques allowed shrimp farming to expand rapidly to an annual production of more than 200 000 mt in the early 1990s, and for scallop to change from a high-value product to one that is readily available. The application of intensive pond systems and more productive farming systems and technology has increased average pond output from 750 kg/ha in 1980 to 4 500 kg/ha in 1998.

311

The rate of use of water has increased through the application of fish pen and cage farming in medium-sized and large water bodies and the application of intensive farming technology (in small to medium and large water bodies). It is estimated that this factor alone has contributed to the doubling of productivity.

Integrating aquaculture with agriculture, forestry and animal husbandry has also assisted the rapid and successful development of aquaculture.

Strengthening the legal framework and fisheries management

Since reform and the introduction of an "open door" policy, China has established a basic policy of "managing and developing fisheries by law". The legal system for Chinese aquaculture is based on the framework of Fishery Law. Its key purposes are to protect resources and utilize them rationally and to guarantee the rights and interests of fishermen. Further measures have been taken to improve the legal framework of Chinese fisheries and to strengthen monitoring and enforcement in order to assure its sustainable and healthy development.

Constraints to the continuous development of aquaculture **The decline of comparative profitability**

In recent years, the price of freshwater aquaculture products has declined. Amongst these, one can note that the prices obtained for eel, softshell turtle, giant freshwater prawn, mitten crab and other high-value products have diminished by as much as 50 percent. The price of the more staple products (e.g. carps) has been more stable, but production costs have increased. Under these circumstances, it was noted that some aquaculture enterprises have encountered serious financial losses, affecting the producer's enthusiasm for development.

The promotion of skills and technology

Although the area devoted to aquaculture and its total production give China the leading position in global aquaculture, there are still great differences in basic facilities and scientific and management levels among regions and provinces. Increased skill capacities need to be promoted.

The decline in genetic quality

At present, basic work on maintaining genetic fitness, including research, genetic purification and rehabilitation, is weak, a position that could result in genetic degeneration and lead to a potential degradation of many of the productive advantages, such as growth rates and disease resistance.

The economic impact of diseases in aquaculture

Although statistics are incomplete, expert analysis reveals that diseases are responsible for losses of some 15-20 percent of production, which would imply an economic loss of 5-7 billion Yuan (US\$525-875 million) annually.

An outline of china's aquaculture development plan for 2001-2020

Overview

The main directions for development are to:

- * transform traditional fisheries into a modern activity;
- * transform production activities from extensive to intensive operations; and
- * Improve the quality of aquaculture products.

By taking the improvement of product quality as a core issue, increasing both production and income are the goals, where the sector will rely on scientific progress and producer skill improvements, allowing the promotion of aquaculture as an effective, healthy and sustainable sector.

The practical work to be done includes:

- * establishment of aquaculture systems for both traditional and high-quality species;
- * development of aquaculture standards and disease control; and
- * fishery engineering activities for developing the potential of shallow seas and mudflats, low-lying and saline lands (along the Yellow River), large- and medium-size water bodies and paddy-field fish farming.

312

Production targets

The tentative target for national fisheries production for the year 2010 is 51 million mt, which represents a 24 percent increase from the predicted production of 41 million mt in 2000, indicating an APR of 2.2 percent. The total value is estimated to reach 350 billion Yuan, contributing 15 percent to that of the entire agriculture sector. The

targeted per capita availability of fisheries products is estimated at 36 kg.

The demand for fisheries and aquaculture products

Both fish species and fish products will develop in different and diversified directions according to consumers' buying power, consumption habits and perceptions. According to present trends, the consumer appreciates and welcomes nutritious and safe fish products, with a particular appreciation for the highly rated species, which represent a considerable development opportunity. These include freshwater species like mandarin fish, snakehead, perch, catfish, shrimp, softshell turtle and tortoise, while marine species of interest include fish, shrimp, molluscs and seaweed.

The diversity of food preferences gives a wide range of consumption patterns, which is good for both the exploitation and the utilization of natural resources. This contributes to the avoidance of the irrational exploitation of the food chain and environmental destruction and is, therefore, good for the sustainable development of fisheries.

Due consideration has been given to ensure basic fish supplies and improve the food security situation in rural areas. Fish farming is considered as the quickest and most effective way to increase fish supplies, and it has been given high priority in the national fisheries development plan in the context of rural development. The government has been extremely supportive to rural aquaculture development through its technical extension service, particularly for production of species that are low in the food chain and with a wide adaptability and high productivity.

The distribution and management of resources

The diversity encountered in respect of both production and consumption determines that the fishery resource should be utilized and exploited evenly. Such exploitation should not be that of natural fisheries (low investment, low output, light pollution, low benefit) nor should it be an industry (high investment, high output, high energy consumption and heavy pollution) that would exhaust the natural resource and degrade the environment.

The rational approach should be to take into consideration the total resource capability, the environmental capacity and social needs. On one hand, it is necessary to obtain higher fish production by enhancing the weaker points of the resource and increasing productivity. On the

other hand, the production should be kept within a certain scale in order to respect the issues concerning sustainability. It is necessary to use modern science and technology to transform the traditional fishery activities into modern ones, to increase productivity using science, and to improve the productivity of water bodies and labour, and thus the yield rate of resources. This approach will realise the unification of the social, economic and ecological benefits of aquaculture.

China has 17.47 million ha of inland waters, of which only 35 percent are used, meaning that there is still a lot of space for aquaculture development. Nearly 6 million ha have been developed, but aquaculture remains predominantly at the stage of extensive farming. There is great potential for improving the rate of resource use, increasing the productivity, the product quality and the contribution of science. For example, out of the 6 million ha of inland aquaculture area, some 2 million ha, about one third of the total area of inland waters under cultivation, constitutes 70 percent of the total inland aquaculture production. The yields obtained from pond-fish farming are highly variable, noting that the average harvest figure in China is 4 500 kg/ha, but this can reach up to 9 200 kg/ha in high-yield regions, i.e. Jiangsu, Guangdong and Zhejiang provinces. However, significant differences can also be seen within the same region, depending on economic and technical conditions, which include modifications to ponds, integrating water flow and/or equipment and scientific training.

313

Reservoirs constitute 31.6 percent of the inland waters under cultivation, but they also have the lowest production yields (750 kg/ha) and therefore, have great development potential. The application of cage and fish pen culture in reservoirs would not only be a measure for increasing production, but also one that can contribute to resolving problems of employment and livelihood for immigrants in these areas. The recovery of lakes from land also provides a new chance to develop fisheries along the lower reaches of the Yangtze, the Pearl and the Songhua rivers. The activities of fishery enhancement, and cage and pen culture in new open waters would not affect the ecological environment of the land returned, but could recover the agricultural loss.

In addition, the area of paddy fields is underused for aquaculture, being 1.3 million ha, which is only one third of the area considered suitable for aquaculture. Practice has shown that fish farming in paddy fields does not affect rice production, but it can provide a double

harvest of both fish and rice. The goal of 1 500 kg fish and 15 000 kg rice/ha is not difficult to reach. In some remote and poor areas, to develop the paddy-fish combination, along with intensive culture, would assist the employment of surplus labour and help poverty alleviation.

To sum up, even if there was no increase in the availability of land and water resources specifically for aquaculture, the full exploitation of the potential of resources now available could meet the needs of sustainable aquaculture under both economic and environmental aspects. Meanwhile, encouragement is made for the use of wastewater for fish farming and the achievement of sustainable aquaculture, policies that are supported by the provision of preferential loans, fiscal conditions and technical services for aquaculture operators. For increasing the efficiency of the use of water resources, well-established techniques should be adopted to exploit those water bodies that are not cultivated (65 percent of the total). On the other hand, resource enhancement (e.g. cage and pen culture in open waters) would be beneficial for the development of the reservoirs, lakes and other water bodies.

Aquaculture techniques and technological applications should be reformed for some waters. For example, the extension of the use of hard, floating feed pellets could assist the elimination of eutrophication or pollution in waters that is caused by the poor management and feeding strategy.

The aspirations for aquaculture development for the period 2001-2020

In the next 20 years, the emphasis of fisheries and aquaculture development in China will be to:

- * meet the needs of social and economic development;
- * increase the efficiency of fisheries production;
- * develop and promote aquaculture, agriculture and the rural economy;
- * expand and diversify production so as to meet the demand for fish and fishery products; and
- * make the best use of market potential.

To realise these goals, the state will primarily support the development of six core systems and six areas of concern. The systems to be developed are:

- * original and fine species diversification system;
- * fishery scientific and standardization system;
- * fishery technology extension system;
- * disease control system;
- * fishery marketing system; and
- * fishery management and environmental protection system.

The six fields to be developed are the:

- * vertical integration of aquaculture production in the fish culture bases;
- * development of offshore and distant water fishing;
- * processing of fish products and comprehensive utilization of materials;
- * building of fish ports;
- * building of fishing vessels and
- * manufacture of fishery machinery and new technical exploitation.

The implementation of the "TWO SIXES" systems will play an important role in strengthening Chinese fisheries and aquaculture, realising sustainable and healthy development, as well as speeding up the modernization process.

The distribution of fishery resources

It is unlikely that there will be any significant increase in pond areas in view of the limited suitable land available in China.

314

Consequently, the emphasis is on the upgrading of pond conditions, as well as the readjustment of culture techniques and the structure of the species cultivated. The enhancement and protection of the natural resources has to be encouraged, applying cage and pen culture in other water bodies, where appropriate. The development of polyculture alongside the capacity for multispecies applications will provide opportunities for diversification and the production of high-quality species and products.

Meeting market demand through recognized consumption patterns and economic realities would also encourage diversification. The assurance of stability within the aquaculture sector will support efforts towards

the production of higher value species, providing greater economic benefit and a wider market potential.

The administration of fish farming

A number of requirements has been identified to allow the efficient administration of fish farming in China, including:

- * establishing, as soon as possible, a specific legal system for fish farming to guarantee the realisation of sustainable aquaculture development;
- * implementing a sector support system for fish breeding, fry supply and disease control;
- * optimizing the industrial structure to reconfigure production and have a rational distribution of the activity; and
- * modernizing fish farming.

The plan for upgrading the national technological base

The fishery technical development trends to be seen in China in the next century have been identified as the following:

- * research on bioengineering technology with emphasis on the improvement of new culture species or strains;
- * research on the sustainable development of fishery enhancement and aquaculture in order to assure positive and rational development;
- * research on disease control and production technology for aquaculture, with particular reference to molecular biology tools;

- * research and development to transform traditional aquaculture systems, develop new culture technology systems (e.g. raceways), eliminate self-pollution and improve management systems; and research to develop applicable technologies for the culture of marine species and to guarantee the supply of high-quality aquatic products.

Strengthening technical services

In order to bring fishery technical extension into full play, it is necessary to develop different types of services for the benefit of the production sector. These include technical associations, mutual insurance aid and other nongovernmental service organizations that can serve the fisheries and aquaculture sectors. It is also necessary to improve the abilities for self-protection and self-development of the labor force under the conditions of a market economy.

Strengthening legal and institutional capacities

Firstly, current legislation and regulations require full implementation, where the following issues require completion or establishment:

- * 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 systems and technologies should be developed in accordance with accepted ecological standards. Measures to promote the application of ecological standards and “green” products that have been reared in such systems should be the subjects of research and extension, giving focus on the supply of healthy, nutritious food. These are instruments that will assist the policies adopted for readjusting the market.

Thirdly, a licensing system for the discharge of sewage drain waters into fishery environments should be implemented where sewage could only be released after approval by the fishery environment monitoring department, which would be required to demonstrate discharge standards. Financial charges would be collected from those discharging sewage, the money to 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.

315

Planning to transform Chinese aquaculture into a professional industry

Aquaculture has become an industry, and it is necessary to organize farmers’ associations, such as the National Collaboration Network for Eel, the Scientific Aquaculture Association, and others, in order for these to help in the management of the aquaculture sector and to coordinate the development plans for the industry. Detailed actions would include:

- * collection and dissemination of updated information;
- * exchange and dissemination of experiences (e.g. production techniques, marketing etc.); and
- * guarantee the support and benefits of the industry.

Economic and social expectations of aquaculture

Aquaculture can effectively promote economic development and societal progress. Firstly, the basic expectation for aquaculture should be that it should be an activity to guarantee the supply of fish products and, hence, food security, thus contributing to social stability and development.

Secondly, aquaculture can create significant employment opportunities, absorb and utilize surplus rural labour, encourage women and young people to be engaged in production activities, increase farmers' income and assist in poverty alleviation. Aquaculture development can also provide opportunities for leisure and recreation through sports fishing and tourism.

Thirdly, the awareness of the needs for environmental protection and social responsibility should be heightened when developing aquaculture. It is the duty of the sector to control pollution and resource degradation and to meet the needs of current social and economic development, achieving these aims without threatening the viability of the resource for the next generation.

Fourthly, aquaculture should be developed as an economic activity that can provide significant export earnings. As the world economy becomes more and more unified, it is necessary to take advantage of resources and technology to advance the economy and improve the stability of society.

1 People's Republic of China.

2 The original Chinese manuscript was translated by Mr Zhou Xiaowei, Programme and Training Specialist at the Network of Aquaculture Centres in Asia-Pacific (NACA) Secretariat. Additional inputs were taken from the review of Chinese aquaculture and development plans presented by Mr Miao Weimin, Deputy Director of the Chinese Freshwater Fisheries Research Centre in Wuxi, at the Asian Regional Aquaculture Development Planning Workshop in Kanchanaburi, Thailand, September 1999.

3 This refers to a national campaign in China in the late 1980s and early 1990s to convert low-lying and saline-alkaline or waterlogged lands that are not suitable for crop production into fish ponds for large commercial-scale freshwater fish (in some cases also for shrimp and brackishwater species) production. With the expansion of pond area to approximately 500 000 ha, a significant increase in fish production was achieved.

4 FAO statistical data show 27 million mt because FAO counts shelled weight for molluscs and live weight for seaweed, while Chinese figures are in meat and dry weight, respectively.

5 1 US\$ = 8.27 Chinese Yuan (exchange rate for 2000).

316

<http://www.fao.org/DOCREP/003/X6945E/x6945e03.htm#TopOfPage>

Background on aquaculture, geography, culture, economy

1. Background

1.1 Introduction

1.2 Fisheries

China is one of the oldest countries with a recorded history of 4 000 years. The Chinese nation is well known for her great contributions to the evolution of the human society. After the Opium wars in 1840, China was reduced to a semi-colonial and semi-feudal society. After an extremely brave and protracted struggle for more than one hundred years by the Chinese people, the People's Republic of China was founded in 1949 at last, and since then has followed a socialist road. Through hard work during the last five decades, China has achieved tremendous socio-economic progress and has improved the living conditions of her people. Seventy percent of China's total population of about 1.2 billion are rural and the rural economy is primarily agricultural. Agriculture contributes about one third of the Gross Domestic Product (GDP). Agricultural GDP in 1997 was 2 458.7 billion yuan of which fisheries contribution was 228.2 billion yuan, about 9.3%. Aquaculture contributed more than 50% of the gross value of fisheries output. Aquaculture is the fastest growing sub-sector of fisheries; and with a total production of 20.2 million mt in 1997, aquaculture contributed 56.2 percent of total fisheries production. China, the world leader in aquaculture production, produces more than 50% of the world aquaculture production.

1.1 Introduction

1.1.1 Physical geography

China is located in the eastern part of Asia and on the western shore of the Pacific Ocean. China is contiguous to Korea, Russia, Mongolia, Kazakhshtan, Kirghizstan, Tadjikistan, Afghanistan, Pakistan, India, Nepal, Sikkim, Bhutan, Myanmar, Laos and Vietnam (counter clockwise from the east) with her total mainland boundary line of more than 20 000 km. In the east and south, she faces Japan, the Philippines, Malaysia, Singapore, Indonesia and Brunei (Fig. 1). China has a vast territory, the distance of the mainland exceeds 5 200 km from east to west and more than 5 500 km from north to south, with a total land area of 9 600 000 km², the third largest country in the world. As a country of the Pacific Rim, she faces the Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea to the east and the south, and has a coastline of 18 000 km. Starting from the mouth of Yalujiang River in the north, which is bounded on by Korea, and stretches southward to the mouth of Beilun River, which is adjacent to Vietnam, there are over 5 400 islands scattered in the sea with a coastline aggregating over 14 000 km. Eighty percent of the islands are scattered over the sea area to the south of the Yangtze River and 20% to the north. Taiwan is the largest island of the country (35 788 km²) and followed by Hainan (34 000 km²), Chongming (1 083 km²), Zhoushan (524 km²), Donghai (317 km²), Haitan (290 km²), Changshandao (229 km²), Dongshan islands (207 km²), etc.

Bohai Sea is an inner sea. The Yellow Sea, the East China Sea and the South China Sea are all continental apron seas in the northwest and western Pacific Ocean. The total area of the four seas is about 4.72 million km². The continental shelf, within isobath of 200 m water depth, covers about 1.4 million km². There are numerous rivers along the coast with a total of 1 889 billion m³ runoff into the sea every year, that bring large quantities of organic material and nutrients to form a superior habitat for marine animals and plants, which have become most important fishing ground of the country. There are plenty of bays and gulfs distributed along the sea shore. And the vast mudflats and shallow sea water areas form the excellent places for marine aquaculture.

The Chinese continent is high in the west and low in the east. The first step is Qinghai-Xizang plateau, which is more than 4 000 m above the sea level. Mount Qomolangma (the Himalays, 8 848 m), the highest mountain in the world is situated in the southwest edge of the plateau between China and Nepal. Within the boundaries of the plateau, the river system of the continental rivers is well developed. The three large seagoing rivers, the Yangtze River, the Yellow River and the Yarlung Zangbo River, rise in the plateau. The second step is from the Qinghai-Xizang Plateau to the north and east, the average altitude declines to 1 000-2 000 m. It includes the Yunnan-Guizhon Plateau, the Huangtu Plateau, the Inner Mongolia Plateau and the Sichuan Basin, the Talimu Basin and the Zhungeer Basin. The large rivers such as the Helongjiang River, and the Pearl River originate from this area. The third step is along the line of Mount Daxinganling, Mount Taihang and the east edge of the Yunnan-Guizhon Plateau to the east. It mainly consists of vast plains (less than 200 m above sea level)

and some small low-lying hilly land (less than 1 000 m). The Northeast, North China and the middle-lower reach of the Yangtze River plains are three major plains which cover a total area of about one million km², and made up roughly one tenth of China's territory. These are the most densely populated areas of China. On the whole, the Chinese topography is roughly classified into five categories: mountainous regions, 33%; plateaus, 26%; basins, 19%; plains, 12% and hilly areas, 10%. The plains and basins are densely covered with rivers, lakes, ponds and small reservoirs which have become the most important areas for freshwater fisheries, especially freshwater aquaculture.

China has numerous rivers, with over 1 500 of them having drainage basins of 1 000 km² or more. Most of the rivers, which flow into Pacific Ocean eastward or southeastward in accordance with the topography, belong to the Pacific water system. The major rivers are the Yangtze, the Yellow, the Heilongjiang, the Pearl, the Liaohe, the Haihe, the Huaihe, the Qiantangjiang, the Lanchangjiang rivers and so on. The Yarlung Zangbo River and Nujiang River in the southwest China, which flow across the national territory into the Indian Ocean, belong to the Indian Ocean water system. Only the Eerduosi River in the northwest Xinjiang belongs to the Arctic water system. The total area of the rivers reaches 12 million ha, making up 45% of the total inland water area of the country. The Yangtze River which has a mainstream of 6 300 km long, is the largest river in China and the third longest river in the world. It rises from the northern foot of Mount Tanggula in Qinghai Province, flows through Tibet, Sichuan, Yunnan, Hubei, Hunan, Jiangxi, Anhui, Jiangsu provinces, and finally empties into the East China Sea at Shanghai. Its drainage basin is 1 808 500 km². The Yellow River, which has a mainstream 5 464 km long, is the second longest river in China. It originates from the northern foot of Mount Bayankala in Qinghai Province, flows through Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan provinces and finally empties into Bohai Sea in Shandong Province. Its drainage basin is 752 443 km². The Huai River originates from Mount Tongbai in Hunan Province, flows through Hubei, Anhui, pours into Hongze lake in Jiangsu Province and finally empties into the Yangtze River with a total length of about 1 000 km and with a drainage basin of 189 000 km². The natural conditions in the north and in the south of the mainstream of Huai River are significantly different, and have become an important geographical dividing line. The rivers in the south of the Huai River are abundant in water with little change of water level all the year round and does not freeze in winter. However, the rivers in the north, fluctuate greatly in water level and freeze in the winter. There are many inland rivers in the north and west of China. The water sources of these rivers are mainly glaciers on high mountains and melting snow. Besides, there are some seasonal rivers, in which there is usually no water except for rain storms. These rivers flow down to low-lying land; thus lakes are formed, or disappear in deserts. They are of great importance to local irrigation and water supply for human beings and animals, and have a lot to do with the fisheries development as well. The Talilao River in Xinjiang Autonomous Region is the longest inland river in China, with a total length of 2 179 km.

Thousands of lakes dot the vast Chinese landscape. There are more than 2 800 lakes having a water surface of over 1 km². The total lake surface area covers 75 610 km². Most lakes are found in the middle and lower reaches of the Yangtze River and the Qinghai-Xizang plateau. In the former region are scattered most of freshwater lakes and in the latter are mainly scattered saltwater lakes. The well-known lakes include the Boyang Lake, the Dongting Lake, the Taihu Lake, the Hongze Lake, the Chaohu Lake, etc.

China has 84 837 reservoirs (1997) of various kinds, with a water storage capacity of 458.3 billion m³. Among them, there are 397 large-scale reservoir each has a water storage capacity of over 100 million m³, 2 634 medium-scale reservoir each has a water storage capacity of 10-100 million m³, and 81 806 small-scale reservoir each has a water storage capacity of 0.1-10 million m³. Besides, there are 6.2 million mountain reservoirs (the water storage capacity for each reservoir is under 0.1 million m³) with a total storage capacity of 26 billion m³. The total area of the reservoirs cover 2.05 million ha. Those reservoirs located in Guangdong and Jilin provinces are the largest, each making up about 10% of the total area. The reservoirs in Jiangsu, Hubei and Hunan provinces come second, each accounting for 6.5%-7.5%. Those in Henan, Guangxi, Sichuan, Zhejiang, Heilongjiang, Shandong, Liaoning, Inner Mongolia and Xinjiang occupy 3%-6% respectively. The reservoir areas in the rest provinces are all below 3%.

China lies across from north to south 55 degree of latitude covering the tropical, subtropical, and temperate zones, and lies across from east to west more than 60 degree of longitude. The east part facing the sea has a marine climate, and the west part being of high altitude, is dominated by a continental climate. And China is divided as humid, sub humid, semiarid and arid climate zones from east to west. The monsoons exert an extremely remarkable influence on China's climate. The yearly rainfall all over the country is mainly concentrated from May to September and decreases gradually from the southeast to the northwest. An annual precipitation line of 400 mm slanting from the Daxinganling in the northwest through Zhangjiakou and Lanzhou to Lasa in the southwest divides the country into the southeastern part and the northwestern part. The semi-wet region and semi-dry region are also divided by this line. The more to the east the more plentiful the rainfall. A 800 mm isohyte conforms approximately to the line from Qinling to the Huaihe River and forms the dividing line of humid region and the subhumid region. This is an important dividing line which shows the distribution of the yearly precipitation in China - more in the south and less in the north. The Yangtze basin has an annual precipitation of 1 000-1 600 mm, and some places in Guangdong Province, 2 000 mm or more, but the precipitation in most places in the northwest is below 250 mm. The yearly average rainfall of the country is about 630 mm or 6 000 billion m³, of which 2 600 billion m³ forms the water resources of the country.

1.1.2 Demography

There are 23 provinces: Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Hainan, Sichuan, Guizhou, Yunnan, Shaaxi, Gansu, Qinghai, Taiwen; 5 autonomous regions: Inner Mogolia, Guangxi, Tibet, Ningxia, Xinjiang; one special administrative region: Hong Kong and 4 municipalities directly under the Central Government: Beijing, Shanghai, Tianjin, Chongqing. Under them, there are 668 cities, 332 prefectures and 2 135 counties.

China is well populated. In 1997, estimated total population was 1.236 billion or a density of 128/km²; this represents about one fifth of the world population. The Chinese government has paid the greatest attention to controlling population growth and treated it as a basic state policy for the last 20 years. The birth rate has been dropping gradually from 33.43 per thousand in 1970 to 16.57 per thousand in 1997, and the population growth rate has decreased to 10.06 per thousand. There were 866.37 million people (1997) residing in rural areas and depending primarily on agriculture for their livelihood.

China has 56 nationalities, of which Han nationality is by far the largest, accounting for 94 percent. There are 15 minority nationalities, which have a population of one million and over. They are the Zhuang, the Hui, the Welwuer, the Yi, the Miao, the Man, the Zang, the Mogolian nationalities, etc. Each nationality has her language but Mandarin is the common language used in the country.

1.1.3 Socio-economics

After the foundation of the People's Republic of China, the first three years (1949-1952) was the economic restoration period. The country started to do away with feudal exploitative land ownership system, conducted land reform, established collectivization, and then set up communes. The state worked out and implemented the First Five-Year Plan (1953-1957) for the national economy and social development with great success in every field all over the country. Afterwards, the Great Leap Forward Movement was carried out in 1958 and the Cultural Revolution, a political movement, lasted from 1966 to 1976. The two movements were disastrous to the nation's economy. Since 1978, the state has revised the policies and implemented the policies of "reform and opening to the outside world". The country's economic system has been largely geared toward the market-oriented economy from the past strictly and highly centralized planning economy and has developed household production responsibility and contract system from collectivization and communization. The people's enthusiasm has been greatly arose. The establishment of the economic zones along the coastal areas such as Shenzhen, Zhuhai, Shantou, Xiamen, Shanghai, Tianjin, Dalian, etc, and joint ventures have drawn a large amount of foreign capital. The national economy developed once again at an unprecedented speed. In 1997, the Chinese GDP reached 7 477.2 billion yuan, an increase of about 9 times against 775.6 billion yuan in 1978.

During the past twenty years, the average growth rate of GNP was 9.8%, much higher than other developing countries and nearly twice higher than the world average level. With the rapid growth in production, the people's living standard has been greatly improved. The yearly income of per head in town or city before 1978 was only 340 yuan and reached 5 160 yuan in 1997, a yearly average rise of 6.2%. Medical care has been improved as well. Serious infectious diseases endangering people's lives have been wiped out. The average expectation of life has exceeded 70. Nine-year compulsory education system has been implemented in the whole country. Culture, science and technology have been further developed.

China is an age-old agricultural country. Now, agriculture is the foundation and most crucial sector of China's economy. In 1997, there were 234.1 million agricultural households, with an agrarian population of 866.37 million, making up 70.1% of the total population. Agriculture includes crops, livestock, forestry and fisheries, contributing 32.8% of the country's GDP. In 1978, agricultural GDP was only 139.7 billion yuan, but by the end of 1997, it had reached 2 458.77 billion yuan, of which food grain and crops, accounted for 1 386.69 billion yuan, 56.4%; forestry, 81.77 billion yuan, 3.3%; livestock, 762.03 billion yuan, 31.0%; fisheries, 228.27 billion yuan, 9.3%. At the same time, per capita net income of rural population grew from 134 yuan in 1978 to 2 090.13 yuan in 1997.

1.2 Fisheries

China has a fairly long history both of capture fisheries and aquaculture. But till 1949, the total fisheries production was only 0.45 million mt. Since the founding of New China the government has stressed the development of agriculture including fisheries. Through three years of hard work, by the end of 1952, the total fisheries production ran up to 1.66 million mt, which exceeded the highest output in the Chinese fisheries history. In the course of the First Five-Year Plan (1953-1957), the fisheries production increased at an average annual rate of 13.3% and in 1957 rose up to 3.11 million mt; but due to the implementation of improper policies and mismanagement, at the end of Second Five-Year Plan (1958-1962), it dropped to 2.28 million mt. In the three-year readjustment period (1963-1965), the fisheries production went up again at an average annual increase rate of 9.3%. In the following three Five-Year Plans (1966-1980), the annual production increased only at an average rate of 1.3%, 6.7% and 0.4% in the three Five-Year Plan Period respectively. During the 25 years from 1953 to 1978, the total fisheries production increased by 2.75 million mt, only an average increase of 110 000 mt per year (Table 1).

Since 1978, the government has placed unprecedented emphasis on economic development and modernization of the country with special emphasis on rural economic reform. The fisheries grew up rapidly again. In 1988, China became the third country in the world whose yearly fisheries production was over 10 million mt. Then in 1990 and thereafter, China's annual fisheries production

ranked first among the world producers. In 1996, fisheries production broke through 30 million mt, and in 1997 reached 36.01 million mt, contributing more than one fourth to the world total. In the past 20 years, it had the fastest growing period in the history.

According to statistics, there are 447 fishery townships, 6 720 fishery villages and a total of 4 188 127 fishery households, with a fishery population of 18 876 799. There are 12 216 876 fishery labourers. Among them 6 487 377 are part-time labourers. Fishery households, population and labourers accounted for 1.78%, 2.18% and 2.66% of the agricultural households, population and labourers respectively. These fishermen produced 33.36 million mt (1997), making up 92.6% of the total fisheries production of the country. Besides, there are 2 709 state-owned fisheries enterprises with a total staff of 284 829. However, their contribution was only 7.4% of the total production. The average per capita income of fishfarmer/fisherman in 1997 stood at 3 974 yuan, an increase of 148 yuan over the previous year.

1.2.1 Capture fisheries

Capture fisheries, especially marine capture fisheries was the main source of fisheries production in the country. In the early 1950s, about 90 percent of the total fisheries production was contributed by capture fisheries and it still accounted for 74.3% in 1978. Compared with marine capture fisheries, freshwater capture fisheries only provided a small percentage to the total capture fisheries production. In 1997, capture fisheries output was 15.74 million mt, representing making up 43.7% of the total fisheries output, of which, marine capture output was 13.85 million mt, accounting for 38.5% (Table 2). From the taxonomy point of view, there are over 1 500 species of fishes along the coast, but common species with economic value are about 200.

The freshwater capture fisheries is carried out in inland water bodies such as lake, river and reservoir, using various kinds of fishing gears to catch fish, crustacean and mollusc. Just after the founding of New China, freshwater capture was recognized as an important component in fisheries and accordingly priority was given for its development. In 1950, freshwater capture output was about 0.3 million mt, making up one third of the total fisheries output. During 1950s, it went up rapidly with an average yearly output of 0.524 million mt. However, in 1970s the average annual output declined to just over 0.3 million mt. Since 1980, the annual output began to rise and by 1997 it reached 1.88 million mt, respectively 5.2% of the total fisheries production.

Freshwater capture fisheries is widely distributed. About 50-60% of the production come from the Yangtze valley, 10-15% from the Heilongjiang and Nenjiang valleys and 4-6% from the Pearl valley. Apart from 0.62 million full-time fishermen, a considerable number of farmers take this as their side occupation all over the country.

1.2.2 Aquaculture

China is one of the countries which have a long history of aquaculture. Its recorded history of freshwater fish culture is more than 3 000 years. Marine molluscs culture has a recorded history of over 2 000 years. But aquaculture as a whole didn't attract great attention and didn't develop rapidly until the founding of the People's Republic of China. In 1949, aquaculture output in the whole country was only 20 000 mt, making up less than 4.5% of the total fisheries output. As a result of rapid development through half a century, aquaculture output in 1997 exceeded 20 million mt, amounting to 56.3% of the total fisheries output. Aquaculture has not only become the fastest growing sub-sector, it has made China the largest aquaculture producer country in the world.

China is endowed with favourable natural conditions. There are over 32 000 km coastline along mainland and islands, more than 1.3 million ha shallow sea water and mudflats, and about 17.47 million ha freshwater areas including rivers, lakes, reservoirs and ponds, of which more than 6.75 million ha are suitable for aquaculture. From 1978 to 1997, aquaculture output increased from 1.21 million mt to 20.27 million mt, a rise of 19.06 million mt or an average annual growth of 953 259 mt. This is mainly attributed to the following facts: the state has implemented the reformed free market policy to support aquaculture development, especially the production policy with stress upon the implementation of household contract responsibility system with remuneration linked to output. During this period, culture area went up from 2.82 million ha to 5.89 million ha, of which pond culture was 1.99 million ha, lake culture 0.87 million ha, reservoir culture 1.56 million ha, river culture 0.37 million ha, shallow sea culture 167 852 ha, marine bay and gulf culture 180 431 ha and mudflat culture 589 650 ha. In addition, there were 1.3 million ha paddy fields for culture of table fish and 281 403 ha paddy fields for culture of fingerlings. Thanks to the improvement of technology, the average per ha output of freshwater aquaculture in ponds, lakes, reservoirs and rivers rose from 279 kg in 1978 to 2 389 kg in 1997. The marine aquaculture per ha output reached 8 434 kg in 1997. In 1997 the full-time labourers engaged in aquaculture were 3.29 million, of whom 2.83 million went in for freshwater aquaculture and 0.46 million for marine aquaculture. Besides there were huge part-time labourers engaged in aquaculture. They have become a massive production force. The development of rural aquaculture has given a strong impetus to the social-economic growth in the countryside.

Pond fish culture is the major component of freshwater aquaculture. In 1997, its output was 8.9 million mt, making up 72.25% of the total output of 12.36 million mt. Followed by reservoir culture, the output of which was 1.16 million mt, amounting to 9.42%. Lake culture output was 810 055 mt, accounting for 6.55%; river culture output was 622 275 mt, making up 4.87%; paddy field culture output was 455 083 mt, representing 3.68%, etc. Shallow sea culture output was 3.71 million mt, amounting to 47.02% of the total marine aquaculture output, mudflat

culture output was 3.70 million mt, making up 46.86%; and bay and gulf culture output was 484 020 mt, accounting for 6.12%.

In terms of culture varieties, cyprinid holds an overwhelming proportion in freshwater fish culture. The output of silver carp, big head carp, grass carp, black carp and common carp in 1997 stood at 9.13 million mt, making up 73.8% of the total freshwater aquaculture output; marine aquaculture output dominated by shellfish reaching 6.51 million mt, amounting to 82.4% of the total marine aquaculture output; the seaweeds output was 961 365 mt, accounting to 12.2%; fish culture output was 254 979 mt, making up 3.2%; and the output of prawn and crab was 161 601 mt, representing 2.1%. Owing to the facts that artificial breeding of some varieties has achieved successes one after another, and many new varieties have been introduced and transplanted, culture varieties are constantly increasing. Nowadays, there are more than one hundred species cultured. Some culture of high priced species are growing particularly fast. For instance, in 1981 the prawn culture output was only 3 352 mt; however, it reached 219 571 mt in 1991. But the output rushed down to 87 756 mt in 1995 due to the outbreak of prawn disease. Later on it rose again to some extent, but still has not fully recovered. Disease control and water pollution have become important research subjects as they are hindering the development of aquaculture.

China has great potential for further development of freshwater cultivable areas, particularly large and medium-sized water bodies. The potential for further expansion of marine culture is even greater. With the progress of science and technology, and the raising of per ha output, aquaculture is playing an increasingly important part in food security by producing food fish, creating employment and generating income for rural households.

2. Role of Rural Aquaculture in Development

2.1 Historical Aspects

2.2 Current Status

2.3 Impact on National Economy

2.1 Historical Aspects

The pisciculture history in China began in the late stage of the Shang Dynasty (c. 16th-11th centry B. C.). The earliest record is seen in inscriptions on bones or tortoise shells of the Shang Dynasty. It was recorded that the Emperor in Shang Dynasty grazed different kinds of animals, and also bred a large quantity of fish and soft-shelled turtles in the garden, which were used for sacrifices offered to gods or ancestors. In fact, success in rearing fish has something to do with the

accumulated experience in breeding animals. At that time, animal husbandry was well-developed. Horse, cattle, sheep, pig and chicken were already bred artificially. The accumulated experience of breeding animals in land was expanded to fish in water. So in the ancient literature, fish was called water animal. In the Western Zhou Dynasty (c. 11th-771 B.C.), it was discovered that in 1137 B.C. the Emperor Zhouwenwang ordered his slaves to dig a fish pond in the animal farm. It is the earliest record of artificial fish pond, which was located somewhere in Haizecun Village, Changan County, Shaanxi Province.

The monograph "On Pisciculture", written by Fan Li in 460 B.C., is the world's first paper on aquaculture. In this not very long monograph, pond area, depth, structure for common carp culture, and selection of parent fish, proportion of male and female, stocking time, mixed culture of large and small fish, and harvest in rotation, etc. were expounded. At the same time, he pointed out that profits gained from fish farming ranked first among the trades of the same kind. It is thus evident that people then accumulated rich and valuable experience in culturing common carp in ponds and it also shows the social and economic position of aquaculture at that time.

In the Three Kingdoms (220-265), raising fish in paddy field began in Pi County of Sichuan Province. In the late period of the Tang Dynasty (618-907), freshwater fish culture made a breakthrough progress, developing from common carp culture it extended to black carp, grass carp, silver carp and bighead carp culture. At the same time, methods of capturing, packaging and transporting of fish fry, developed during the North Song Dynasty (960-1127) helped in the promotion of aquaculture. In particular, aquaculture in the Yangtze River valley flourished vigorously. During the same period, artificial breeding of pearls was recorded, indicating that China has a history of pearl culture for nearly one thousand years.

In the Ming Dynasty and Qing Dynasty, freshwater fish culture achieved a remarkable development, particularly in the Pearl River Delta and Taihu Region. Some fish culture speciality households and regions were found in some parts of Jiangsu, Hunan, Hubei, Guangdong and Zhejiang provinces. In these regions, fish culture developed from sideline production to an independent specialized business in the countryside, showing the characteristic of commodity production. Fish culture techniques made great progress then, particularly the culture practices of black carp, grass carp, silver carp and bighead carp. A series of theories were propounded with respect to seed selection, site determination, pond building, feed and feeding, toxin elimination and disease control. In particular, a unique mode of production and culture practice with fruitful benefits were created through mixed culture and integrated culture.

In marine aquaculture, China has a 2 000-year history of rearing oyster, and carried out transplantation of oyster 900 years ago. In the Northern Song Dynasty, records of culture of oyster in bamboo enclosure already existed. In the Ming Dynasty and the Qing Dynasty, large-scale oyster cultures were

established. It was recorded that in a mudflat of about 20 km long on the sea shore of Luoyuan County and Xiapu County people used bamboo stakes for rearing oyster. However, in Dongwan County, the area for rearing oyster reached 200 ha or so. According to the record made in 1182, 1 130 ha mudflat along the coast in Fuzhou was used to culture razor clam. In the year of 928, laver was treated as tributes in Pingtan County of Fujian Province. In the Qing dynasty, a large stretch of mudflat was used to rear blood clam in Haifeng County of Guangdong Province, for there was little farmland along the sea shore. Rearing blood clam brought people there a good income. At least two or three hundred years ago, people in Haifeng, Shantau and Zhanjiang counties of Guangdong Province already made use of harbours, bays and low-lying mudflat along the coast to build dykes and sluice gates for reserving fish, shrimp and crab seeds which came in with high tide water. As many as several dozens of species were cultured extensively, but mainly mullet and sea bream.

2.2 Current Status

After the founding of the New China in 1949, With the restoration and development in agricultural production and rural economy, fisheries including aquaculture was restored and grew rapidly. Up to 1952, the total fisheries output in the whole country reached 1.66 million mt (the maximum yearly output before the founding of the New China was 1.5 million mt), of which freshwater aquacultural output went up to 136 000 mt, marine aquaculture output approached 60 000 mt. Compared with 1949, the proportion in the total fisheries output increased by more than 2.5 times. Owing to the fact that the government encouraged fishermen and farmers to develop aquaculture, in 1957, freshwater aquaculture area in the country rose to 1.05 million ha, a rise 1.8 times over 1954; and marine aquacultural area reached 59 757 ha, a rise of 1.4 times over 1954.

Through the efforts made by fisheries technicians for several years, the technique of artificial propagation of silver carp and big head carp succeeded in 1958, followed by the technique of artificial propagation of black carp and grass carp. Thus the development of freshwater aquaculture was no longer dependent upon natural fry as the only source of seed. Freshwater cultured area further increased by 35.4%, reaching 1.43 million ha in 1958. In the same year, artificial breeding and culture of kelp in the southern coastal area succeeded. Kelp culture developed widely from the north to the south. The production of dried kelp in 1952 was only 263 mt, in 1958 increased to 6 106 mt and in 1959 reached 23 886 mt.

Owing to policy errors of the government, serious food shortage occurred during 1959-1962. In many places, people reclaimed land from lakes and ponds for planting crops. Fisherman's grain ration was reduced and an acute fish feed shortage occurred. As a result of these factors, aquaculture was forced to decline. In 1961, culture pond area was only 470 266 ha as against 663 600 ha in 1957, a drop of 25.9%. Lake culture area decreased from 672 000 ha in 1959

to 391 333 ha; freshwater aquaculture output came down from 596 000 mt in 1959 to 315 000 mt in 1962, a drop of 47.1%; marine aquaculture area declined from 102 200 ha in 1959 to 498 300 ha, a drop of 51.2%. From 1960s through late 1970s, aquaculture development suffered due to many reasons, including socio-political changes that took place during the Cultural Revolution.

However, dramatic growth and development of aquaculture during the last twenty years was made possible by the introduction of policies related to the development of market economy and the introduction of responsibility contract system of production. Because of new incentives, by 1997 aquacultural area in the country reached 5 892 770 ha, of which freshwater culture area and mariculture area stood at 4 954 837 ha and 937 933 ha respectively. There were 3 292 497 full-time labourers engaged in freshwater aquaculture and 547 177 in mariculture. In addition, there were millions of part-time labourers and hundreds of thousands of rear-service personal. The total aquaculture output reached 20 276 988 mt in 1997, of which freshwater aquaculture was 12 366 559 mt and marine aquaculture was 7 910 429 mt, a rise of 15.73, 15.22 and 16.6 times respectively over 1978. These productions include 1 266071 mt produced by state-run enterprises, of which 1 019 323 mt was from freshwater aquaculture and 246 748 mt was from mariculture. The output of the newly-developed industrial aquaculture in recent years, such as indoor and/or running water high-density intensive fish culture (eel, trout, tilapia, etc.) and abalone culture, was very little, at most several thousand tons a year, and the definition of industrial aquaculture is still a subject of dispute. The Chinese aquaculture as a whole is still operated by small-scale farming households, communities or state-run enterprises, usually with extensive or semi-intensive low-cost production technology appropriate to their resource base. However, it is still a typical traditional rural aquaculture.

2.3 Impact on National Economy

It can be seen from many fisheries statistical tables of the early stages of the founding the People's Republic of China, only marine and freshwater capture output figures were listed in the tables, as the total yearly fisheries production of China. In fact, marine and freshwater aquaculture already existed, but it was only because their outputs were little and scattered, it was difficult to obtain accurate figures, therefore they were simply included in capture output. Obviously, at that time aquaculture output was regarded as of little importance, to say nothing of the impact on rural economy, and was even ignored in fisheries. Now marine and freshwater aquaculture output figures of the early stage listed in the Table 1 were estimated by the experts concerned in accordance with references from different sources. It is obvious that they are rough figures. Since 1954, aquaculture output has been estimated more accurately, and its proportion in fisheries output has been steadily increasing, from less than 4.5% in 1949 to 26% in 1978. In 1988, it increased to 50.2%. For the first time, it exceeded the capture output. In 1997, the marine aquaculture output was 7 910 429 mt; freshwater aquaculture output

was 12 366 559 mt. Aquaculture output exceeded 20 million mt, representing 56.3% of the total fisheries output (Table 3). However, fisheries is increasing at the fastest rate among the various agricultural sub-sectors. Its share in the total agricultural production value is on the rise (Table 3). In 1997, the total fisheries production value was 2 458.77 billion yuan, amounting to 9.3% of the total agricultural production value (Table 10). The role played by aquaculture, which has accounted for over 50% in the total fisheries production and output value, is perfectly obvious, and steadily on the increase. Foreign exchange earnings from export of aquaculture products was substantial. In 1997, the export of aquatic products reached 929 000 mt with a total value of US\$ 3.14 billion, most of which was from the export of high value aquaculture products.

In 1997, about 3.3 million full-time labourers were engaged in aquaculture. They together with several hundred thousands of full-time rear-service personal and several millions of part-time labourers had produced more than 20 million mt aquatic products. Aquaculture provided jobs for millions of rural labourers. Hundred of thousands in tens of villages lived on income derived from aquaculture. Thus, it became an important economic activity producing fish as food, providing employment and income and earning foreign exchange. Its impacts on the rural socio-economic life is clearly visible.

China has a vast territory with a large population but less farmland. The Chinese population makes up one fourth of the world total, but the farmland is only 7% of the world total area. It is impossible to expand farmland area by a big margin due to the limitations of natural conditions. The government has taken measures to control population growth, but the population is still increasing year by year. In China, inland waters suitable for aquaculture is about 6.75 million ha, shallow sea water area and mudflat suitable for aquaculture is about 2.6 million ha, which together make up about 10% of the total agriculture cultivated land area. Rational exploitation of these waters through the development of aquaculture has become a prime objective of the country's development plan. So far as fisheries itself is concerned, capture fisheries is limited by natural resources, and thus sustainable increase is also limited. During 1978-1997, capture fisheries output only increased by 3.57 times, while aquaculture output increased by 15.73 times. Development of aquaculture is expected to reduce the pressure on capture fisheries and other aquatic resources.

3. Rural Aquaculture Systems

- 3.1 Freshwater Production Systems
- 3.2 Mariculture Production Systems
- 3.3 Production Facilities
- 3.4 Species Cultured
- 3.5 Extent of Rural Aquaculture

3.6 Social and Economic Aspects

3.7 Environmental Issues

3.1 Freshwater Production Systems

3.1.1 Pond fish culture

Rural freshwater fish culture in China mainly refers to pond fish culture. In 1997, pond fish culture area reached 2 million ha (not including paddy field culture area), with an output of 8.9 million mt, accounting for 72.1% of the total freshwater aquaculture production. Technological system for pond fish culture is basically the ancestors' traditional Chinese fish farming technology refined and improved through knowledge and experience gained from research and development efforts of last five decades. The system has the following outstanding features:

- i) ***Rearing short food-chain fish:*** Fish reared in China is largely herbivorous or omnivorous. Their food chain is very short. Fertilizer, grass, wastes from farm products processing industry can be used as fish feed. So their feed sources are abundant and wide, and culture cost is low and resulting in good economic benefits.
- ii) ***Self-sufficiency in seed production:*** Now over 20 species are being artificially bred. Hatchery produced seed of all the major culturable species are available in almost all rural areas where aquaculture is an important activity. Culture activities therefore can be done in a planned way and in accordance with demands.
- ii) ***Mixed and polyculture with high density:*** Several species are cultured in the same pond. This experience was explored and accumulated by the Chinese fishfarmers in a long period of practical production activities. Different species of fishes are cultured in the same pond according to their biological characteristics, food and feeding habits, and the water column inhabited by different species, so as to fully utilize the water space and the available natural feed to maximize production per unit area.
- iv) ***Integrated culture:*** Pond fish culture is carried out by integrating it with other farming activities such as livestock rearing (chicken/duck/pig/cattle etc.) and/or crop cultivation/horticulture (vegetables, mulberry, fruits etc.). It is a comprehensive and integrated method of production with fish culture as the main activity and growing different kinds of crops, cash crops, grass as feed, and raising livestock and poultry on and around the pond banks. Fermented waste of farmed animals can be used as fertilizer or as fish feeds, the sludge from the pond bottom can be used as quality fertilizer for crops on land, and crops and grass can be used as feed for farmed

- animals and fish. Such integration allows best uses of all available resources and results in higher household income for the farmer.
- v) **Water quality management:** For healthy growth of fish, the pond water quality is maintained at the optimum level by balancing the pond ecosystem. This is done through carefully managed feeding regime, water inflow and outflow, and aeration.

3.1.2 Culture-based fisheries

Fish culture in large water body, such as lake fish culture, began in the Western Han Dynasty in China (206 B.C.-A.D. 24), but the Dongqianhu Reservoir built in 744 is the earliest record of reservoir for fish farming. However, community fish culture in large water bodies began in the 1950s. At the beginning, it adopted stocking and extensive culture method, which resulted in enhancement of natural resources and improved the productivity of water bodies. Fish species and number for stocking are determined according to size and type of water body. For example, the ratio of fingerling stocking in fertile lakes is generally silver carp and big-head carp 80%, grass carp and black carp 5%-10%, common carp, crucian carp and bream 10%-15%, etc. At the same time, 0.5 kg crab seed and 0.5 kg eel fry can be stocked per 20 ha water area. Fish screen facilities and daily management must be stressed in such water area. Owing to the fact that large-sized fingerling is required for stocking in large water body, this gives an impetus to rearing of fingerlings in surrounding areas and has encouraged the development of a complete and separate production system. For the purpose of tapping the potentials of lake and reservoir fish culture, net enclosure and net cage cultures are gradually developing in large water bodies depending on their suitability.

3.1.3 Cage culture

The Chinese modern net cage culture started in the early days of 1970s and major efforts were devoted to developing and extending the method in 1980s. Net cage culture is now being used in lakes, reservoirs, rivers, ditches and shallow sea water and can be largely divided into 4 types: (1) to use natural feed (planktons) to culture large-sized silver carp and big-head carp fingerlings for stocking large water bodies; (2) to use natural feed (planktons) to culture table fish; (3) to use artificial feed to culture table fish; and (4) to culture high value species such as eel, mandarin fish, sea bream, etc. through high density intensive feeding system. Net cage culture in developed countries is usually an intensive culture system, but the culture system in China is either traditional or semi-intensive.

3.1.4 Paddy-fish culture

Paddy-field fish culture in China has a history for more than 2 000 years. In the early days of 1970s, China carried out extensive research on ecology and biology of culturing fish in rice-fields. This led to the development of various methods of rice-fish culture, based on a symbiotic relationship between fish and

rice cultivation, leading to increased economic benefits to the farmer. The major types of rice-fish culture are as follows:

(1) Raise fingerlings in paddy fields in the plains: The fry are directly reared in early rice fields and after they have grown to 4-5 cm they can be transferred to the semi-late rice fields to grow them to market size by the time the rice is harvested. This is the easiest and most effective way which brings the maximum benefits to fishermen.

(2) Planting rice on a ridge and rearing fish in a ditch: The best specifications are a ridge - containing two rows of rice seedlings and a ditch of one meter in width and one meter in depth. Some farmers even plant melons and soy-beans on banks and rear duckweeds in water. And thus a kind of multi-layer planting and culture mode is established.

(3) Rearing fish in a wide ditch: Wider ditches of varying sizes are prepared in the rice-field and are connected with the water inlet for fish culture. The total area for fish culture may vary from 5-10% of the rice-field.

(4) Culturing fish in an adjacent pond which is connected with the rice-field. The fish pond serves as a water reservoir for the rice-field.

(5) Another way of rice-fish culture is to cultivate rice and fish in rotation in the same field.

The above-mentioned culture methods are extensive, though in some cases supplemented feed are given to the fish.

3.2 Mariculture Production Systems

Before 1950s all mariculture systems in the country were extensive type. Baby fish and shrimps used to be trapped during high tides in ponds with sluice gates built on the mudflats, and various types of substrates were used to help settle spat.

Successful research and developmental activities of last four decades resulted in the improvements and modernization of culture systems. Most oyster, mussel, shrimp and seaweed culture are of semi-intensive type, nowadays. This has been made possible by the success in artificial breeding of many marine species for rearing seed for stocking, in the development of formulated feed, in the health management of cultured organisms, etc.

Mariculture in China is generally divided into mudflat culture and shallow sea water culture. Mudflat culture refers to the culture which makes use of intertidal area. It has had a long history and places stress on culture of oyster, constricted tagelus and bloody clam. Mudflat culture methods are as follows: (1) planting

seeds of shellfish in mudflat directly, such as constricted tagelus etc; (2) using stone, bamboo pole etc, as an attachment to collect seeds and spats such as oyster, gracilaria, and cultured in mudflat; (3) pond building in mudflat for prawn and fish culture. In 1997, the mudflat culture output made up 50% of the total mariculture output.

Shallow sea culture is mainly employed in the places near gulfs and islands, where water flows smoothly; water quality is good and there are shelters against stormy waves. By using racks, floating rafts, floating ropes etc., kelp, laver, gracilaria, undaria, oyster and mussel are cultured. Also, fish culture is carried out in net cages.

3.3 Production Facilities

Rural aquaculture facilities in China are very simple in those districts where farmers give priority to agriculture and aquaculture is only their sideline production. For example, in paddy field fish culture the most basic facilities are paddy fields and their connected ditches for water to flow in and out, sluice gates; and in mariculture are earth dykes and bamboo wooden sticks, etc. But the professional fishfarmers, who culture fish in ponds, use machineries for digging ponds and clearing away sludge, equipment for increasing oxygen supply to the pond water, as well as machinery for preparing feed and for harvesting. For water supply and draining of ponds, different kinds of general-purpose water pumps are mainly used. In some small districts where pond culture is not very well developed, water supply and drainage are carried out by small pumps for individual pond. However, if pond culture is well developed with clusters of ponds, a pump station is used to pump and convey water through distribution pipes to the surrounding ponds. Heavy machineries such as bulldozers and dredgers are used for excavation/desilting works.

Also used are locally made aerators of various kinds such as impeller, paddle wheel, sprinkling and jet flow type are used to supply oxygen to the pond waters. The fishfarmers also use locally made simple machines for crushing snails and clams, greenfeed cutting machine used for cutting aquatic plants into small pieces or as a palp for feeding fish or for using as a pond water fertilizer. Machines for making pellet feed in the small fishfarms are also used. For harvesting, winch and rope winding pulley are usually used for drawing the harvesting net from one end to the other end of the pond.

The old structures of production such as production team, production brigade and people's commune disappeared and therefore large production units no longer exist. With the promotion of production-related contract responsibility system, the rural aquaculture is basically run by households. In most cases, each household contracts a pond covering about one ha. Small-scale lakes and reservoirs are mainly contracted by several households.

3.4 Species Cultured

Freshwater fish culture mainly refers to 8 species: common carp, silver carp, big-head carp, black carp, grass carp, crucian carp, freshwater bream and mud carp. Owing to the improvement of culture technologies, and through introduction and domestication, controlled breeding, and hybridization, fish species of economic value that can be cultured now have reached nearly 50 species, of which over 20 species are cultured in ponds. In addition, crab, shrimp, soft-shelled turtle, pearl shell are also important varieties in rural freshwater aquaculture. The major species of freshwater aquaculture are listed in Table 4.

Before 1950s, rural mariculture was mainly limited to a few species of shell fish cultured in mudflat, such as oyster, bloody clam and constricted tagelus. After 1950s, with the advancement of science and technology, cultured shell fish species list now includes mussel and scallop. Also, marine seaweeds, prawn, crab and fishes are widely cultured (see Table 5).

3.5 Extent of Rural Aquaculture

In the past 20 years, aquaculture yield has been increasing year after year, from 1 221 792 mt in 1978 to 20 276 988 mt in 1997, a rise of 15.7 times. It is the period in which aquaculture developed at the fastest speed. Freshwater aquaculture yield increased from 762 254 mt to 12 366 559 mt, a growth of 15.2 times and that of mariculture increased from 449 538 mt to 7 910 429 mt, an increase of 16.6 times. Aquaculture yields over the years are shown in Table 1. The outputs in different provinces are shown in Fig. 2. In 1997, in freshwater aquaculture output, Guangdong, Hubei, Jiangsu and Anhui each exceeded one million tons, so did Shandong, Fujian, Guangdong and Liuning in mariculture output.

The steady expansion of culture areas was the main reason for steady increase in aquaculture yield. In 1997, aquaculture area of the country reached 5 892 770 ha, of which mariculture area was 937 933 ha, and freshwater aquacultural area was 4 954 837 ha, a growth of nearly twice as against the total cultured area in 1978. Mariculture area increased by 8.3 times and freshwater culture area increased by 82%. In freshwater aquaculture, pond culture area was 1 994 208 ha; lake, 879 661 ha; reservoir, 1 567 973 ha; river, 370 977 ha; and others 142 018 ha. Compared with 1978, pond increased by 76%; lake by 65.6%; reservoir by 29.7%; and river by 41.8%. The expansion of aquaculture area in the recent twenty years is shown in Table 6. Marine aquaculture area is shown in Table 8. It can be seen that in the recent fifteen years from 1983 to 1997, the areas for shallow sea water culture, bay and gulf culture, and mudflat culture were expanded by ten times, seven times and over three times respectively. Because aquaculture can reap profits more quickly, a large number of farmers engaged themselves in aquaculture. Up to 1997, full-time labourers engaged in aquaculture reached more than 3 million. In addition, several hundred thousands of rear-service labourers and several millions of part-time labourers constituted a

huge contingent of producers. On average, there was nearly one labourer working on each ha culture area. Per unit output of different kinds of water areas varied greatly. In 1997, per unit output of freshwater aquaculture is listed in order of output: pond, 4 474 kg/ha; river, 1 623 kg/ha; lake, 921 kg/ha and reservoir, 743 kg/ha. Per unit output of marine aquaculture is listed in order of output: shallow sea, 22 155 kg/ha; mudflat, 6 288 kg/ha and bay and gulf, 2 683 kg/ha. This reflects that the per-unit output of rural aquaculture was still not very high. However, a steady growth in production has been maintained by bringing in more and more ha under various culture systems.

Fish is in the dominant position in freshwater aquaculture. Silver carp and big-head carp outputs rank first, making up 37.2% of the total output of freshwater aquaculture, followed by grass carp 21.3%, common carp 14.2%, crucian carp 6.9%, tilapia 3.9%, etc. In marine aquaculture output, shellfish forms an extremely large proportion, amounting to 82.3%, followed by algae 12.2%, fish 3.2%, and prawn and crab 2.1%. To be more exact, oyster output before 1996 was calculated in terms of fresh meat only. However, since 1996, it has been calculated in live weight, so the output figure has increased greatly. In 1997, oyster occupied first place with an output of 2.32 million mt, accounting for 29.4% of the total marine aquaculture; clam was 15.9%; scallop, 12.8%; mussel, 5.1%; and prawn, only 1.33%. The yields of marine and freshwater aquaculture in terms of species are shown in Table 7. And aquaculture output by environment, species and per hectare yield are shown in Table 8a-8e.

3.6 Social and Economic Aspects

In China, the production relations in rural aquaculture are similar to those in agriculture. During the early years of New China, the government led fishfarmers to the socialist road of collectivization step by step, to develop collective ownership economy. By 1957, fishery cooperative economy system of single public ownership of means of production was established in the country. In the second half of 1958, people's communes were set up. Generally, there was one commune in a township. Several advanced fishery producers' cooperatives were merged into one fishery commune, under which there were production brigades and production teams. Because people's communes were too large in scale, it was divorced from the productive and management level of that time, and production enthusiasm of the masses was seriously affected. "Large and Public", the basic characteristics of people's communes, and equalitarianism in distribution gravely destroyed productive forces. During 1959-1961, there was a serious shortage of food; people enclosed and filled up some lakes and pond areas for food crop production in many places. Fishfarmers' rations were reduced, and a serious shortage of fish feed made aquaculture wilt. In 1961, the pond culture area was only 470 266 ha as against 633 600 ha in 1957, a decrease of 25%; the area of lake culture came down from 672 000 ha in 1959 to 391 333 ha, a decrease of 42%. The production of freshwater aquaculture decreased from 596 000 mt in 1959 to 315 000 mt in 1962, a decrease of 47.1%.

Marine culture area dropped down too year by year. In 1959 it was 102 200 ha, and in 1962, there was only 49 833 ha, a decrease of 51.2%. Cultural Revolution beginning in 1966 further emphasized "Large and Public" of people's communes, and stressed that large and medium-sized water area must be run by the state or people's communes; pond culture must be run by production brigades. Fish culture run by production teams were limited and fish culture by households were prohibited. Aquaculture production came to a standstill and 1969 the total production had not reached the level of 1959. In the following ten years, the total production only increased by 73.2%, an average increase of a little more than 50 000 mt/yr.

However, in 1978 with the introduction of new socio-economic reform policies, the "Contract Responsibility System" was introduced, which broke through the single public ownership and formed a new structure, in which state, collective, individual and private economies existed side by side. From then on, the organizational form of people's commune was abandoned and instead various forms of cooperation and operation which broke equalitarianism were adopted. The government encouraged competition among fishfarmers by carrying out different forms of contract systems. Water areas, mudflats owned by the state or collective were allowed to be run by individuals or households by contract, or jointly run. The government encouraged people to contract to develop large areas of coastal and inland unoccupied water areas and mudflats. Capital, labour, goods and materials, and technology could be regarded as share capital and people were permitted to draw dividends and employ helpers. At early stages of the contract system, the contract period was short. Recently, it has been extended to 40 years. All these mobilized the initiative of the masses to develop aquaculture. But contract and production responsibility system did not change the original system of property right. Therefore some time later, share holding cooperative system was promoted on a trial basis in order to resolve contradictions and abuses caused by the separation of ownership of means of production and right of running. This further stimulated the fishfarmers' enthusiasm.

The state-run aquaculture enterprises still had a certain position in aquaculture production. In 1997, there were 1 010 aquaculture enterprises in the country with a staff of 80 664 and an output of 1 266 071 mt, making up 6.24% of the total aquaculture production of the country. Of them, mariculture enterprises were 169 with a staff of 10 322 and a production of 246 748 mt, accounting for 3.11% of the total; freshwater culture enterprises were 481 with a staff of 70 342 and an output of 1 019 323 mt, accounting for 8.24% of the total. Although the proportion of state aquaculture production was not big enough all along, the state-run enterprises played a very important role in demonstration, and supply of fish seeds. But unfortunately in 1997, over 400 state-run enterprises out of 1 010 suffered great losses in their business. Now, those state-run enterprises are undergoing reform. The majority of the enterprises are located in the countryside or in the outskirts of cities. Only a few enterprises are engaged in so-called

industrial production, mainly in propagation of seeds, however there is little difference in the way of fish culture between the majority of state-run enterprises and fishfarmers. So, on the whole, the state-run aquaculture still belongs to rural aquaculture.

From 1959 on, China implemented centralized purchasing and marketing on aquatic products. The aquatic products produced by people's communes and production brigades were all sold to the state-run supply and marketing companies commissioned by the state except a little amount left for themselves. Purchasing and selling prices were fixed by the state. Black market transactions were strictly banned. In doing so, people's communes and brigades had no right to deal with their own products. As a result, they gradually felt no concern about their fruits of labour any more, and for a long time setting prices were lower than production costs. In view of this, fishfarmers could not maintain their level of production. This highly-centralized planned economy did not change until the implementation of the policy of opening to the outside world.

From 1978 on, the state stipulated that the fish farmers must sell the set quantity of their aquatic products to the government only at a fixed price and the rest were permitted to sell at a negotiated price in the free markets. In 1981, 21 species were controlled by the government and then further cut down to 8 species. The proportion of products which must be sold to the government was also reduced gradually except prawn, the most important culture products for export. However, in 1985 the seller quota system was completely abolished and prices of aquatic products were regulated by the market. The government encouraged state-, collective-owned as well as private enterprises and individuals to go in for increased production and free trading activities. Subsequently, fisheries production started to increase with the new free marketing systems and now fish farmers.

Now, supply and marketing formed a simplified commodity circulation system of multiple economic forms, diversified channels and varied management modes. The marketing system works like this: fish producers - wholesale organization in production areas - wholesale companies in marketing areas - retailers - consumers. Each dealer in the above link will have 10-20 percent profit margin. The price paid by consumers maybe double than that of the farm gate. The average retail price of crucian carp, common carp, silver carp and grass carp was 13.4 yuan/kg; 10.9 yuan/kg; 8 yuan/kg and 10.4 yuan/kg respectively in 1997.

In 1997, the amount of trade in aquatic products at markets in cities and counties reached 12.46 million mt, or the value of trade being 138.6 billion yuan, with a rise of 22.8% and 54.5% over last year respectively. Villages shared 50.6% and 45.2% respectively. The species commonly cultured in large water areas, such as silver carp, grass carp and common carp were dealt with chiefly by individual small retailers in periphery areas. In large and medium-sized cities, it was done

mainly by state-run enterprises. In recent years, specially wholesale markets have been booming, greatly promoting the prosperity of aquatic products markets. In 1997, the amount of trade in consumer goods wholesale markets was 2.3 million mt, an increase of 25.4% over 1996. The system of auction have become major ways of business at many wholesale markets in some large cities with cold storage. In 1997, there were 963 service enterprises for aquatic products circulation with a staff of 78 435. State-run enterprises have solid strength, dominating in the whole aquatic products market, particularly in wholesale markets. They are the principal channels of aquatic products. Private enterprises are developing fast in aquatic products markets and hold a distinct advantage in retail markets for their low cost and flexibility in business. Recently, many private enterprises are gradually becoming wholesaler, which has made the competition in market place fierce.

According to the survey of some aquaculture units made in 1995, the economic benefits and production expenditures of various water areas and species groups are shown in Table 9a-9b. It can be seen from the table that the average income per labourer engaged in mariculture was more than 6 000 yuan, but a labourer engaged in kelp culture obtained an income as high as 16 189 yuan; followed by oyster, scallop, prawn and mussel in descending order. In freshwater culture, the average income per labourer of pond culture was over 6 000 yuan. Production of lake culture was low, the average income per labourer was less than 4 000 yuan. In paddy field fish culture, it was only 720 yuan, but this was an additional income for farmers, where paddy was the primary product.

3.7 Environmental Issues

3.7.1 Land and water use

China has vast seas and mudflat areas. The continental shelf within isobath 200 m water depth covers about 1.48 million km². And it has a network of rivers, lakes, ponds and reservoirs with a total inland water area of about 17.47 million ha, almost one fiftieth of the land area. The annual rainfall is about 6 000 billion m³, of which 2 600 billion m³ forms the water resources of the country. The cultivable water areas are: shallow sea 1 622 560 ha, bay and gulf 180 550 ha, mudflat 797 000 ha and freshwater area 6 749 250 ha. These areas provide favourable natural conditions for developing aquaculture. In 1997, marine aquaculture area was 937 933 ha, which was about 36% of the cultivable sea water area; and freshwater aquaculture area was 4 954 837 ha, which was about 73.4% of the cultivable area. There still exist suitable areas for expansion of aquaculture.

Inland aquaculture is more closely linked with agricultural production. The utilization of water area and land is often affected by such factors as State policy, food supply and prices of aquatic products. At the beginning of 1960s, owing to tension in food supply and shortage in feed, the aquaculture areas of the country were reduced from 2.1 million ha in 1960 to 1.58 million ha in 1963, a decrease

of 25%, and it was not restored to the level of 1960 until 1965. During Cultural Revolution, because undue emphasis was put on the slogan "To take grain as the key", people enclosed areas of lakes or ponds for grain production, which resulted in a radical reduction of fish pond and lake areas. Hubei Province known as a land with thousands of lakes had 1 056 lakes of different sizes, with an area of 826 666 ha, and by 1976, there were only 236 666 ha left, a decrease of 70%. Water area of Dongting Lake in Hunan Province reduced from 435 333 ha to 266 666 ha. Fishing and fishculture were stopped in many lakes in Jiangsu Province and Anhui Province. Consequently, fish production decreased. For example, in Huanggang District fish production decreased from 6 500 mt at the beginning of 1960s to 2 350 mt owing to the enclosure of lakes. In the counties of Wuxing, Deqing, Yuhang and Haining in Zhejiang Province, which are the dense pond fish culture areas, about 3 300 ha ponds were filled up for planting crops, resulted in the production decrease by nearly 10 000 mt.

After the new policy of opening and reform was implemented, the aquaculture area has been tremendously expanded; the total culture area of 1997 increased by 100% and more over 1978, of which marine aquaculture area went up from 100 593 ha to 937 933 ha, a rise of 8.32 times. Freshwater aquaculture area grew by 81.9%. The expansion of aquaculture area varies with demand for fish and fish price. When price is high, some farmers gives up crops and vegetables planting, silkwarm breeding and mulberry growing, and turn to fish culture. When fish price comes down and brought less benefits than cash crops, they filled up ponds to do other things. The market-oriented economy is increasingly exerting a direct influence on the utilization of land and water for aquaculture. It is evident that competition among aquaculture, agriculture, water conservancy, land reclamation, hydroelectricity, navigation and tourism in the use of land and water is intensifying day by day.

3.7.2 Environmental impacts

China, a vast country with varied climatic zones, has the potential for all types of aquaculture production systems. The bigger part of the territory being in the north temperate zone, and a small part in the south being in the tropics, temperate species are dominant. The distribution and development of aquaculture are affected by the distribution of rivers, lakes, and precipitation. The Pearl River, and the middle and low reaches of the Yangtze River have a long history of fish farming. The Pearl River delta and the Yangtze River delta which have a network of rivers, lakes and ponds, are the most important regions for fish culture.

Aquaculture is heavily affected by typhoons and cold waves. The season of typhoon lasts from July to September. The area from Liaoning in the north and Guangdong and Guangxi in the south can be hit by typhoons. In the areas where typhoon sweep down, the culture of kelp, shellfish, prawn, etc. are ruthlessly destroyed. Cold waves and strong wind in winter flow from the north to south now and then, and the temperature in the affected areas decrease by more than 10°C within 24 hours. In the north of China and the Yangtze River basin, strong winds often come together with rain, snow and frost. But in the south, it is semi

tropical. Temperature therefore determines the culture systems and the species to be cultured. As for example, an important species like tilapia, which can be cultured all year round in the south, cannot be overwintered in the outdoor in the north.

Along with the rapid development of industry and agriculture, people reclaim water areas for industrial use and cultivation. As a result, culture area is reduced. At the same time, sewage drained from factories and cities, and the application of large quantities of pesticide and chemical fertilizer not only deteriorate water quality, but also destroy culture areas. It is reported that in 19 000 km of 7 large river systems, the water in about 5 000 km is below the required water quality standard for fishculture. In some important culture areas, fish die due to pollution. According to incomplete statistics, in 1995, 510 incidents of water pollution affecting fisheries/fishculture occurred throughout the country, with 138 000 ha culture area and 1 160 km river were seriously affected, causing a loss of 560 million yuan. In the five years from 1991 to 1995, there were over 2 700 pollution incidents that had impacts on fishculture in the country, causing 764 000 ha culture area polluted, resulting in a loss of 350 000 mt aquatic products with a direct economic loss of 3.1 billion yuan. In Zhejiang Province, the losses due to pollution greatly exceeded 10 million yuan in 1996 and 1997. In the coastal area of Jiangsu Province, clams were seriously polluted, which led to the prevalence of hepatitis A in Shanghai.

The development of aquaculture has its positive effect on the environment. For example, paddy field fish culture can fully utilize water bodies, resulting in bumper harvests of both rice and fish. But on the other hand, development of aquaculture also has its unfavourable effects. High-density intensive culture of fish and prawn causes eutrophication of water area and produces fish diseases. Recently, along the coast, particularly in river mouth area, the frequency of red tide occurrence is becoming higher and higher, and the affected areas becoming wider and wider. In 1993, prawn disease broke out in coastal areas, causing decrease in prawn production from 206 866 mt in 1992 to 87 756 mt in 1993. Even now, the impact of the disease lingers on. In recent years, cage culture of fish, in some areas, has decreased mainly because of water pollution caused by net cage culture itself. Owing to the degradation of water environment, red tides increasingly occurred, causing high mortality of cultured animals or made them unconsumable. Economic losses every year because of pollution and red tides amounts to several billion yuan.

4. National Policies, Strategies, Plans and Programmes for Rural Aquaculture Development

Fishery is a component of agriculture. Aquaculture village is also a agricultural village. The fundamental policies adopted by the state towards agriculture and rural development are the same for the development of rural aquaculture. The

state has pointed out that agriculture must be treated as the foundation, and insisted that agriculture must be placed before everything else. The state has also formulated policies and strategic plans for rural reforms and for the development of rural economy through the development of agriculture, capture fisheries and aquaculture. A series of concrete fishery policies have been formed in accordance with the above principle.

In March of 1985, the Central Committee of the Chinese Communist Party and the State Council issued the document titled "The Instruction of Broaden Policies to Accelerating Fisheries Development", in which the development of aquaculture is considered as strategic importance, especially promotion of production in rural areas. The document clearly points out, aquaculture must be put in the first place in fisheries in China, with culture, capture and processing developing concurrently, and state-run, collective and individuals are all encouraged. It is the first time that the fisheries development with stress on aquaculture is clearly written down in the State policies for fisheries development. The policy also encouraged the expansion of contract responsibility system.

With the gradual establishment of the socialist market-oriented economic system, great changes have taken place in aquaculture development. At the end of 1996, the State Council authorized and transmitted the document "The Suggestion on Further Speeding Up Fisheries Development" submitted by Ministry of Agriculture. The document pointed out that the policy of fisheries development at the new stage was "to quicken aquaculture development, to protect and rationally utilize offshore resources, actively enlarge distant fishery, pay special attention to processing and circulation, and strengthen legal management". This policy once again gave first priority to aquaculture development. It was essential to widen and deepen the way of aquaculture development, to put the first priority to increasing per unit production through the measures of strengthening new technologies, to bring more species under culture, to regulate culture species and to increase production by a big margin. And efforts were made to stabilize production of traditional species, and meanwhile to actively develop high value species in line with local conditions and according to demands in the market. The State requested that aquaculture development be based on comprehensive exploitation of uncultivable land resources that are suitable for aquaculture. In line with local conditions, the unused water and land can be contracted to one household or households, leased or transferred. In addition, the right of use can be sold by auction. In the course of stabilization and perfection of family responsibility contract system and diversification of the economy, fishery shareholding cooperative system should be introduced and standardized so that aquaculture could be managed on an appropriate scale.

The State recommended that in the projects aiming at developing rural economy, aquaculture should be combined with agriculture in an integrated way wherever it is possible. For example, paddy-fish culture should be expanded to increase food production. In poverty stricken regions, particularly in the mid-western region,

aquaculture development should be expanded as one of the important channels to promote the development of rural economy and to lead farmers out of poverty. For the purpose of advancing the development of aquaculture, the state stipulates that taxes on special products should be reduced, so also incentives should be offered to those units and individuals who are engaged in aquaculture on newly-exploited water areas and land. The money collected from contract, lease, transfer and auction of the right of use of waste water areas and lands should be used exclusively on construction of fisheries basic facilities. Funds to support aquaculture allocated by the State at various levels should be used to develop aquaculture, and the sum will be increased along with the advancement of production. For requisitioned aquaculture sites located in the sub-urban areas, requisition units should consult the regulations relating to requisition of vegetable plots and pay development funds in addition to compensation paid according to compensation standard. The development funds should be used to build culture facilities.

The State also stipulated that seed production system and disease control system should be strengthened and quality fish feed production technology improved. In the process of prevention and cure of diseases, the guiding principle of "Taking prevention as the dominant factor; combining prevention with cure in a comprehensive way" must be carried out. Disease prevention and cure network must be formed at various levels; monitoring, forecast and organization of prevention and cure strengthened; and management of production and sale of fish seed and medicines for aquaculture must be improved.

In the whole process of fisheries/aquaculture production, stress was placed on forming a clear conception of sustainable development; deepening consciousness of resources protection; perfecting fisheries legal system; protecting of fisheries ecological environment; improving scientific research, education and technical extension, and building up aquatic products marketing system.

At present, China is implementing the Ninth Five-Year Plan (1996-2000). Fisheries is a component of the five-year agriculture plan. It was originally planned that by 2000 the total fisheries production would be 28.5 million mt, of which aquaculture production would be 17 million mt. But the target was already attained in 1997. Now the new target has been set. The total production target by 2000 is 35 million mt, of which aquaculture production will make up more than 60%, that is, over 21 million mt. It is believed that this target will surely be fulfilled.

The aquaculture development plans and programmes are embodied in the Five-Year Fisheries Development Plan drawn by Bureau of Fisheries and implemented by the institutions concerned under the inspection of the Ministry of Agriculture.

In order to develop agriculture and rural economy, in recent years, the State has formulated and promoted two important plans - the Bumper Harvest Plan and the Thriving Agriculture through Science and Technology Plan. In these plans, fisheries and fishery village development plans are included. The Bumper Harvest Plan is to help the selected regions to reform and develop so as to reap good harvests in every aspect in the whole region through the implementation of some projects. The Thriving Agriculture Through Science and Technology Plan is to set up some projects with advance, mature technologies to help the selected production units to raise production and income by a bigger margin. As for fisheries, in concrete terms, under the unified planning, the National Fishery Bumper Harvest Plan and Plan of Important Fisheries Technology Extension by the Ministry of Agriculture were formulated following the same method. These plans and projects mainly implemented by the fishery technical extension stations are playing a major part in promoting the development of rural aquaculture.

The conventional capital investment for fisheries is allocated by the State, and the portion used for aquaculture is increasing year by year. In 1978, it stood at 7.5 million yuan, representing 11.6%. In 1997, it went up to 1.22 billion yuan, representing 46.4%. The fund is mainly used for the establishment of seed propagation stations and production demonstration stations. The main purpose of this support is to help develop rural aquaculture.

5. Institutional Aspects

5.1 Government Organization and NGOs

5.2 Support Services

5.3 Credit

5.4 Other Inputs

5.1 Government Organization and NGOs

5.1.1 Government organization

According to the State stipulations, the responsible institution for the Chinese fishery is the Ministry of Agriculture of the People's Republic of China. Under the Ministry, there is the Bureau of Fisheries which is responsible for management of fisheries routine affairs. The Bureau of Fisheries is an amalgamation of the former Department of Fisheries and the Bureau of Fisheries Management and Fishing Port Superintendence in 1994. The Bureau of Fisheries is also called the Bureau of Fisheries Management and Fishing Port Superintendence in order to facilitate carrying out the duty entrusted by the Fisheries Law of the People's Republic of China. In 1998, the state reformed the governmental institutions, streamlined organizations, and reduced the staff. Before there were 18 divisions and now only 10 are left, and the staff is reduced by 50%. The Aquaculture Division remains, the other divisions are shown in Fig. 3.

As before, the major functions assigned to the Bureau of Fisheries are as follows:

- a. to formulate plans, strategies, policies and programmes for fisheries development;
- b. to guide fisheries economic reform;
- c. to implement and monitor fisheries laws, regulations and international/bilateral fisheries agreements;
- d. to strengthen fisheries management so as to ensure proper utilization of fisheries and aquatic resources and to protect fisheries environment;
- e. to support fisheries education and scientific research;
- f. to supervise and examine fishing vessel safety and to superintend fishing port; and
- g. To administer the manufacture of fisheries processing industry, fishing boat building, fisheries machinery and gear industries.

The fisheries departments in different provinces and counties have more or less the same functions as the Bureau of Fisheries in their respective geographical areas. They are under direct leadership of their provincial or county governments, and guided by the Bureau of Fisheries. During the reform, some provinces such as Guangdong and Shandong merged Department of Fisheries and the Bureau of Oceanography into the Department of Oceanography and Fisheries. Their duty is extended accordingly.

The Ministry of National Land and Resources of the People's Republic of China is a newly-established ministry. The former National Bureau of Oceanography and State Bureau of Environment Protection are under this ministry. It is evident that the work of the Ministry of National Land and Resources has a lot to do with fisheries water area management and environmental protection.

The Ministry of Water Resources is mainly responsible for nation-wide river draining and harnessing, irrigation, urban and rural water supply, flood control and drought resistance. The establishment of water conservancy facilities, particularly the establishment, utilization and management of reservoirs plays an important part in fishery production, particularly in freshwater aquaculture development.

5.1.2 Non-governmental organizations (NGOs)

(a) The Fishermen's Association:

The fishermen's Associations have been organized step by step under the guidance of the government since the beginning of 1990. Its major objective is to unite fishermen together to exchange experience and technology relying on fishermen's own strength, to help to jointly organize necessary production and sale activities, to take precautions against risk and to supply materials. The associations are developing fast and come under several names, such as Fish Farmer Association, Fish Farming Technology Association, Prawn Farmer Association, Fisheries Production Service, Fishermen Management Commission,

etc. Their common characteristics are - free organization, free participation and free withdrawal, possession of its own organizations rules and regulations, as well as participants' unequivocal rights and obligations. These are a non-profit organizations, in which fishermen can have a hand in market-oriented economic activities and exercise self-management, self-education, self-protection, self-service and self-development. The associations have become a bridge between fishermen and the government, and a link between production and market. At the beginning of 1997, the city of Dalian established the first aquaculture association for individuals. And in the middle of 1998, 39 aquaculture households in Tongzhao Township, Fenghua City, Zhejiang Province established a Marine Net-Cage Culture Association claiming that they would provide various kinds of technical services through their members' mutual cooperation to quicken mariculture development in the township. In fact, the fishermen's associations are usually organized by administrative village, township or even higher level and their leaders are elected by democratic election. So they are authoritative as well as representative organization.

(b) *The China Society of Fisheries:*

The China Society of Fisheries was founded in 1963 with a membership of 15 000. Scientists and professionals or people related to fisheries can voluntarily join the society. It is the largest non-governmental academic organization in fisheries. Promoting scientific knowledge, and providing technical service and training courses are the most important activities carried out by the society. There are 14 professional commissions under the society, such as: Freshwater Fish Pond Culture Commission, Mariculture Commission, Natural Water Body Fish Farming and Resources Enhancement Commission, etc. The commission is usually composed of 20 to 50 specialists and holds academic workshops annually. Besides, there are two national networks - the Fish Diseases Prevention and Treatment Cooperation Network, and the High Density Intensive Fish Culture Technology Cooperation Network. These networks are organized on membership system and have actively held a number of conventions, seminars, workshops and field visits every year.

5.2 Support Services

5.2.1 Educational institutions

The fisheries education in China includes higher, secondary, elementary, specialized, vocational and adult education at many different levels. In 1997, there were 39 fisheries educational units with a staff of 4 434, of which 5 are higher fisheries schools. They are Shanghai Fisheries University, Dalian, Zhanjiang, Xiamen, and Zhejiang fisheries colleges. The five fisheries universities/colleges have Department of Mariculture, and Department of Freshwater Fisheries (mainly freshwater aquaculture). These schools offer courses for 4 years duration. There are 8 marine and freshwater culture farms with water area of over 80 ha for students' field work. Besides, the other 17 higher schools have fisheries speciality (including aquaculture). There were also

17 middle fisheries specialized schools at provincial (or municipal) level with an enrolment of more than ten thousand students. In addition, fisheries as a special subject is available in 9 middle agricultural schools and fisheries courses are held in middle schools with an enrolment of 25 000 students. The majority of them specialized in aquaculture, and have become technical backbone of the frontline technical services of rural aquaculture. Starting from 1990, the Shanghai Fisheries University, Fisheries College of Oceanology University, and Dailian Fisheries College started offering postgraduate degree courses and have been authorized by the Academic Committee of the State Council to confer degrees of doctorate, mastership and bachelorship.

The students go through the basic theory courses on one hand and on the other hand follow practical courses with stress on field work. Students have to fulfil the production targets set in field work, which are regarded as a check on the students performance and graduation. The well-trained graduates are well received by employers.

5.2.2 Research, extension and training

(a) *Research*

In 1997, there were 201 fisheries research institutions with a staff of 7 814, of whom 5 061 were technicians, 809 were seniors and 1 891 were of intermediate level.

The Chinese Academy of Fishery Sciences (CAFS) was founded in 1978. Under the CAFS, there are three integrated marine fisheries research institutes along the coast of the Yellow Sea, the East China Sea, and the South China Sea, and three integrated freshwater fisheries research institutes along the valleys of the Yangtze River, the Pearl River and the Heilongjiang River. Besides, there are Freshwater Fisheries Research Centre, Fishery Machinery and Instrument Research Institute, Fishery Engineering Research Institute, Fish Disease Research Division, Bohai Sea Enhancement and Scientific Experimental Base, etc. (Fig. 4). The basic research on aquaculture development and culture technology improvement is one of the most important tasks of the CAFS and its institutes. The academy has 1 800 professional staff, of which more than 300 are senior. The scientific research personnel in fisheries universities/colleges are also an important force in aquaculture research.

Most of the provinces and many prefectures and counties have set up their own research institutes. Now there exist 36 provincial institutes, 73 prefectural institutes and nearly one hundred county institutes. The majority of these institutes are engaged in aquaculture, closely combine research with production and resolve technical problems existing in production. They play an important part in promoting rural aquaculture development in their regions.

Provision of seed is considered as one of the fundamental elements for aquaculture. The success obtained in artificial propagation of a number of

species sequentially and in large-scale production, are substantial achievements in scientific research. Each breakthrough in a species resulted in a marvellous production system development. The first breakthrough was made in some freshwater fishes (1958), followed by kelp (1950s), laver (1960s), mussel (1970s), prawn, scallop, abalone (1980s), etc. which resulted in a high tide of culture practices and production. Now, there are few problems related to production and supply of seed of the cultured species of today. In 1997, artificially bred freshwater fish fry reached 379.57 billion; river crab seed, 143 619 kg; marine fish fry, 566.5 million; prawn seed 39.39 billion; scallop seed, 789.8 billion; abalone seed, 3.22 billion; kelp seed 7.92 billion. There are 1 167 non-profit seed propagation and supply farms and stations with a total personnel of 29 310. Many rural culture units propagate seed themselves and have attained self-sufficiency.

(b) *Extension services*

Extension is a major input to turn science and technology into productive forces, and to accelerate production. In China, extension of some major technical achievements has led to significant production increase. Highly successful activities of the extension services at all levels of operations have helped to spread the technologies of silver carp and big-head carp artificial breeding (1950s & 60s), artificial breeding and raft culture of kelp (1950s); river crab stocking and enhancement (1960s); prawn and shellfish artificial breeding and culture (1980s and 1990s); production and culture of hybrid carp (1980s and 1990s); etc. Recent dramatic growth of rural aquaculture, to a major extent, is the result of effective extension services being made available all over the country. After the founding of New China in 1949, along with the development of fisheries research and technology, the national fisheries technology extension system was established during 1950s. By 1957, more than 120 extension stations had been set up in the country, but unfortunately, all the stations were abolished during 1960s and 1970s. The government did not emphasize to restore the extension service system until 1979. The China National Fishery Technology Extension Centre was established in 1991, directly under the Ministry of Agriculture. The major assignments of the National Centre are as follows:

- a. Implementation of Law of Agriculture, Law of Agriculture Technical Extension and national fundamental policies of technical extension and monitoring;
- b. work out and implement the rules and regulations of fishery technical extension;
- c. check, sum up, exchange and give guidance to fishery technical extension service in the country;
- d. present and implement the annual plan of fishery technical development and extension in the country;
- e. organize and implement model extension of the national scientific achievements and advanced technology;
- f. give guidance to local fishery technical extension, staff training, and social service;

- g. Check and accept scientific and technological extension projects, and evaluate and give awards to the extension of scientific achievements;**
- h. organize and participate in national activities in exchange, transaction, development and management of scientific achievements;**
- i. provide special service such as professional training, technical consultation, and make scientific achievements commercialized;**
- j. take part in evaluation and identification of scientific achievements, carry out information exchange of scientific achievements, and spread and propagate scientific and technological knowledge.**

At the end of 1997, a total of 2 227 fisheries technology extension stations were set up, with a total staff of 15 427. The Central Government has a staff of more than 30, mainly technical personnel. The extension stations at provincial and county levels are usually staffed with 5-20 persons, depending on workload, and furthermore in a town/township station, the number of workers is dependent upon aquaculture area within the station. There are a large number of fisheries technology extension groups in the villages and they derive their income from the payments received for extension services provided to the fishfarmers, not from fixed salary. Including these private group, the number of fisheries technology extension units were 14 872 at the end of 1996, an increase of 5.8 times over 1990. The staff totalled more than 39 000, of whom 80% were professionals mainly from fisheries schools.

(c) Training

Since the country carried out the open policy and economic reforms, opportunities related to fisheries training have been offered through more than 71 newly-established training centres. At the end of 1980, training courses of different kinds held by these centres were 3 414, with an attendance of 1 770 fisheries technicians and 183 167 fisheries workers. The training courses held by Shanghai, Dailian, Xiamen and Zhanjiang fisheries university/colleges were for training officials for freshwater fishes and mariculture management.

For the purpose of quickening the development of freshwater aquaculture, 4 nationwide freshwater aquaculture training courses organized in Wuxi, Huzhou, Shunde and Liaoyang in 1983 were responsible for training the staff from state-run fish farms and productive labourers from individual speciality households. After eight months of training from artificial propagation, fry and fingerling production, fish culture to harvesting, the trainees became skilled technicians who possessed not only theoretical knowledge, but also practical operational skill. In the 4 years 1 166 persons were trained. Afterwards, some of them passed on the knowledge they acquired to local fish farmers in the training courses held by themselves. In 1984-1986 more than 30 000 people were trained only in the field of prawn culture. From 1985, the Central Agricultural Broadcasting School organized by the Central People's Broadcasting Station began to set freshwater fish farming training courses. According to incomplete statistics, the number of students exceeded 20 000. In order to develop culture of special species, Congyang county in Anhui Province held 10 training courses in

1988 with an attendance of over 2 000. Dangyang city in Hubei Province trained ten thousand people by way of 6 courses of lectures on television and videotaped teaching for 80 times. Many short-term training courses on a specific topic or a particular technical issue are being held by fisheries research institutes, extension stations, universities, colleges and fisheries schools, mainly on the production locations, on a regular basis.

The “Green Certificate” system was adopted on a trial basis in the early 1990s. Nine counties and cities from six provinces were selected to carry out this experiment. Those selected fish farmers who had participated in one or two production cycles, proved themselves to be qualified for their job. Then the trainees passed the final examination and were awarded “Green Certificate”, or called “Qualified and Skilled Fish Farmer Certification”, by local authorities. The fish farmer with this certification could enjoy priority in obtaining production contract, technical information, extension service; loan support, etc. Altogether 552 Certificates were issued in the first training course.

In cooperation with the United Nations Development Programme (UNDP) as well as the Food and Agriculture Organization of the United Nations (FAO/UN), the government has established the Asian-Pacific Regional Research and Training Centre for Integrated Fish Farming in Wuxi of Jiangsu Province. This famous institution has trained many local and foreign aquaculturists in integrated aquaculture system.

5.3 Credit

In order to support fishfarmers to increase production and improve production facilities, the State has been giving priority to providing credit facilities. At the early days of the founding of the New China, the government supported fishfarmers to restore production with 20 000 mt millet and 50 000 mt salt as fisheries credit. In the First Five-Year Plan, the credit in major fishery regions added up to 195.77 million yuan, of which 70% or so was used to build fishing boats at that time, and only a little was used for aquaculture. Afterwards, the amount of credit availability got more and more. At the end of 1988, it reached 1.61 billion yuan. Under the influence of “Big Leap Forward” and “Cultural Revolution”, a considerable number of communes and brigades could not pay back the credit. So the State had to take measures to reduce and remit credits in arrears, with the amount totalling up to as many as several hundred million yuan. In a few cases, the government supported culture production by way of granting subsidies. For example, since 1980, Finance Ministry allocated part of the fund from the Agriculture Supporting Fund to help fishfarmers in the suburbs of Beijing, Tianjin and Shanghai to build fish ponds every year, mainly to support collective units to build fish ponds in low-lying waste land and saline-alkaline land in the outskirts of these cities. For each 1/15 ha standardized fish pond, the state provided 500 yuan as working fund, and the rest was raised by the farmers themselves. In 1980-1985, the supporting funds by the government totalled up to 36.9 million yuan, and the area of the fish pond built with the funds reached 16

200 ha. In 1982, in building commercial fish production bases, the state allocated funds to remould old fish ponds, 1 500 yuan per ha; intensive culture on small natural waters was subsidized up to 150 yuan per ha. In order to promote prawn culture, at the starting stage, the State gave 3 000 yuan for building one ha of prawn culture pond. In 1980-1984, the state subsidies in this field amounted to more than 50 million yuan. Funds arranged by provinces, municipalities and counties to prawn culture were more than ten millions yuan every year. With the increasing of individual and private culture operations, and the development of market economy, in recent years, fishfarmers obtained credits from banks, mainly from Agricultural Bank of China and Agricultural Credit Cooperation. Credit policy was formulated on the basis of national agriculture development strategy. Credit was largely used to support crop production, integrated development, technology extension, township and village enterprises and export-oriented agriculture industries. Presently, the government is encouraging to develop agriculture of high yield, high profit, superior quality and high export potential, and some aquaculture activities just possess such features. But owing to great risks involved in aquaculture production, individual and small-sized private aquaculture farms can hardly gain credits from banks. In 1992-1994, the monthly interest rate set up by the People's Bank of China for culturing eel was 1.26%. Some fish farmers had to borrow usurious loans from illegal private credit units, and the monthly interest could be as high as 20-30 percent. Now, the aquaculture risk insurance is offered by insurance companies, but the premium is rather high.

5.4 Other Inputs

Reliable estimates on the amount of feed consumed in the aquaculture industry which is mainly based on extensive and semi-intensive culture systems. Supplementary feed is mainly farm-made or made by small to medium size feed mills in areas where aquaculture is well established and is a recognized economic activity, and the farming system is at various stages of intensification. Such farmers are demanding formulated and pelleted feed. On the whole, it is believed that about one tenth of the production from fish culture and most of the shrimp culture production are based on compound feed (farm-made/mill produced) of varying quality, and that the total supplemental feed used by aquaculturists may be in the order 4-6 million mt. However, with the rapid rate of intensification of culture operations of fish and shrimps, the demand for quality pelleted feed will also increase very rapidly.

In 1997, the agricultural chemical fertilizer output in the country reached 26.51 million mt, of which 21.2 mt was nitrogen fertilizer, 5.1 million mt phosphoric fertilizer and 209 000 mt potassium fertilizer. Besides, 22.98 million mt urea and 3.37 million mt mixed fertilizer were produced. The above fertilizers were mainly used on agriculture. In aquaculture, a large quantity of farm manure and green manure are used. Nowadays, there is no shortage of supply of chemical fertilizer required for aquaculture.

In 1995, there were over 200 factories that produced medications needed for aquaculture, both preventive and curative, and there were countless sellers. In Gaoyou County of Jiangsu Province, the culture area covers 1 500 ha, but fish medicine sellers are as many as 200. It is estimated that based on the present culture area, the demand for fish medicine approximates to an output value of 8 billion yuan. However, in 1995, the fish medicine output value in the country was only about 200 million yuan. Therefore the kinds and volume fell far short of meeting the requirements. More research and development works must be done with a view to producing chemical/medications, both preventive and curative, required for fish health management.

6. Outlines of Major Projects in Rural Aquaculture

The national rural aquaculture projects were formulated and implemented by the Bureau of Fisheries in accordance with demand and needs. The State financial and material supports were extended to fisheries departments of local governments concerned, mainly by way of mobilizing fishfarmers in project locations (in the past, these locations were referred to people's communes, brigades and teams) to achieve project objectives with their own efforts. These projects played an active part in promoting aquaculture in rural areas with significant successes. The major projects implemented are outlined as follows:

- i) **Fish culture in the outskirts of cities:** at the beginning of 1970s, the supply of aquatic products was getting more and more tight. And there were many water surfaces and waste land which could be exploited for fish farming in the suburbs of many cities. In order to ensure the supply of aquatic products for city residents, the Ministry of Agriculture and Forestry held meetings formulating fish culture projects on the outskirts of cities, and popularized the experience of Hengyang city which dug fish ponds of 666 ha in hilly districts in the outskirts, with a yearly production of 2 000 mt for city nearby. After the meeting, many large and medium-sized cities went into action one after another by making concrete plans. Nanjing mobilized a total of 1.07 million people to remodel desolate beaches into fishponds of 253.3 ha. Nanchang built 300 ha fish ponds too, and in the following year 140 mt fresh fish appeared on the market for the National Day. In 1971-1973, 25 communes and 95 brigades in Wuhan transformed low-lying land and lake beaches into fish ponds of 804.8 ha with 2 million labourers. By 1974, project cities had built 14 666 ha of high and stable yielding fish ponds. The majority of them benefited a lot the same year from the ponds, with increased fish and income for the communes and brigades. By 1977, fish pond culture area in 35 large and middle-sized cities reached 230 000 ha, representing 7% of the total freshwater culture area in the country, and fish production went up to 125 000 mt, making up

12% of the total freshwater fish production of the country, with the average per unit production of 2 490 kg/ha, 2.6 times higher than the state average, which greatly increased fish supplies of the concerned cities. From 1980 on, Ministry of Finance used the Agricultural Supporting Funds to set up projects to help develop fish culture in the outskirts of Beijing, Tianjin and Shanghai. Up to 1987, in 46 large and medium-sized cities including Beijing, Tianjin and Shanghai, fish culture area reached 681 000 ha with a fish production of 783 000 mt, representing 17.7% and 19.2% of the State's total respectively. This production made substantial contribution to meeting fish supply for the major cities. The foreign aid projects starting from 1980 also included some projects of promoting fish culture in city outskirts. These projects were completed with great success (see Foreign Aid Projects).

- ii) **Construction of commercial fish production bases:** Freshwater fish production is highly dispersed. Even when the state executed the centralized purchase policy, the proportion of actual volume purchased seldom reached 20%. Since 1977, the State started implementing projects for commercial fish production. In the regions where conditions were favourable for fish culture, the State helped collective units in communes and brigades to build new fish ponds or rehabilitated old ponds, with the State subsidy of 3 000 yuan/ha. Most of the products were purchased by the State. For instance, in 1978 Hunan Province dug 2 333 ha fish ponds with a production of 1 196 mt, of which 673 mt were purchased by the State. Jiangsu Province constructed fish ponds of 1 266.6 ha with a production of 750 mt, of which 550 mt were purchased by the State. By 1987, 101 000 ha of standardized fish ponds were built with a production of 267 000 mt in Jiangsu Province alone. And 166 000 rural labourers were recruited into production. During the same period (1978-1987) other provinces also established their own commercial fish production base projects one after another. However, in 1987 there were 19 141 freshwater commercial fish production bases throughout the country, of which 208 266 ha were newly-built ponds and 32 466 ha were remodelled ponds, with a yearly fish production of 613 000 mt, representing 17.3% of the total fish culture pond area and 23.4% of the freshwater culture production of the country.
- iii) **Paddy field fish culture:** At the beginning of 1950s paddy field fish culture was already a reality, doing no harm to rice but with a good harvest of fish. In 1970s the ecological theory of fish and rice combination was further elucidated. In 1986, the area for paddy field fish culture reached 692 000 ha with a production of 98 000 mt, or 141 kg per ha. In many projects, high yielding models such as "thousand ji of rice with hundred ji of fish" production in 1 mu (2 ji = 1 kg; 1 mu = 1/15 ha) became the goal. Fish produced from paddy fields were no longer consumed by farmer themselves but could be sold as a commodity. Cultured species included

crucian carp, grass carp, silver carp, tilapia and Chinese bream, crab, shirmp, etc. In average, rice production also increased by 5%-10%.

- iv) **Kelp culture:** in 1957, kelp was transplanted southward from latitude 40°N to 30°30'N with success. One year later, there was a breakthrough in artificial propagation of kelp seeds. A project on kelp culture was implemented with tremendous success and this was regarded as a starting point in rapid development of kelp mariculture. In 1958, kelp yield was only 6 000 mt, but in 1980 culture area reached 16 466 ha with an output of 253 000 mt, a rise of 40 times over 1958, which could meet the needs of both home market and export. Kelp culture became a high profit business in 1978 with average profit margin in major production districts stood at 56%-59%. In 1977, the area for kelp culture in Shandong Province was 8 200 ha with a production of 125 000 mt, valued at 110 million yuan, with a net income of 50 million yuan. The labourers engaged in kelp culture in the province were 28 000, per-capita net income being 1 800 yuan. Kelp culture development helped in the improvement of fisheries production structure, thus changing a single-sided capture fisheries in coastal area into a diversified fisheries with culture and capture developing concurrently.
- v) **Mussel culture:** The beginning of 1970s was the starting point of successful raft culture of mussel in the north. In 1974, the mussel culture area stood at 526.6 ha with a production of 15 141 mt; and by 1977, the area was expanded to 2 726.6 ha with the production reaching 102 000 mt. Along with the rise of prawn culture, mussels were used as feed for prawn, and therefore mussels were needed in large quantities. By 1987, the culture area rose to 3 420 ha with a total production of 312 700 mt.
- vi) **Prawn culture:** In July of 1979, the State convened the first national prawn culture meeting, which decided the guiding principles and policies for prawn culture, as well as the arrangements for the use of Agriculture Supporting Funds. This meeting laid a solid foundation for prawn culture. In 1981, the prawn culture area was already over 13 300 ha with production reaching 3 682 mt. In the beginning of 1980s, artificial propagation of prawn and culture technologies were improved. Especially in 1982, industrial large-scale artificial propagation of prawn was achieved and the seed supply problem was finally solved. And a series of practical prawn culture technologies were in operation, thus raising per unit output. Prawn was mainly for export creating considerable economic benefits. So prawn culture projects were pursued in different parts of the country. And there was a great upsurge in prawn culture along the coast. The prawn culture area and production increased by a big margin year after year. In 1984, the culture area rose to 33 400 ha with a production of 19 371 mt. In 1991, the total culture area increased to 147 150 ha with the highest

production reaching 219 571 mt. During that period, about 80 000 mt prawn were exported every year, creating foreign exchange of nearly USD 500 million. In the period from 1979 to 1983, the State invested a total of 550 million yuan on artificial propagation of prawn seeds, cold storage and processing as well as construction of complete sets of production facilities. From 1980 to 1984, the State also arranged more than 50 million yuan subsidies to support communes and brigades to culture prawn. The development of prawn culture stimulated the development of feed processing, seed production, cold storage, transportation and other services, and particularly played an extremely important role in regulating coastal area development. This also generated employment to large numbers of labourers, and various skilled workers and thus raised the standard of living in many coastal rural areas. Efforts are now being made to strive hard to make prawn production restore to its original level.

- vii) **Raft scallop culture:** In 1982, the area for scallop culture was only 186.6 ha with a production of 1 162 mt. Scallop culture developed at a high speed after the successful introduction of Atlantic bay scallop. The culture methods developed from mudflat planting into rack culture, long-line culture and raft culture, which resulted in a great increase of production. By 1991, the culture area went up to 4 866 ha with a production of 189 000 mt, a growth of 25 and 161 times respectively. Changdao County in Shandong Province became a major production area in the country. In 1986, the area for scallop culture in this county already reached 466.6 ha, representing 57.4% of the total in the country, and the production amounted to 16 000 mt, making up 67.5% of the country's total. There were 67 households whose average annual income from scallop culture was 10 000 yuan. Some speciality households earned more than 100 000 yuan per year.
- viii) **Seed propagation facilities:** In order to support the implementation of the above projects, the State started projects for construction of hatcheries. In 1987, more than 600 prawn hatcheries and over 50 hatcheries for high value species were built. In 1997, the yearly seed propagation capacities of the country were: kelp seedling 6 billion, for 133 000 ha of culture; laver spats 60 million shells, for 6 600 ha culture; prawn seed propagation area of 700 000 m³, in which 100 billion prawn seeds could be propagated; scallop, abalone and sea cucumber seed propagation area of 70 000 m³, which could produce more than 10 billion scallop seeds, 5 million abalone seeds and sea cucumber seeds of 10 million. Besides, a number of marine fish and clam hatcheries were built.
- ix) **Foreign aid projects:** Since 1983, some international donor agencies have begun to assist China to develop fisheries in various fields such as aquaculture development, fisheries resources management, fisheries education and training, etc. The major international organizations include

the World Bank, the World Food Programme, the United Nations Development Programme, the International Funds for Agriculture Development etc. Up to the end of 1992, China had accepted funds aggregating USD 900 million including about USD 200 million as contributions and USD 700 million as credits. More than 20 projects have been implemented. At the same time, the Food and Agriculture Organization of the United Nations, the Canadian International Development Research Center, and the Japan International Cooperation Agency supported through their technical Assistance Programmes. It is believed that external assistance has played a significant role in increasing fisheries production in China. Some projects related to rural aquaculture development are described below

a. Development of Fishery Resources in Hongze County, (WFP-2633 Project). It was the first WFP fisheries project implemented in China. Its main objective was to resettle 2 000 fishing families living in poverty on their houseboats in Hongze Lake, to provide them a new livelihood by providing houses, schools, and a hospital, and to encourage them to develop aquaculture in the lake. The lake covers an area of 2 275 km². It was one of the undeveloped regions of Jiangsu Province. Through 4 years of hard work in 7 project townships such as Linhuai, Chenghe townships, etc. the scheduled targets of the project were achieved with good socio-economic benefits. Two thousand fishermen families living in small boats settled down on land, of whom 2 791 fishermen went in for aquaculture production. Nearly 3 000 children studied in a good environment. The rate of enrolment went up from 76% to 95%. The fishery resources in the lake area were restored due to the practices of stocking fish and crab seeds, cultivation of 7 534 ha of water weed and establishment of protected regions. The fisheries output in 1986 reached 12 500 mt. The newly-built nursery pond of 200 ha, and 667 ha production pond registered significant benefits. The output of 1986 hit 3 252 mt of fish. Thus the total aquaculture output value amounted to 10.49 million yuan. The average annual income of fish culture labourers reached 919 yuan, and the people living in the project areas were also benefited from the setting up of pump station, feed processing factory, cold storage, harbour construction, electricity and water supply, hospital, etc. The project was evaluated as one of the most successful projects in China.

b. Development of Aquaculture in Low-lying Area, Boyang Lake, Jiangxi Province (WFP-2799 Project). The Boyang Lake is the largest lake in China; its fish catch dropped from 38 200 mt in 1964 to 1 575 mt in 1984. And, as a result, the per capita income of the farmers and fishermen living in the four project townships was very low. The per capita income was only 155 yuan, less than half of the national rural average. The project was designed to transform about 3 000 ha low-lying land suitable for aquaculture into fish farms and support facilities such as hatcheries

and cold storages; to provide job opportunities; to increase food consumption of the people living around the lake and ultimately to lessen the fishing pressure on the lake. From 1987 to 1990, 3 818.9 ha fish pond was put into production, 9 375 mt fish and 788 mt fingerling were produced, with a total output value of 33.44 million yuan. In 1990, the average income of fish culture labourers reached more than 1 700 yuan, 50% percent higher than those of agricultural labourers. Two thousand and six hundred rural surplus labourers were employed by the project. The people in the project area have gained great benefits in terms of income and protecting resources of the lake for future generations.

c Development of Aquaculture in Low-lying Saline, Alkaline Areas in Hangzhou Bay, Zhejiang Province (WFP-2700 Project). The project area is located along the Hangzhou Bay in 47 townships of Shaoxing, Cixi and Shanyu counties, Zhejiang Province. Most of the land reclaimed proved too salty to be suitable for planting crops. The result was that the annual per capita income of the people was only about 100 yuan, far below the country's rural average income. The project was to establish fish farms as a suitable and sustainable economic activity on recently reclaimed marginal land. From 1984 to 1987, 36 fish farms were established with a total of 1 066 ha production ponds and 226 ha nursery ponds. Up to January 1988, a total of 3 357 mt of fish had been harvested and 349 mt of fingerlings produced. The income for each pond culture household was 2 074 yuan for production pond (1 530 households) and 1 382 yuan for nursery pond (500 households), which represents an increase of 180 to 300 percent over the pre-project household income of 500 yuan. 3 480 permanent and over 2 000 part-time jobs were created. One hundred and eighty five ha of pond embankments, out of a total of 400 ha, became productive as the salinity was reduced to an acceptable level over three years of cultivation, and in 1987, 1 459 mt animal fodder, 354 mt fish feed (bean-cake), 352 mt melons and 253 mt vegetables were produced with a total gross value of 298 000 yuan. Poultry, egg and pork production from the 355 animal farms put into operation in 1987 had a total gross value of 2.5 million yuan. The project has successfully demonstrated that marginal low-lying land can be put to more productive uses. Afterwards the local people built an additional 666 ha of fish ponds in the three project counties with this project as a model.

d. Development of Fish and Dairy Production in the Low-lying, Saline-alkaline Areas, Tianjin Municipality (WFP-2730 Project). The soil salinity of the 20 000 ha of low-lying saline-alkaline wasteland in Tianjin Municipality is around 1.6-3.0 per thousand which is not suitable for crop plantation. Over the years, transformation of these land has been done in many ways, but the results were not very satisfactory. The farmer's annual per capita income in these areas accounted for only 52.8% of the agricultural population of the municipality. The objective of

this project was to make the best use of 4 500 ha low-lying saline-alkaline wasteland and play an important role in putting the natural resources of the city to rational use, helping the people in the project area to shake off poverty and to increase fish and milk supply of the city. In the three years from 1984 to 1987, 5 496 people were employed, of whom 2 738 (866 women) were engaged in fish culture and 2 758 (1 017 women) in animal husbandry. In 1986, the area of fish ponds reached 502 ha with a total output of 658.7 mt fish and a net profit of 831 300 yuan. The labourer's average income was 802.41 yuan. The planting of the raised fields reached 819.7 ha. There were 200 000 chickens, 4 600 ducks, 798 pigs, 508 goats and 32 cows raised every year. And by the end of 1986, 951.8 mt milk had been produced. In 1987, fish pond was further extended to 933.3 ha, which produced more than 2 000 mt fish and the per capita income increased by nearly 70%. The project proved that fish culture is a powerful economic activity for promoting socio-economic benefit to the rural poor.

e. Development of Coastal Aquaculture in Bohai Bay (WFP-2771 Project). The project sites are located in Huanghua County, Hebei Province, and Lijin, Shouguang and Changyi counties, Shandong Province. The objective of this project was to raise the living standard of submarginal fishermen whose income had dwindled due to depletion of the Bohai Sea marine resources, and to provide them with a new livelihood through prawn culture. Major construction was to convert nearly 4 000 ha unproductive mudflats and saline-alkaline plains into 2 200 ha prawn culture ponds as well as other infrastructure such as roads, bridges, pumping stations, hatcheries, feed mills, cold storages, etc. In 1989, 16 prawn farms were established with a total pond area of 2 860 ha in full operation. In 1988, 2 220 ha ponds were put into production and 2 089 mt prawn were harvested. The average income for a prawn culture labourer (4 171 households) was 1 920 yuan, increasing over 100% over the pre-project household income of 875 yuan. Five thousand one hundred and eighty six permanent jobs were created, including 4 171 pond operators, 205 management staff and assistants. There were 422 working in cold storages, 145 in feed processing, 183 in hatcheries and 58 in pumping stations. As seasonal employees, 13 worked in cold storages, 390 in prawn collection, 220 in transportation and marketing, and 182 in feed processing. Of the above employees, 866 women were permanent employees (16.7%) and 1 706 were seasonal workers (28%). Eighty-five percent of the permanent and seasonal workers were transferred from capture fisheries, thus lessening the fishing pressure on the natural fish stocks in the Bohai Bay. Moreover, the project had a demonstration effect to the neighbouring areas. Since 1986, an additional 3 000 ha prawn ponds has been built by fishermen themselves with this project as a model.

f. Development of a Pilot Demonstration Plant for Compound Fish Feed (FAO/TCP/CPR/0053 Project). The project plant is located in Shaoxing County Zhejiang Province and has been outfitted with advanced equipment and technology. The purpose of this plant was to provide a model for the future development of much needed compound fish feed industry, and to facilitate the production of quality fish feed in support of strategy for developing nutritionally balanced artificial fish feeds to supplement and/or replace the traditionally used feed, thus allowing for the introduction of intensive culture practices. In 8 months of trial production (September 1990 to May 1991), the fish feed mill attained a production of 550 mt of fish, poultry and duck feed. The operation of this fish feed mill is progressing in a normal way and has become a good pilot demonstration plant for compound fish feed in the country.

g. Development of Integrated Fish Farming In Nine Cities (WFP-China 2814 Project). The project was to convert 9 735 ha of unused and marginal land into 6 833 ha of fish ponds in nine cities to increase their fish supply and to create job opportunities. The Fisheries Project Office of Ministry of Agriculture as an executive agency provided direct supervision and advice on all aspects of project implementation including fish farm design, construction and management. Through project implementation, 175 fish farms have been built. The project created employment of 8 455, of whom 6 008 are fish culture labourers, 687 skilled workers, 907 management staff, 418 technicians and 435 other workers. The project began in April 1987 and closed in March 1990. Its principle of “construction, production and benefits in the same year” has been achieved. In three years the total area brought under culture was 13 800 ha with fish output 34 090 mt (3 645 kg/ha), fingerlings output 7 662 mt (1 725 kg/ha). The total output value stood at 196.95 million yuan. Besides, the output values of planting, animal husbandry and processing were 7.94 million yuan, 10.62 million yuan, and 4.49 million yuan respectively. Along with the increase in of production, the per capita income of workers and fish supply in the cities increased. The project was highly successful.

h. China Freshwater Fisheries Project (Credit 1689-CHA). The project was financed by the World Bank, and its principal objective was to develop freshwater fish culture in the outskirts of the eight cities (Beijing, Shanghai, Hangzhou, Chengdu, Chongqing, Harbin, Nanchang and Shenyang) by improving 6 100 ha existing fish ponds, using land unsuitable for crops to construct 11 100 ha new ponds, providing techniques and equipment for pond management, and strengthening support facilities for production and marketing of fish. The project is regarded as highly successful, and has played an important role in raising fish supplies. It is said that in Beijing fish markets at that time, one out of every three fish came from the project.

i. Pilot Project to Increase the Output Of Fish Farm (EEC/CHN/85/28 Project). The project was financed by EEC as a grant. Two feed mills with an annual production capacity of 10 000 mt each were constructed in Tianjin Municipality and Cixi County Zhejiang Province. Technologies of feed formulation and processing were transferred to the Chinese technicians and scientists. The project contributed to further development of formulated compound feed for intensive culture system.

j. Fisheries Development In Qinghai (UNDP/FAO Assisted Project CPR/88/077). This was the first international assistance to the fishery sector in Qinghai Province. Its two main objectives were: i) improvement of the local carp fishery in Qinghai Lake by introduction of good management practices and development of hatchery techniques for production of juveniles of this little-known species; and ii) demonstration of the technical and economic feasibility of commercial rainbow trout farming in Qinghai Province. It was a successful project, particularly in the rainbow trout farming in the Longyangxia Reservoir.

k. Northern China Mariculture and Resources Management Project (ADB Loan Project). In this project, a dozen of counties in Liaoning and Shandong Provinces along the Bohai Sea made use of the loans provided by the Asian Development Bank and fund allocated by the local governments to set up hatcheries and expand shellfish and seaweeds culture areas, so as to fully utilizing the local shallow sea and mudflat to enlarge marine culture production on one hand and on other hand to improve the local fisheries resources management. The project is now being implemented.

7. Contributions of Rural Aquaculture to Rural Development

7.1 Contribution to Food Supply, Employment and Income

7.2 Women in Rural Aquaculture

7.1 Contribution to Food Supply, Employment and Income

Aquatic products represent an important component of the food basket of the Chinese people. Since the birth of New China in 1949, the State has always given high priority to the production of aquatic products through the development of fisheries, with great emphasis on aquaculture development. In 1997, fisheries production reached 36 million mt of which aquaculture production was over 21 million mt, representing about 56% of the total fisheries production. Aquaculture is the fastest growing sub-sector of agriculture and it has made China the largest aquaculture producer in the world. In a short period of 50 years, aquaculture production has increased from 20 000 mt in 1949 to 20 million mt in 1997, an

increase of 1000 times. In 1997, per caput availability of aquaculture product in China was estimated at 17.5 kg. This is a big contribution to their own food supply. China is now the largest producer, producing over 55% of the global aquaculture production.

There is a saying in China “where no fish, there is no money”. From ancient time people regarded fish farming as a highly profitable business and even more profitable than any agricultural activity. This old saying is still good. Anhui Province devoted major efforts to expand rural aquaculture to develop rural economy. The aquaculture production reached 750 000 mt in 1995 as against 360 000 mt in 1993, doubling in two years. In 1996, there was another increase of 47.6%; the production reached 1.107 million mt and total output value stood at 6.7 billion yuan (at constant prices), accounting for 10.8% of the total agriculture output value. The vigorous development of aquaculture promoted an increase of local revenue; one tenth of local revenue in some counties came from aquaculture, and at the same time spurred the growth of processing, storage and transportation industries. Congyang was a poverty-stricken county, but in recent years, the county led its people to develop aquaculture, and combined flood control/irrigation with fish pond rehabilitation works. Part of the low yield paddy fields which yielded two crops of rice a year were transformed into one crop of rice and one crop of fish. In 1996, the fish production reached more than 40 000 mt with output value 350 million yuan, making up one third of the total agriculture output value. Taxes from aquaculture amounted to 15 million yuan. In China, in the last 20 years, about 100 million people have received benefits directly or indirectly from aquaculture. In 1997, the Chinese fishfarmer's/fisherman's average per capita income was 3 974 yuan (90.2% higher than that of farmers'), rising steadily from 1 051 yuan in 1987 (Table 11). In 1997, full-time aquaculture labourers reached 3.29 million as against 1.53 million in 1989, an increase of 115%; part-time aquaculture labourers even increased by several hundred thousands. That means in 8 years aquaculture created about 1.75 million jobs for villagers. Further development of rural aquaculture may help absorb the surplus labourers in rural China.

Detailed statistics of aquaculture household/labourer income are not available. However, information available on this subject from recent surveys are as follows:

In a survey of 1 139 aquaculture households in 7 cities and provinces (Beijing, Tianjin, Heilongjiang, etc.) in 1996, there were a population of 4 900 and 2 541 labourers (Table 11a). The per capita net income of that year was 3 425 yuan, and the average net income of labourers was 6 860 yuan, much higher than the average income of farmers (the per capita net income was 1 926.07 yuan). The survey of aquaculture households in 1997 shows that family members were 2 781 and labourers were 1 515. The per capita net income was 5 325 yuan and average net income of labourers was 10 097 yuan, which showed a sizable increase over 1996. In Tianjin where stress is placed on prawn culture, the per capita net income of 20 households in 1996 stood at 5 645 yuan and the average

net income of labourers was 12 145 yuan. In 1997, the per capita net income and the average net income of labourers reached 7 491 yuan and 15 202 yuan respectively, which were 1-2 folds higher than that of aquaculture households in general.

According to a typical survey of agriculture households conducted in 1997 (Table 11b), the per capita net income was 2 090.13 yuan, of which 1 617 yuan was on average spent on living expenses such as food, clothing, housing, transportation, communication, medical care and recreation, making up 64% of the total income. The typical surveys of aquaculture households made in Beijing, Henan, etc. the same year, the per capita net income was 5 325 yuan, 210% higher than that of agriculture households. The average living expenses stood at 2 651.1 yuan, (63.9% higher than that of agriculture households), amounting to 50% of the total. These figures show that the fish farmer's income is much higher than farmer's income. So is the living expense. However, the fish farmers had more money to spend for other uses than farmers.

7.2 Women in Rural Aquaculture

After liberation, the Chinese women' social position radically changed. The Chinese women not only are equal to men politically but also enjoy the same right of employment as men. Production conditions and environment of capture fisheries are quite special so few women work in the forefront of capture fisheries, but just do rear-service work such as knitting or mending nets, processing, etc. Rural aquaculture is a kind of labour-intensive production, which is suitable for women to participate directly. As for some production operational activities, they do much better than men such as in seed production, seed collection and rearing, seeding, rope culture and so on. In addition, the women do very well in the making of culture facilities such as rack, raft, seedling collector, rope and line, drainage, ditches, etc. Women are also involved in harvesting and transportation, processing. Therefore, the development of rural aquaculture is creating more jobs for women. The present statistical figures are not very accurate, but it is estimated that the proportion of women engaged in aquaculture is not less than one third of the total workforce employed in rural aquaculture. There are 1 167 non-profit seed propagation stations with a staff of 29 310 throughout the country. Of them, 7 878 are female, representing 26.8%. The proportions of females in fisheries technical extension units, scientific research units and educational units are 20.9%, 27.4% and 37.9% respectively. As for rural aquaculture households, the whole family (including children) all throw themselves into production regardless of sex, if needed. Women have made substantial contributions to the development of rural aquaculture, and at the same time have made valuable contribution to the family income and thus helping in raising the quality of family life.

8. Opportunity for further Development

8.1 Highlights of Past Development Projects and Their Socio-economic Impacts

8.2 Current and Planned Projects

8.1 Highlights of Past Development Projects and Their Socio-economic Impacts

In this decade under the 8th and 9th Five Year Plans, the State is implementing the national fisheries ‘Bumper Harvest Plan’, ‘Thriving Agriculture Through Science and Technology Plan’, ‘Fisheries Technology Extension Plan Through the Ministry of Agriculture and Local Government’. Under these plans, many programmes/projects of rural aquaculture development are being implemented with great successes. From 1989-1996, under the above plans, 137 projects were organized and implemented covering a total of 443 866 ha culture area. The yields of fish, prawn, shellfish, seaweeds and new species with high value amounted to 582 000 mt, with output value of 4.57 billion yuan and tax contribution of 1.32 billion yuan. The major projects were as follows:

i) *High-yielding integrated culture in freshwater ponds*: the projects have been carried out in vast areas. The implemented area totalled more than 106 000 ha, and production increased by more than 200 000 mt with output value of 1 billion yuan only through the fisheries ‘Bumper Harvest Plan’. This gave an enormous impetus to the development of freshwater pond culture and their intensification and standardization. Fish pond culture area rose up from 1.415 million ha in 1990 to 1.96 million ha in 1996; average output per ha increased from 2 380.5 kg to 4 104 kg. Accordingly, the total pond fish output went up from 3.37 million mt to 8.042 million mt in the country. Number of species cultured were increased and some high-value and well-liked species such as tilapia, prussian carp, giant freshwater prawn, shrimp, river crab, California freshwater perch, channel catfish, soft-shelled turtle, etc. were included. In 1996, river crab and soft-shelled turtle output reached 63 000 mt and 32 000 mt respectively with enormous economic benefits.

ii) *Paddy field fish culture*: the projects set off a new upsurge in paddy field fish culture throughout the country. The culture area went up from 733 000 ha in 1990 to 1 445 000 ha in 1996; output per unit area increased from 177 kg/ha to 312 kg/ha. Not only carp species but high-value and speciality species were also cultured in paddy fields. As a result, the gains from fish culture averaged 3 600 yuan per ha.

iii) ***Prevention and treatment of prawn diseases:*** major efforts were made to apply advanced prawn culture technology from foreign countries. In 1994, projects called ‘Demonstration of Comprehensive Prevention and Treatment of Culture of Prawn Diseases’ under the national fisheries ‘Bumper Harvest Plan’ were established. These projects played an important part in prawn culture rehabilitation. In 1996, prawn production in the country was 89 000 mt against 64 000 mt in 1994, restoring the production level of 1993.

iv) ***Transplantation and enhancement of large icefish:*** In recent years, in spite of the fact that the large icefish output in the original major production areas such as Taihu Lake decreased, the large icefish output still went up from 6 000 mt in 1994 to more than 9 000 mt in 1996. Technology of large icefish transplantation and enhancement was extended from 18 to 31 provinces. Transplantation area was expanded from 266 000 ha to 1.333 million ha. In 1996, the culture area of this project in Qingdao was 4 400 ha with 42.9 million fertilized eggs stocked. The project produced 132.8 mt large icefish from 8 reservoirs. The selling price was 90 000 yuan/mt and the project made a net income of 9 170 200 yuan. The ratio of input to output was 1:8.5. Now with the expansion of large icefish culture areas, the annual production is expected to reach 200 mt with a net income of about 16 million yuan.

v) ***Development and exploitation of low-lying saline-alkaline land areas:*** The projects did a remarkable job, most of all in Shandong Province. In this province there are 666 000 ha saline-alkaline land suitable for exploitation. In recent years, 133 000 ha low-lying land has been exploited by way of digging ponds for fish culture and planting crops in raised fields. Of the 133 000 ha, the raised field constituted 66 000 ha and water surface for fish culture was about 46 600 ha. The total income exceeded 2.1 billion yuan. Fish output reached 280 000 mt with output value of 1.4 billion yuan equivalent to the output of 233 000 ha cultivated field. In the exploitation of these lands, the governments at different levels adopted contract responsibility system, and stuck to the principle of ‘the exploiter must be the runner and beneficiary’. The contract term was for 30 years. In the first 5 years, agricultural taxes and agricultural special taxes were reduced or remitted. This form of comprehensive exploitation is beneficial to improving ecological environment and raising rate of land utilization. It has become an important way for the people living in the districts along the Yellow River to improve their household income through fish culture.

vi) ***Net cage culture:*** owing to the extension of net cage culture projects, large and medium-sized freshwater bodies were more effectively utilized, and culture production of valuable marine fish species was also increased rapidly. Anhui Province took net cage culture seriously. Therefore net cage culture area increased from less than 13.3 ha in 1985 to 93.4 ha in 1996. From then on net cage culture became one of the main economic activities in the poverty-stricken rural communities. The number of net cages for culturing high priced fish in Guangdong Province was 19 000 in 1989 with a production of 1 384 mt. There

were 6 000 and 4 000 cages in Fujian and Hainan provinces respectively. The net cage culture area throughout the country in 1988 stood at 666 ha and doubled in 1989. After carrying out the ‘Bumper Harvest Plan’ extension project of net cage fish culture in Zaozhuang City, Shandong Province, net cage culture area increased at an average rate of 84% a year during 1990-1995. In 1996, the area reached 33.7 ha with a yearly production of more than 155 000 mt. Fifty thousand residents living along reservoirs who only owned 0.02 ha unfertile land per person, formerly lived on the relief granted by the government authorities throughout the year. In 1996, 89% of the population emerged from poverty by going in for net cage fish culture. The development of net cage culture has brought along the development of fish seed and feed production. Now, in the city there are 28 hatcheries, 1.73 ha temperate running water fingerling rearing ponds and 42 feed and additive factories with an annual production of 31 000 mt pellet feed and 200 mt additive. There also are 160 trucks for transportation of live fish. The high-density net cage fish culture technology has brought economic prosperity to many depressed, poverty stricken rural communities.

8.2 Current and Planned Projects

Until the Year 2000, the fisheries ‘Bumper Harvest Plan’, ‘Thriving Agriculture Through Science And Technology Plan’ and ‘Plan of Important Fisheries Technology Extension by Ministry of Agriculture’ will continue to be carried out to promote rural aquaculture in the country. And under the framework of the above plans, more projects will be drawn up and put into effect with stress on increasing production per unit area, improvement of culture facilities, improvement of auxiliary services, popularization of speciality species culture, strengthening of disease prevention and treatment; standardization of culture practices, etc. To further expand culture area, efforts must be devoted to utilization of uncultivated land resources and large water bodies suitable for aquaculture. Some of the major projects that are being planned for promoting rural aquaculture development are mentioned below:

i) *Project on disease prevention and treatment*: To promote good health management, disease control and treatment, the project will cover 400 000 ha.

ii) *Project on high-yield and high-efficiency integrated culture*: 200 000 ha will be brought under this project. Efforts will be made to promote mixed culture and culture in rotation; combination of aquaculture with agriculture and animal husbandry; low input and high output; energy saving; full utilization of local resources; etc.

iii) *Project on paddy field fish culture*: stress will be put on expansion of culture area by 333 333 ha, increase in number of culture species and mixed culture. Efforts will be made to turn paddy cultivation into an important way to develop freshwater fish culture in the western part of the country.

iv) *Exploitation and utilization of land resources suitable for aquaculture:* The main objective is to expand aquaculture in low-lying saline-alkaline land and bring 15 million ha under aquaculture operation.

v) *Development of shallow sea and mudflat culture along the Bohai Bay in Shandong and Liaoning provinces:* This region includes two islands and one bay. It is an important region for marine culture and resources enhancement. Shallow sea and mudflat culture will be further developed with emphasis on culture of prawn and other high-value species culture. A project on ‘Marine Culture and Resources Management in the Northern China’ supported by the Asian Development Bank is being carried out in this region.

vi) *Comprehensive development of large- and medium-sized lakes and reservoirs:* Emphasis will be placed on the development of culture of fish in large lakes and reservoirs in the middle and lower reaches of the Yangtze River. Also encouraged will be the development of ‘three nets’ (net cage, net enclosure and net screen) culture so as to combine extensive culture with intensive culture in large and medium water bodies.

vii) *Genetic improvement of cultured species and production of quality seed:* Centres for genetic improvement of species and centres for more advanced hatcheries will be established mainly along the Yangtze River, Pearl River and Heilongjiang River, to take full advantage of rich germplasm resources pool. The traditional culture species will be rejuvenated. Seed propagation and supply capability of new species will be strengthened, and hatcheries will be modernized for increasing production efficiency and for quality seed production.

viii) *Establishment of new and improvement of old fish disease prevention and treatment stations:* The existing stations will be upgraded both with equipment and expertise and new places will be selected in provinces and/or prefectures suitable for the establishment of fish disease prevention and treatment stations.

x) *Establishing and strengthening monitoring and management capacity of fisheries environment:* Efforts will be made to monitor water quality of culture areas, avoid water pollution, prevent and reduce self-pollution caused by culture activities with a view to ensuring a healthy aquatic environment for sustainable aquaculture development.

9. References

China Today: Fisheries Editorial Commission. China Today: Fisheries. Beijing, China (1991).

China Society of Fisheries. Aquaculture In Mainland China. Beijing, China (1994).

Cong, Z. M. and Li, T. The History of China Fisheries. Beijing, China (1993).

Department of Aquatic Products (DAP). China Fisheries Statistics Yearbook. Beijing, China (1985-1997).

Department of Aquatic Products (DAP). Reformation and Development of China Fisheries. Beijing, China (1989).

Department of Aquatic Products (DAP). Achievement, Problem and Development Strategy of China Fisheries. Beijing, China (1992).

Department of Aquatic Products (DAP). Fisheries Resources of Inland Waters in China. Beijing, China (1990).

Department of Aquatic Products (DAP). Inland Waters Fishery Divisions of China. Hangzhou, Zhejiang, China (1990).

Department of Aquatic Products (DAP). Marine Fishery Resources of China. Hangzhou, Zhejiang, China (1990).

Department of Aquatic Products (DAP). Coastal and Mudflat Fishery Resources of Intertidal Zone and Shallow Sea in China. Hangzhou, Zhejiang, China (1990).

FAO. World fisheries statistics. Rome, Italy (1950-1995).

FAO. Reform and Development of China's Fisheries. FAO Fish. Circ. No. 822. Rome, Italy (1989).

Fisheries Project Office, Bureau of Aquatic Products. Project Completion Report of China Freshwater Fisheries Project. Beijing, China (1992).

Guang, R. J. China Fisheries Policy and Future Development, The Internal Report of Department of Aquatic Products. Beijing, China (1993).

Jiang, S. F. and Wang, X. Z. China Fisheries Statistics of Forty Years. Beijing, China (1991).

Lu, N. J. Fisheries Infrastructure and Market of China, Report for Department of Aquatic Products. Beijing, China (1993).

Ministry of Agriculture PRC. China Agriculture Development Report 1995. Beijing, China (1995).

National Statistics Bureau PRC. China Statistics Yearbook. Beijing, China (1994, 1995, 1996, 1997).

Qian, Z. L. and Guan, R. J. The Development of the Chinese Fisheries and Manpower in Aquaculture. Beijing, China (1994).

Shang, J. R. and Liu, R. Y. Prawn and Crab of China. Beijing, China (1976).

Zhang, C. Y. Fisheries Resources and Production of China, Report for Department of Aquatic Products. Beijing, China (1993).

Zhang, X. and Qi, Z. Y. Shellfish of China. Beijing, China (1975).