

AT MICROFICHE
REFERENCE
LIBRARY

A project of Volunteers in Asia

Freshwater Fisheries and Aquaculture in China
FAO Fisheries Technical Paper No. 168

by: D.D. Tapiador, H.F. Henderson, M.N. Delmendo
and H. Tsutsui

Published by:
Food and Agriculture Organization of the
United Nations
Via delle Terme di Caracalla
00100 Rome
Italy

Paper copies are \$ 6.00.

Available from:
UNIPUB
P.O. Box 433
Murray Hill Station
New York, NY 10157 USA

Reproduced by permission of the Food and
Agriculture Organization of the United Nations.

Reproduction of this microfiche document in any
form is subject to the same restrictions as those
of the original document.

**FRESHWATER FISHERIES
AND AQUACULTURE IN CHINA**



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

FRESHWATER FISHERIES AND AQUACULTURE IN CHINA

A Report of the
FAO Fisheries (Aquaculture) Mission to China
21 April - 12 May 1976

by

D.D. Tapiador (Team Leader)
H.F. Henderson (Lake and Reservoir Fisheries)
M.N. Delmendo (Aquaculture)
H. Tsutsui (Land and Water Management)

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

M-44
ISBN 92-5-100328-9

The copyright in this book is vested in the Food and Agriculture Organization of the United Nations. The book may not be reproduced, in whole or in part, by any method or process, without written permission from the copyright holder. Applications for such permission, with a statement of the purpose and extent of the reproduction desired, should be addressed to the Director, Publications Division, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.

PREPARATION OF THIS REPORT

This document was prepared by the FAO Fisheries (Aquaculture) Mission to China which visited the People's Republic of China, 21 April to 12 May 1976, to study the aquacultural and fishery practices of the country and consider ways of utilizing the Chinese experience for the further development of inland fisheries and aquaculture in other member countries of FAO.

Distribution

FAO Department of Fisheries
FAO Regional Fishery Officers
FAO Country Representatives and
Senior Agricultural Advisers
Selector SI
UNDP/SF Projects in Inland Fisheries
and Aquaculture

Bibliographic reference

Tapiador, D.D. et al. (1977)
FAO Fish.Tech.Pap., (168):84 p.
Freshwater fisheries and aquaculture in
China. A report of the FAO Fisheries
(Aquaculture) Mission to China 21 April -
12 May 1976

Inland water environment. Water management.
Inland fisheries. Freshwater fish. Aqua-
culture. Agropisciculture. Fish culture.
Pearl culture. Aquaculture development.
Production(biological). Fishery management.
Stocking(organisms). Rearing. Disease
control. Fishery products. Marketing.
Education. Sociological aspects. Economics.
China, People's Rep.

TABLE OF CONTENTS

| | <u>Page</u> |
|---|-------------|
| Chinese Units of Measure | (xi) |
| Acknowledgements | (xiii) |
| 1. INTRODUCTION | 1 |
| 2. BACKGROUND INFORMATION | 2 |
| 2.1 Geography | 2 |
| 2.2 Recent history and social organization | 2 |
| 2.3 Status of freshwater fisheries and aquaculture | 4 |
| 3. LAND AND WATER MANAGEMENT | 7 |
| 3.1 Introduction | 7 |
| 3.2 Water and its uses | 7 |
| 3.3 Land and water development strategy | 9 |
| 3.3.1 Major schemes | 9 |
| 3.3.2 Hupei Province (as an example) | 10 |
| 3.3.3 Integration of major, small-scale and on-farm schemes | 11 |
| 3.4 Reservoirs and ponds | 11 |
| 3.5 Natural lakes | 12 |
| 3.6 Canals and creeks | 13 |
| 3.7 On-farm water supply system | 14 |
| 3.8 Fish ponds | 14 |
| 3.9 Paddy fields | 16 |
| 3.9.1 Modification of paddy fields for fish | 16 |
| 3.9.2 Fish culture with rice cultivation | 16 |
| 3.9.3 Water and farm inputs management | 16 |
| 3.10 Water lifting devices | 17 |
| 3.11 Water consolidation | 17 |
| 3.12 Fishways | 18 |
| 3.13 Summary and recommendations | 18 |
| 3.13.1 Summary | 18 |
| 3.13.2 Recommendations | 19 |
| 4. LAKE AND RESERVOIR FISHERIES | 20 |
| 4.1 Productivity | 20 |
| 4.1.1 Reservoirs and lakes | 20 |
| 4.1.2 Rivers and canals | 20 |
| 4.2 Management | 21 |
| 4.2.1 Principles | 21 |
| 4.2.2 Special methods | 22 |
| 4.2.2.1 Stocking | 22 |
| 4.2.2.2 Fertilization | 23 |
| 4.2.2.3 Bulk or large-scale harvesting | 23 |
| 4.2.2.4 Subdivision | 27 |
| 4.2.2.5 Bottom grading and clearing | 27 |

| | <u>Page</u> |
|---|-------------|
| 4.3 Environmental problems | 27 |
| 4.4 Summary and recommendations | 28 |
| 5. FISH CULTURE SYSTEMS | 29 |
| 5.1 General | 29 |
| 5.2 Aquaculture development | 29 |
| 5.2.1 Ponds | 29 |
| 5.2.2 Lakes, dams and reservoirs | 30 |
| 5.2.3 Paddy fields | 30 |
| 5.2.4 Canals and ditches | 30 |
| 5.3 Fish culture techniques | 30 |
| 5.4 Aquaculture management | 32 |
| 5.4.1 Eradication ("sterilization") of pond pests and nuisances | 32 |
| 5.4.2 Application of fertilizers | 33 |
| 5.4.3 Feeds and feeding of cultivated fish | 33 |
| 5.5 Artificial spawning of fish | 40 |
| 5.5.1 Facilities for spawning | 40 |
| 5.5.1.1 Spawning pools | 40 |
| 5.5.1.2 Incubation and hatching pools | 44 |
| 5.5.2 Methods and procedure of artificial fish spawning | 44 |
| 5.5.2.1 Broodfish rearing | 44 |
| 5.5.2.2 Induced spawning technique | 50 |
| 5.5.2.3 Incubation and hatching | 51 |
| 5.6 Rearing of fry and fingerlings | 51 |
| 5.6.1 Fry rearing | 51 |
| 5.6.2 Rearing of fingerlings | 53 |
| 5.7 Fish diseases | 53 |
| 5.8 Fish-farm design | 53 |
| 5.9 Aquaculture production | 54 |
| 5.10 Aquaculture devices and equipment | 54 |
| 5.10.1 Aerators | 54 |
| 5.10.2 Dredging machine | 56 |
| 5.10.3 Harvesting equipment | 59 |
| 5.11 Other aquaculture activities | 60 |
| 5.11.1 Pearl culture | 60 |
| 5.11.2 Mink production | 62 |
| 5.12 Fish genetics | 62 |
| 5.13 Summary and recommendations | 62 |
| 5.13.1 Summary | 62 |
| 5.13.2 Recommendations | 63 |
| 6. FISH DISTRIBUTION AND MARKETING | 65 |

| | <u>Page</u> |
|--|-------------|
| 7. RESEARCH, EDUCATION AND TRAINING | 66 |
| 7.1 Introduction | 66 |
| 7.2 Research | 66 |
| 7.3 Education and training | 66 |
| 8. SOCIO-ECONOMIC ASPECTS OF THE DEVELOPMENT OF AQUACULTURE | 68 |
| 8.1 Introduction | 68 |
| 8.2 Integration of productive activities | 68 |
| 8.3 The organization of the communes | 68 |
| 8.4 "Take agriculture as the base" | 68 |
| 8.5 Simple but effective promotional campaigns | 68 |
| 8.6 The "three-in-one" combination and "open-door" research and education | 69 |
| 8.7 Production-oriented motivation | 69 |
| 8.8 Other factors | 69 |
| 8.9 Moving fishermen to the land | 69 |
| 8.10 A planned economy | 70 |
| 8.11 Provision of recreational facilities | 70 |
| 8.12 Fish as food | 70 |
| 8.13 Summary | 70 |
| 9. GENERAL OBSERVATIONS AND RECOMMENDATIONS | 71 |
| 9.1 Impressions | 71 |
| 9.2 Conclusions | 71 |
| 9.3 Recommendations | 72 |
| 10. LIST OF REFERENCES | 74 |
| Appendix I - Itinerary and persons met | 75 |
| Appendix II - List of publications brought from China | 82 |

LIST OF FIGURES

| <u>No.</u> | <u>Page</u> |
|--|-------------|
| 1 China, with main administrative subdivisions and their capitals | 3 |
| 2 Causeway on East Lake separating lake into different basins | 22 |
| 3 Poster at East Lake showing successive positions of the blocking nets used to concentrate fish into one arm of the lake for harvest | 24 |
| 4a Lifting the trap portion of a large blocking net used in reservoir harvest (Ho lung Reservoir, Kwangtung Province) | 25 |
| 4b Emptying the trap, Ho lung Reservoir | 26 |
| 5 Pig manure composting tanks with canals to convey the liquid product to the water supply system leading to the fish ponds, Pai-tan Lake, Fish Cultivation Station, Hupei Province | 34 |
| 6 Water supply system fed with pig manure, Pai-tan Lake Fish Cultivation Station | 35 |
| 7 Water control structure along the water supply canal, Pai-tan Lake Fish Cultivation Station | 36 |
| 8 Collection of pond humus and its application to crops grown near the pond, Shia-Kia People's Commune, Kwangtung Province | 37 |
| 9 Mulberry trees planted between ponds, Le Liu People's Commune, Kwangtung Province | 38 |
| 10 Pond slopes planted with grass to serve as food for grass carp, Shia-Kia People's Commune, Kwangtung Province | 39 |
| 11a A circular spawning pool and hatching facility, Pai-tan Lake Fish Cultivation Station, Hupei Province | 41 |
| 11b Design of the circular spawning pool (dimensions in centimetres) | 42 |
| 12 Water inlet installed in a diagonal position on the wall of a spawning tank to circulate water, Pai-tan Lake Fish Cultivation Station | 43 |
| 13 Rectangular collection chamber between a large spawning pool (lower right) and two circular hatching pools, Nan-hai Station, Kwangtung Province | 43 |
| 14 Another type of hatching pool from the Hwa Chung Agriculture Academy, Wuhan | 45 |
| 15a A multiple-chambered hatching pool with paddle wheels for water circulation in locations where there is insufficient water for continuous circulation, Hwa Chung Agriculture Academy | 46 |
| 15b Design of a three-chambered hatching pool (dimensions given in centimetres) | 47 |
| 16a Portable hatching jars installed below a concrete water reservoir, Hwa Chung Agriculture Academy | 48 |
| 16b Design of portable hatching jars as used at Hwa Chung Agriculture Academy | 49 |
| 17 Injection of hormone to induce spawning at Nan-hai Station, Kwangtung Province | 50 |

| <u>No.</u> | <u>Page</u> |
|--|-------------|
| 18 Egg collection net installed in the egg-collection chamber, also used for collecting fry from the hatching pool | 52 |
| 19 Transferring fry from holding nets to plastic bags for transport, Nan-hai Station, Kwangtung Province | 52 |
| 20 A section of the fishpond/farmland layout of the Shia-Kia People's Commune, Kwangtung Province (see also Fig. 10) | 54 |
| 21 Pond layout at Pai-tan Lake Fish Cultivation Station. Structure in foreground is used as a holding area for fry before release and pumping well. An electric water pump used to empty the ponds can be seen in the background | 55 |
| 22 Floating aerator as used at the Jie-fang People's Commune, Shanghai | 56 |
| 23 Operation of the dredging machine, Jie-fang People's Commune. The suction pump at the centre transports the mud formed to the site of dike construction | 57 |
| 24 Settling of mud from the dredging operation to form a pond dike. Pipes at right pump excess water from sand filters embedded in dike | 58 |
| 25 Seining a pond using rubber tire floats to hold net above water, Ho Law People's Commune, Wushi | 59 |
| 26 Fish transport at Le Liu People's Commune: (a) shoulder pole, (b) live fish boat in canal | 60 |
| 27 Pond for culture of the freshwater mussel for pearl production, Chen-tung People's Commune, Shanghai | 60 |
| 28a Freshwater mussel opened for the removal of pearls, Chen Tung Commune | 61 |
| 28b Pearls produced at Chen Tung Commune | 61 |

LIST OF TABLES

| <u>No.</u> | | <u>Page</u> |
|------------|---|-------------|
| 1 | Discharge of the Major Rivers of China | 8 |
| 2 | China - Precipitation and Runoff in Major River Basins | 8 |
| 3 | China - Water Use in Yellow and Yangtse River Basins | 9 |
| 4 | Productivity and Other Characteristics of Various Lakes and Reservoirs in China | 21 |
| 5 | Stocking Density for Multigrade Polyculture | 31 |
| 6 | Various Combinations of Species used in Polyculture in China | 32 |
| 7 | Stocking Combination for Broodstock Rearing in Kwangtung Province | 44 |
| 8 | Production in Intensive Culture | 55 |

CHINESE UNITS OF MEASURE

| | | | | |
|--------------|---|-------------------------------|----------------------------|-------------------------------|
| 1 <u>mu</u> | = | 0.066 ha ($\frac{1}{15}$ ha) | = | 0.165 acres |
| 1 <u>jin</u> | = | 1 catty | = | $\frac{1}{2}$ kg = 1.1 pounds |
| 1 <u>dan</u> | = | 50 kg | = | 110 pounds |
| 1 <u>li</u> | = | 0.576 km | - approx. $\frac{1}{2}$ km | = $\frac{1}{3}$ mile |
| 1 Yuan | = | U.S.\$ 0.50 | | |

ACKNOWLEDGEMENTS

The members of the Mission wish to express their appreciation, both to the Government of the People's Republic of China and the Food and Agriculture Organization of the United Nations, for the opportunity to visit China.

In a special way, the Mission also wishes to record its gratitude to officials of both China and FAO who arranged this trip, namely: Messrs. Li Yung Kai and Chang Shih-jang of the Foreign Relations Bureau, Ministry of Agriculture in Peking and Mr. Edouard Sacuma, FAO Director-General and Mr. Dioscoro L. Umali, Assistant Director-General and Regional Representative for Asia and the Far East. The Mission also appreciates the kind assistance given by the Chinese Embassy both in Rome and Bangkok.

In the organization and conduct of this Mission, hundreds of people in many places helped. It is impossible, in this brief note, to list all of them but many are listed in Appendix I, where the names of the persons to whom we were introduced are given. This does not diminish in any way the debt of gratitude that the Mission members owe them.

Members extend too their thanks for the patient interpretation done by Ms. Chu Tsung-hsian and Ms. Kung Chien-ying of the Ministry of Agriculture, Peking, and by Mr. Tsai Fu-chun of the Fisheries Bureau of Kwangtung Province. They are also grateful to Mr. Juan L. Mercado of the FAO Regional Office in Bangkok who helped prepare this report.

1. INTRODUCTION

The FAO Fisheries (Aquaculture) Mission is the second FAO Professional Study Group to visit China.

The first Mission concentrated on agricultural productivity and study of the people's communes. It travelled through China between 8 September and 7 October 1975.

These two study missions constitute part of a "package" of three mutually agreed upon by the Chinese Government and FAO in 1975^{1/}. The original invitation that made these missions possible was extended by the Ministry of Agriculture, through the FAO Regional Office for Asia and the Far East, at the 12th FAO Regional Conference in Tokyo in 1974.

Late April and May is the season for artificial fish propagation in China. The Ministry therefore suggested that the Aquaculture Mission be in China between 21 April and 12 May 1976. This was agreed.

The Mission assembled in Bangkok on 19 April. The members were: Mr. D.D. Tapiador (Team Leader), Dr. H.F. Henderson (Lake and Reservoir Fisheries), Mrs. M.N. Delmendo (Aquaculture) and Mr. H. Tsutsui (Land and Water Management). They entered China on 21 April.

The Mission's itinerary and a list of persons met while in China are given in Appendix I.

The Mission visited the provinces of Kwangtung, Hupei and Kiangsu as well as the municipalities of Peking and Shanghai. Notes were taken on the specific places, stations and communes visited, and on the briefings received by the Mission.

The report which follows is based mainly on these notes, supplemented where indicated by information drawn from available references.

^{1/} The third Study Mission was concerned with forestry practices and visited China 9 September to 10 October 1976.

2. BACKGROUND INFORMATION

2.1 Geography^{1/}

The People's Republic of China is vast. Its territory sprawls over 9.6 million km². The distance from borders in the east to those in the west measures 5 000 km and from north to south it spans over 5 500 km.

China's present population is about 800 million^{2/}.

Administratively, China consists of three municipalities (Peking, Shanghai and Tientsin) directly under the central authority, 22 provinces and five autonomous regions. Figure 1 shows the main administrative subdivisions and their capitals.

China's topography varies widely. Cloud-capped peaks give way to basins of different slopes and sizes. Wide, rolling plateaus alternate with low, broad plains. There are great deserts and wilds in the northwest. Rivers, streams and lakes slice the plains on the middle and lower reaches of the Yangtse River. The Mission, while travelling almost 4 500 km within China, saw only part of this diversity.

Some areas are warm the year round; others have long winters and short summers. Most of the land lies in the temperate zone. A combination of high temperatures and adequate rainfall provides favourable farming conditions, especially in the east and south.

China has rich water resources. From the Changpai Mountains in the northeast to the Hengtuan Mountains in the southeast, huge potentials for generating hydraulic power and building water conservancy projects exist.

The three major plains - the Northwest, the North China and the lower Yangtse Plain - have a total area of about a million square kilometres. They make up roughly one tenth of China's territory. These plains are the most densely populated part and the region where most cities are located.

Today, about 107 million ha (1 600 million mu) are under crops. These are concentrated mostly in the plains which, with thick top soil and suitable climate, constitute the key farming areas. The Yangtse Plain is also a key fishery area with large lakes and a terrain favourable to fish culture.

2.2 Recent history and social organization^{3/}

To understand China's recent progress in agricultural and aquacultural production, it is necessary to keep in mind a little of her history.

China's cultural and technological histories are very long. Nevertheless development and modernization were slow in coming. The general large-scale expansion of agriculture and industry, which is now occurring, is relatively recent.

This expansion began with the end of the Revolution and formation of the Socialist People's Republic in 1949. The new government, under Chairman Mao Tse-tung's leadership, instituted a programme of land reform, distributing the holdings of the landlords to peasants. Mutual-aid teams were formed to enable pooling of resources to fight recurrent floods and drought. The central government emphasized control of the major rivers along with general reconstruction.

1/ This information is summarized from Anon., China, a geographical sketch, 1974.

2/ Estimate given by Huang Shu-Tse, leader of the Chinese delegation to the UN World Population Conference in Bucharest, 1974.

3/ Most of this material is taken from the briefing given to the Mission by Mr. Liu, Ho Law People's Commune, the Report of the First Professional Study Tour, and Solecki (1966).

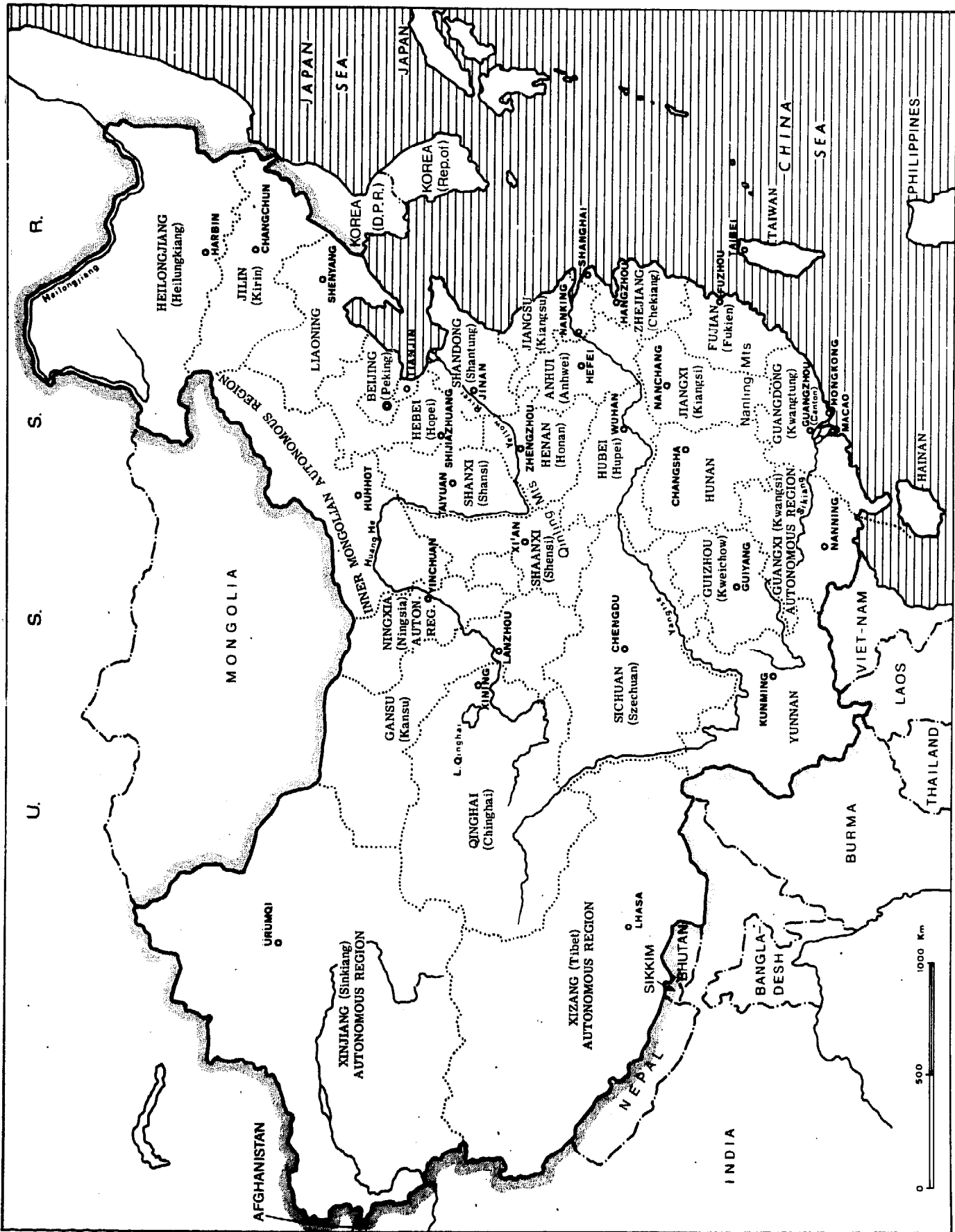


Fig. 1 China, with main administrative subdivisions and their capitals

Success of these mutual-aid teams led to the formation of the so-called primary cooperatives in 1955. In these units, regular as well as emergency work was shared. Income was distributed according to the individual's share in the cooperative (land and other means of production).

By 1956, primary cooperatives were changed to advanced cooperatives. All land and machinery holdings were transferred to the cooperative with work assigned according to ability and income. This period coincided with the first Five-Year Plan (1954-68). It stressed development of irrigation. Most of today's reservoirs were constructed then. The cooperatives usually had only a single economy.

In coincidence with the Great Leap Forward (1958), cooperatives were welded together to form communes with diverse economies and strengthened financial resources.

It may be debated whether the Great Leap Forward did succeed in its immediate aims. But it is clear that the initiation of the commune system marked the beginning of comprehensive, simultaneous development of all sectors of production. With this came a shift in emphasis toward an agricultural economic base.

In 1957, the Yangtse was bridged for road and rail traffic. The first successful artificial spawnings of pond-reared Chinese carps were also made, in Kwangtung, in 1958 - a significant turning point in the expansion of fish culture and production.

By 1961, the main outlines of the new China had taken shape. Considerable progress in agriculture and industry produced improvements in income but along with these came problems of elitism in the professions and Communist Party cadres. This eventually became the stimulus for the Cultural Revolution.

"The Great Proletarian Cultural Revolution" (1966-69) brought important changes in organization. Measures to provide more emphasis on social motivation or "political consciousness" were undertaken. They also gave more participation in decision-making to the worker-farmer, especially within communes and in traditionally professional activities such as medicine, teaching, research and the military. The stress on practical experience and on "learning from the masses" brought a markedly practical orientation to all education and research, including that on fish management and culture.

Evolution of China's socialist society is still continuing.

Today, land is owned by the commune, a merger of social, political and economic administration and a kind of township. It generally covers an area of 1 000 to 10 000 ha.

Hand tools, small tractors, boats, etc. are usually owned by the unit that financed their purchase, generally the production team. The team, at present, is the basic accounting unit. On the average, a team takes in about 100 workers.

Tractors, trucks, larger boats and heavy equipment are generally held by production brigades. These are a more diversified grouping of 10 or so teams.

Much of the housing is individually owned and inheritable. Personal acquisitions such as bicycles and radios are also owned personally. Gradually, however, basic accounting is being passed from the production teams to higher levels. An upward movement of ownership of the means of production is also occurring. In a number of communes the ownership of individual houses has already been transferred to the commune.

2.3 Status of freshwater fisheries and aquaculture

China also has a very long history of freshwater fisheries and aquaculture. A Chinese named Fan Li started breeding and raising fish (common carp) in Wushi, Kiangsu Province, eastern China, more than 2 400 years ago. In the year 473 B.C. Fan Li wrote a book, "Fish Breeding", which is the first known document on fish culture.

Today China has about 20 million ha (300 million mu) of freshwater areas. One third, or about 6.7 million ha (100 million mu), can be used for fish culture. Of this area, about 60 percent is fish ponds (lowland and upland), irrigation ponds and village ponds, while 40 percent is lakes and reservoirs.

The major freshwater fish-producing areas are located in the Heilung drainage system and the lowland reaches of the Yellow-Yangtse and Pearl Rivers. The Yangtse, with its many large and small lakes, is the most important, and includes the provinces with the highest production, Kiangsu and Hupei (Solecki, 1966). Owing to the many canals and lakes the Yangtse Delta is known as the "water net area" of China. Its focus is the city of Wushi, China's Venice.

The next most important production area is in the Pearl River Basin. Like the eastern Yangtse Basin, the lowland areas of the Pearl have long been traditional fish culture regions owing to plentiful water and extensive natural spawning areas for the Chinese "family fish" or major carps.

While four cyprinid species dominate the freshwater fish production, there are over 500 species occurring in the fresh waters of China of which at least 200 are suitable for table use. The species to which reference will most often be made in this report are as follows:

Four majors (family fish, or Chinese carps):

| | |
|--------------|------------------------------------|
| Grass carp | <u>Ctenopharyngodon idella</u> |
| Black carp | <u>Mylopharyngodon piceus</u> |
| Silver carp | <u>Hypophthalmichthys molitrix</u> |
| Bighead carp | <u>Aristichthys nobilis</u> |

Other species commonly used in mixed culture with the above:

| | |
|-------------|---------------------------------|
| Mud carp | <u>Cirrhinus molitorella</u> |
| Common carp | <u>Cyprinus carpio</u> |
| Golden carp | <u>Carassius auratus</u> |
| Wuchan fish | <u>Megalobrama amblycephala</u> |
| Tilapia | <u>Tilapia mossambica</u> |

Favoured predatory species include:

| | |
|---------------|----------------------------|
| Mandarin fish | <u>Siniperca chautsi</u> |
| Snakehead | <u>Ophiocephalus argus</u> |

Freshwater fish culture in China can be divided into two kinds: (i) pond culture, and (ii) lake and reservoir culture. In lakes and reservoirs, culture primarily consists of stocking fish raised in nearby ponds, while in pond culture the fish are also provided with supplementary food both directly, and indirectly through fertilization of the water.

Pond culture is carried out by two types of communes: (i) fishery communes, and (ii) agricultural communes with fishery as sideline occupation. Fishery communes usually adopt "all-round production", i.e., integration through use of fish, pigs and vegetables in the production process. Agricultural communes, with fish culture as a sideline occupation, adopt a comprehensive development of grain, fish, livestock and other crops.

There are three forms of lake and reservoir fishery management: (i) state-owned, (ii) brigade or commune, and (iii) brigade and commune together. Usually, however, reservoirs are under commune management. In the biggest reservoirs, the State does the fish stocking while production brigades organize the commune members to catch fish.

At all levels - from national down to the provincial, county and commune - Chinese agricultural policy is repeatedly presented in the form of Chairman Mao's sayings. Every citizen is aware of these sayings and the policies.

The major ones include:

- (i) "Take agriculture as the foundation and industry as the leading factor"
- (ii) "Water conservancy or irrigation is the lifeblood of agriculture"
- (iii) "In water conservancy, take the direction of undertaking small-size projects"
- (iv) "Take grain as the key link and ensure all-round development of agriculture, industry, animal husbandry, forestry, sideline occupations and fisheries"

The Mission found that freshwater fishery, especially pond culture, has always been taken as an integral part of the farming system. Grain and fish promote each other and they have developed together.

In freshwater fisheries, stress is laid on fish culture and the simultaneous development of culture and catching.

Fish fry and fingerling production form the base for fish culture. In the people's communes, fish fry and fingerling stations have been set up and run by the communes themselves.

3. LAND AND WATER MANAGEMENT

3.1 Introduction

This section highlights some findings of the Mission regarding land and water management as it relates to aquaculture.

All over China Chairman Mao's statements, "Irrigation is the lifeblood of agriculture" and "Take grain as the key link and ensure all-round development of agriculture, industry, animal husbandry, forestry, sideline occupations and fisheries", are frequently quoted.

It was the Mission's impression that these are not mere slogans as, in fact, the Chinese make great efforts to ensure the availability of controlled and timely water supply for agriculture and fisheries.

Mission members found that in the rural areas, crop production, animal husbandry and fish culture are effectively integrated. The basis for such close linkage is assured water supply as a result of water development projects and rural electrification.

The Mission also noted that water conservancy projects - completed or still under construction, such as storage reservoirs, embankments, irrigation and drainage canals or ditches - take fully into account the use of water bodies for aquaculture. Clearly, aquaculture is an integral part of agriculture.

Perhaps the most striking feature is the fact that such integration is practised at the farm level by farmers who are the beneficiaries of water projects.

In China, land and water are used with high intensity to ensure all-round development of rural life through increased agricultural production that includes fisheries. This is by far one of the most significant findings of the Mission.

The Mission found that China's technology is not unique or new. Most of its approaches have been or are being used outside China. It was clear to the Mission, however, that China is one of the few countries putting these relatively simple techniques into practice on a massive scale at the farm level.

There are, at the moment, a number of countries engaged in land and water resources development for crop production and fish culture. Chinese experience indicates the extent to which aquaculture can form an integral component of agriculture. Thus, the close relation between crop production and fish culture, which both require controlled and timely water supply, should be kept in mind when planning, designing and implementing land and water development schemes.

3.2 Water and its uses

Water is an essential input for agriculture and fisheries. A nation's water resources depend, basically, upon climatic and rainfall conditions and then on watershed conditions. Estimates of the annual water flow for China's major rivers are presented in Table 1 and of precipitation and runoff in Table 2.

These tables indicate that the average runoff from the major rivers in the north is markedly less than in the south. Given its more abundant water resources, the south is able to carry rice cultivation and fish culture at more intensive levels.

The estimated water use pattern in the Yellow and Yangtse Rivers is shown in Table 3.

Table 1

Discharge of the Major Rivers of China
(From: van der Leeden, 1975)

| River | (A) Annual flow (m ³ per year) | (B) Drainage area (km ²) | (m ³ /km ² ^{A/B} per year) |
|---------|--|---|---|
| Hai | 15 x 10 ⁹ | 0.26 x 10 ⁶ | 58 x 10 ³ |
| Yellow | 48 x 10 ⁹ | 0.75 x 10 ⁶ | 64 x 10 ³ |
| Hwai | 42 x 10 ⁹ | 0.26 x 10 ⁶ | 162 x 10 ³ |
| Yangtse | 1 020 x 10 ⁹ | 1.8 x 10 ⁶ | 567 x 10 ³ |
| Pearl | 356 x 10 ⁹ | 0.42 x 10 ⁶ | 848 x 10 ³ |
| | <u>1 551 x 10⁹</u> | <u>3.4 x 10⁶</u> | <u>456 x 10³</u> |

Table 2

China - Precipitation and Runoff in Major River Basins
(From: van der Leeden, 1975)

| River system | Basin area km ² | Mean annual precipitation mm | Mean annual runoff mm | Mean annual evaporation mm | Runoff coefficient % |
|-------------------------|-------------------------------|---------------------------------|--------------------------|-------------------------------|-------------------------|
| Sungari | 523 580 | 512 | 141 | 371 | 27.6 |
| Liao | 219 000 | 465 | 74 | 301 | 15.9 |
| Yellow (Hwang Ho) | 745 100 | 415 | 65 | 350 | 15.7 |
| Upper Yellow (Lanchow) | 216 190 | 427 | 148 | 279 | 35.0 |
| Fen (Hochin) | 38 650 | 471 | 50 | 321 | 11.0 |
| Lo (Chuangt'oul) | 62 700 | 436 | 28 | 408 | 6.5 |
| Ching (Chiangchia Shan) | 41 800 | 462 | 47 | 416 | 10.1 |
| Wei (Hu Hsien) | 63 550 | 573 | 142 | 431 | 25.0 |
| Hwai | 164 560 | 840 | 198 | 642 | 23.6 |
| Yangtse | 1 808 500 | 1 050 | 568 | 482 | 54.1 |
| Chinsha | 502 050 | 662 | 329 | 333 | 50.0 |
| Min | 133 570 | 1 100 | 722 | 378 | 65.6 |
| Chialing | 159 810 | 892 | 408 | 484 | 46.0 |
| Wu | 88 220 | 1 135 | 586 | 549 | 52.0 |
| Tungting | 261 130 | 1 445 | 852 | 593 | 59.0 |
| Han | 174 350 | 900 | 356 | 544 | 40.0 |
| Poyang | 158 680 | 1 670 | 971 | 699 | 58.2 |
| Ch'ient'ang | 49 930 | 1 650 | 940 | 710 | 57.0 |
| Min | 60 800 | 1 710 | 1 074 | 636 | 62.8 |
| Han | 29 700 | 1 655 | 982 | 673 | 59.0 |
| Pearl (Si Kiang) | 437 230 | 1 480 | 890 | 590 | 60.2 |
| Tung | 26 300 | 1 758 | 1 203 | 555 | 68.4 |
| Pel | 45 600 | 1 885 | 1 370 | 515 | 73.0 |
| Si (Wuchow) | 328 000 | 1 370 | 770 | 603 | 56.0 |
| Upper Si (Nanning) | 74 310 | 1 340 | 646 | 694 | 48.0 |
| Total Nation | 9 597 000 | 650 | 280 | 370 | 43.1 |

Table 3

China - Water Use in Yellow and Yangtse River Basins
(Source: Tojin Sha, 1964)

(Unit: 100 million m³)

| Water use | Yellow River | Yangtse River | Total |
|------------------------------|--------------|---------------|-------|
| Non-productive ^{1/} | 22.4 | 15.0 | 37.4 |
| Industrial and urban | 12.8 | | 12.8 |
| Navigation | 13.9 | 7.0 | 20.9 |
| Irrigation | 233.0 | 238.0 | 471.0 |
| Fishing | 11.8 | | 11.8 |
| Total | 293.9 | 260 | 553.9 |

1/ Non-productive water uses include:

- (a) 740 million m³ of Tung-ping Lake water losses
- (b) 1 000 million m³ of water losses from the Yellow River
- (c) 500 million m³ of water losses from irrigation in all the provinces
- (d) 1 500 million m³ of water losses from diverting the courses of the Han, Chi and Yellow Rivers.

According to this table water used for fisheries constitutes about 5 percent of irrigation water. In view of the fact that fish do not consume water, fish culture in irrigation ponds and canals is also encouraged and may point the way for others interested in the better use of water resources.

3.3 Land and water development strategy

3.3.1 Major schemes

The Mission was informed that China gives top priority to water conservancy in its various development programmes. Massive investment in both funds and labour has been directed to this end.

Chinese officials say there is much to do in this field. In the case of Hupei Province, only 30 percent of the total water programmes have been completed. Yet there is no doubt as to the tangible benefits this policy has gained. For example, there have been no serious floods on the Yellow or other major rivers during the past ten years.

It was stressed by Chinese officials that the stabilization of river flow and lake water and the formation of new water bodies have created an environment that favours agriculture production, particularly fish culture. Farmers can now direct their efforts to crop production and fish culture without fear of floods and drought.

The hydropower generated has increased power supplies in rural sectors. The Mission was impressed by the fact that this had spurred mechanized operation of farming and fish culture, particularly water pumping, with the widespread use of electric pumps.

The Mission was informed that the basic bench marks on government policy and action in water control and development may be broken down as follows:

- 1950-55 Elimination of major flood damage through rehabilitation and construction of dikes and increase in the flow capacity of rivers by river draining work.
- 1955-60 Storage of water, extension of irrigated areas, particularly in the north.
- 1960-65 Increasing irrigation efficiency and productivity of irrigated areas by installing water regulating structures in completed projects. Improving irrigation system management, paying particular attention to the combined development of irrigation and drainage, and hydropower generation.
- 1965- Continued and increased emphasis on comprehensive development covering flood control, irrigation, drainage, hydropower and navigation; intensification of land and water use, including on-farm watering systems and land consolidation.

As a result of these policies China completed an estimated 130 000 km of dikes and an irrigation network covering 28 000 000 ha of land between 1950 and 1973. The total irrigated area is estimated now at 44 000 000 ha.

3.3.2 Hupei Province (as an example)

Through discussions with Hupei Provincial Government officials the Mission noted that:

- 1949-53 Emphasis was placed on flood control through the reconstruction of river dikes, particularly on those of the Yangtse and Hai Rivers. In total, about 7 000 km of dikes, including 1 200 km along the Yangtse and 900 km along the Hai, were reconstructed.
- 1954-58 Irrigation development was a major objective and included the construction of reservoirs and irrigation canal systems; 5 000-6 000 dams were constructed covering about 30 percent of the total provincial catchment area.
- After 1959 Multipurpose water development, including flood control, irrigation, navigation, hydropower generation and fisheries, has taken place.

Overall achievement: The reconstructed and newly constructed river dikes cover about 8 000 km. More than 7 000 dams, including 32 big ones, have been constructed. As a result, flood damage has been greatly reduced while the production of hydroelectric power has been substantially increased. Irrigation development covering an area of about 700 000 ha contributes to yield increases; compared with yield levels in 1949 the present grain yield is 2.7 times higher and the cotton yield is eight times higher.

Development criteria:

Flood control aims at preventing flood damage which might occur at the frequency of once in a hundred years while drainage pumps are designed to cope with a maximum rainfall expected once in ten years or once in 20 years. As far as the spillway of dams is concerned, it is often the case to design for a thousand-year rainfall.

Irrigation works:

Gravity irrigation is predominant in hilly areas and pump water supply is extensively carried out in the plains. Small reservoirs coupled with ponds are major sources of water supply in mountain areas. At present irrigation systems are designed to cope with drought which might occur for a period of 50 to 100 days.

Fisheries: The promotion of fisheries is always considered in reservoirs and intensive fish culture is always encouraged in small ponds. Fish culture receives due attention in drainage canals but not in irrigation canals. Details are discussed in the following sections.

3.3.3 Integration of major, small-scale and on-farm schemes

The Mission noted that the major water control programmes discussed in the previous chapter play a key role in stabilizing and increasing crop and fish production, and appreciated the part being carried out by small-scale water conservancy projects implemented by the people's communes, production brigades and teams. During its stay in the country, the Mission observed numerous small water conservancy projects, such as small reservoirs, ponds, pumping stations and canals. It was indeed impressive to see a series of small reservoirs and ponds linked together by irrigation networks in the hilly areas of Honan Province. From the sky they looked like a string of pumpkins hanging from a long vine.

It was noted that China's policy on water conservancy is to execute major, minor and on-farm works simultaneously to ensure integrated benefits from the various projects. The State concentrates its investment on key projects, while encouraging the people's communes and their subdivisions to put up small and on-farm projects, mobilizing the people, so that the water made available from major projects is immediately utilized for crop and fish production.

In the deltaic area of the Yangtse and Pearl Rivers, the Mission observed that a number of small pumping stations, including portable ones, are constructed by the communes. Linked with state-run, large pumping stations and hydraulic structures, they form extensive irrigation and drainage systems contributing to rice and fish production.

It is too often the case in other countries that major irrigation systems are kept idle for years after their completion, simply because of the lack of on-farm water distribution systems and of integrated operation of irrigation systems as a whole.

The Mission was extremely impressed by the integration of key projects with small-scale (on-farm) watering systems built and operated by farmers. The Mission believes that this is an area for further study and that FAO member countries would benefit by learning this method from China and putting it into practice in their own countries.

3.4 Reservoirs and ponds

Like countries all over the world, China builds its dams, reservoirs and ponds primarily to regulate runoff or river flow and to store water for agricultural, industrial and urban water use. But the water surface thus created is used by China for fish culture at a high level of intensity.

The Mission had the opportunity to observe various types of dams at the Agricultural Exhibition in Shanghai. From the engineering viewpoint, the design and construction methods adopted in China seem to be similar to those practised elsewhere. A great number of dams, particularly small-scale ones and ponds, are of the fill-type and are constructed mobilizing local labour.

From the fisheries viewpoint, the bottom grading and clearing is noteworthy. The Mission noted that in most reservoirs built before 1958, when speedy construction was needed for flood control and water storage, the bottoms were rarely cleared before water storage began. For the sake of smooth fish harvesting, however, the bottoms of small reservoirs recently constructed are not only cleared but stumps are removed. In some reservoirs, the bottoms are even graded. The subject is discussed further in the following chapter.

Over 280 large-scale reservoirs (storage more than 10^8 m³), 1 800 medium-scale reservoirs (storage 10^7 - 10^8 m³), and countless small-scale reservoirs (storage 10^5 - 10^7 m³) and ponds (storage less than 10^5 m³) were built in China. Of these more than 250 large, 1 300 medium and 11 000 small reservoirs (formed by dams higher than 15 m) were constructed after the Liberation.

From the fisheries viewpoint, the smaller the water area and the shallower the depth the higher the productivity is per unit area. Since medium and large-scale reservoirs are often constructed in remote places, small reservoirs and ponds provide better opportunities for fish culture. In particular, farm ponds closely located to villages and cultivated land are most suited to fish culture.

Chinese farmers seem to be well acquainted with the principles of gravity irrigation, and they have accumulated considerable experience in the construction and use of small ponds.

The Mission observed with interest the integrated management of the series of reservoirs and ponds interlinked by connecting canals. For example, water released from big reservoirs is directed to small reservoirs and ponds to ensure the water storage necessary for irrigation and fish culture. The Mission was informed that when water bodies are used for fish culture, a minimum water depth is maintained, say 3 m in summer and 1.8 m in winter.

In addition to reservoirs and ponds for water storage purposes, the special function of check dams merits attention.

One of the popular methods for preventing or minimizing soil erosion in hilly areas is to build a check dam. This is partly to store water. But the main purpose is to reclaim new farm land in river beds by precipitating and settling nutrient-rich silt behind the dams. Check dams are planned and constructed subsequently in a single small drainage basin. In general, 8-14 small fill dams (say 6-10 m high) per km² are installed. Small reservoirs or ponds are thereafter created. They can be used for fish culture as they are located very close to farm land reclaimed and easily accessible to farmers.

3.5 Natural lakes

The vast Chinese landscape is dotted with lakes, not only in the warm, humid eastern plains but also in the cold high regions in the west. Some 130 lakes have more than 100 km² of water area. These are mainly located in the middle and lower reaches of the Yangtse River.

Lakes in the southeastern part of the country are mostly fresh water. They are connected to major river systems. They play a very important role in promoting irrigation, navigation and fisheries.

The Mission was informed that lake waters were not regulated in the past. Unsystematic utilization of lakes and watershed areas often resulted in devastating flood and drought damage.

Regulation and control of these lakes became a major concern after 1949. The Government laid down lake water regulations and launched control work that aimed at:

- (a) stabilizing lake water level for promoting agriculture, fisheries, navigation and recreation; and

- (b) improving the regulating function of lakes against heavy rainfall in watershed areas as an integral part of comprehensive watershed management.

For this purpose a number of hydraulic structures, including pumps, are installed along the lakes and in the watershed area. Examples of such water-control works can be seen at Taihu Lake in southern Kiangsu Province, which the Mission visited on 7 May 1976. It has an area of 2 250 km² with a shore line of 393 km.

Taihu Lake was originally part of a shallow sea. Encroachment by sand bars in the Yangtse and along the coast enclosed it to form the present-day lake, with water flowing into the Yangtse through 42 outlets.

In the past, control of the water courses in the Taihu Lake region received some attention as they were utilized for transport. But from the Opium War of 1840 to 1949 conditions deteriorated, as the lake water area was reduced to a wide expanse of paddy fields through the construction of dikes. This sharply reduced the water storage capacity of the lake.

Furthermore, poor management of rivers and streams connecting the lake to the Yangtse River cut their drainage capacities, due mainly to siltation. As a result, the area along the lake often suffered flood damage.

After 1949, 18 reservoirs were constructed. Hydraulic structures were installed in about 300 small lakes in the watershed area to regulate the runoff to Taihu Lake.

Parallel to watershed management works, outlets to the Yangtse River were improved through the dredging of the river bottom, embankment, installation of sluice gates and drainage pumps. Numerous pumping stations were constructed for water supply to farm land and fish ponds.

The Mission was informed that this comprehensive approach toward the lake regulation has resulted in stabilized water levels (± 1 m). Together with an integrated management of lakes, reservoirs, canals and water structures this ensures rational utilization of land and water resources in the region for agriculture, fisheries, navigation and recreation.

The Mission was not in a position to obtain information and data on the water management systems of the lake and its watershed area. It seems that the integrated and systematic operation of the numerous hydraulic facilities installed is quite a complicated one. However, a detailed study on the subject merits attention.

3.6 Canals and creeks

The Mission understood that in the low-lying plain where the slope of irrigation canals is quite flat, flow velocity is comparatively low - say 0.1-0.3 m/sec - and fish culture is practised without artificial feeding.

In these low-lying areas rice is the major irrigated crop and canals and creeks usually function for both irrigation and drainage purposes. They are often also used for navigation. Water usually exists throughout the year providing good conditions for fish culture. Since such canals receive residuals from nearby farmlands and townships, water is usually fertile containing a considerable amount of plankton. A regular supply of fry and fingerlings is obtained through intensive fish culture to stock these waters.

Canals are often connected to main rivers or lakes with gate facilities that sometimes have pumps. The mechanism and operation of these water facilities firstly aim at controlling the water table in the canals and creeks to provide adequate water regime for irrigation and drainage. Due consideration is, however, given to fish culture as well as to navigation. Within the water course irrigation is mostly carried out with pumps which have no serious effect on fish culture provided that fish barriers are installed around the pump suction. The Mission was informed that fish barriers in canals and creeks, however, often cause navigation problems so that quickly movable barriers or barriers with a boat passage are being used.

On the other hand, the Mission was told that irrigation supply channels on the farms are generally not used for fish culture. The members of the Mission consider that this is understandable as the water discharge fluctuates from time to time in accordance with the change in water requirement. Such channels are often dried out for maintenance work. Furthermore, they are usually designed to minimize their cross-sectional areas with the velocity as high as possible for economy. As a result, it is often the case that:

- velocity is so high that fish cannot cope with it;
- installation of the structure for fish stocking prevents smooth flowing of water;
- artificial feeding is neither practicable nor possible.

In order to keep the hydraulic capacity of canals and creeks at the desired level, regular maintenance work is carried out, which includes the excavation of the bottom and weed cutting. The Mission observed that often the weed cut and the mud excavated are returned to the cultivated land as organic fertilizer. The effectiveness of grass-eating fish (e.g., grass carp) to clean water weeds in canals and creeks was mentioned but no technical details of this practice in China were available to the Mission. In view of the interest shown by some member countries of FAO in the subject, it merits further study.

3.7 On-farm water supply system

In areas where fish ponds and cultivated land coexist, on-farm irrigation systems are often used for supplying water to fish ponds. This is particularly noticeable in low-lying areas where water supply depends mostly on pumps. Water is lifted and led to the ditches which are connected to both farmland and fish ponds. It is the usual practice for paddy fields to be irrigated continuously while water is supplied to fish ponds when the water level falls below a certain limit (say 50 cm from the full water level). A concentrated water supply is needed when refilling the ponds after drainage, which is usually carried out in the winter when repairing ponds. While no detailed information was given to the Mission, it is assumed that the water supply is well scheduled so as to minimize power requirements.

Concrete or masonry lining is the most popular but precast concrete flume is also sometimes used. In areas where the land is valuable an underground pipeline system is used. The pipeline is buried under the farm road so as not to occupy the cultivated land. An example of this was observed by the Mission in the Chen-tung People's Commune near Shanghai. The Mission members felt that such a pipeline system contributes to increasing irrigation efficiency through the reduction of percolation loss during water distribution. It is felt, however, that the introduction of heavy machinery for mechanized farming may necessitate the use of stronger pipes and may require more earth covering of the pipes buried.

3.8 Fish ponds

The Mission observed a number of fish ponds constructed and managed by communes and governmental agencies. Physical conditions vary according to location and details on their management for fish culture are discussed under section 5.4.

Design criteria given below are extracted from "Fresh Water Fish Culture", prepared by the Chanquan Aquaculture Research Institute and published in Chinese by Nongguo Publishing Company in 1974.

Water source

The availability of abundant and assured water of good quality at low cost is a basic need for planning and designing fish ponds. It is desirable, therefore, to construct ponds along rivers, lakes or canals with guaranteed water supply.

While efforts will be made to obtain water intake and drainage by gravity, the provision of water-lifting devices is necessary to cope with the fluctuation of outer water levels.

Water surface

A large water surface area is desirable. The larger the water surface the greater the effect of wind, which increases dissolved oxygen and promotes the mixing of upper and lower water layers; 0.7 ha (10 mu) is commonly used.

Water depth

Chinese experience shows that the most desirable depth of ponds is 2-3 m. It has been found that below 3-4 m there is not enough photosynthetic activity to keep the deeper water oxygenated, and the water temperature is low and contains less plankton.

Other conditions

As far as possible, high and dense forests and buildings should be avoided around ponds so as not to intercept solar radiation and wind.

It is desirable that the length of ponds should be east-west line in order to benefit from longer sunshine hours.

Dimensions and shape

A rectangular shape with 2:1 or 3:2 ratio is recommended.

The embankment crest width should be decided taking into account its usage but 1.5-2.0 m is usually adopted (for the passage of vehicles a much wider crest, say 2.5-3.5 m, is needed).

The embankment slope should be decided taking into account the soil stability but a ratio of 1:1.5 is usually adopted.

The pond bottom is practically horizontal. In cases where the water inlet and outlet are situated in different places, a 1/200-1/300 slope from the inlet side to the outlet side may be needed.

Soil

As far as possible, permeable soils are avoided. If, however, ponds are constructed on permeable soil, infiltration control should be practised, e.g., soil compaction, lining with clay soil, lime, plastic film and asphalt.

Location

It is economical and convenient to install ponds in waterlogged areas or marginal land. Full consideration should be given to the effect of floods and to the convenience of transportation.

Ratio of various ponds

An example of the design of Tungshan fish breeding farm, Kiangsu Province, is given below:

| <u>Pond use</u> | <u>Area (mu)</u> | <u>Water depth (m)</u> | <u>Water area ratio</u> |
|-----------------|------------------|------------------------|-------------------------|
| Water storage | 3-5 | 3-4 | |
| Adult fish | 4-10 | 3-4 | 7 |
| Fingerlings | 3-5 | 2-3.5 | 2 |
| Fry | 1-3 | 1.5-2 | 1 |

3.9 Paddy fields

The Mission was informed that the extent of fish culture in paddy fields is not as significant as in lakes or fish ponds; some farmers raise fish in paddy fields during the rice-growing period and during the off-season. The Mission could not obtain information on the subject through discussions. The information given here is extracted from literature cited in section 3.8.

Chinese experience of fish culture in paddy fields has demonstrated that:

- fish eat insects that threaten the rice plant, such as the leaf hopper and weed buds;
- fish movements stir the mud and promote nutrient uptake by the rice plant;
- fish excrement nourishes both the water and rice plant.

3.9.1 Modification of paddy fields for fish

Paddy fields should have high and stable ridges. They should be 35-45 cm higher than the normal ones with a width of about 30 cm. The ridges should be well compacted to prevent the escape of fish and water leakage.

It is also often the practice to dig a part of the paddy field to maintain proper water depth for fish retention. Such fish ditches should have a water depth of 60-90 cm. The ditch area varies between 1-2 percent of the paddy area.

Paddy fields used for fish culture are those with assured irrigation water supply and effective drainage. Inlets and outlets are guarded with screens or nets to prevent fish escape.

3.9.2 Fish culture with rice cultivation

Fingerlings are put into paddy fields about a week after rice transplantation, and are kept there until after the harvest. Stocking density varies from 3 000-9 000 fish/ha (200-600/mu) depending on the fertility of paddy soils. Without feeding, fingerlings of 9-12 cm (carps and tilapia) at a density of 3 000-4 500 fish/ha (200-300/mu) are often put into the field.

There are cases, however, where fish are fed intensively. In Kwangtung Province, for example, a brigade cultivates 2.7 ha (40 mu) of paddy field for rice and fish. It harvests about 4 000 kg/ha (530 jin/mu) from the first crop of rice, 5 250 kg/ha (700 jin/mu) of rice from the second crop and 937.5 kg/ha (125 jin/mu) of fish as well.

The brigade also uses 0.4 ha (6 mu) of paddy field for intensive fish culture with a daily addition of 175 kg (350 jin) of pig/cow manure as fertilizer and 200 kg (400 jin) of green grass as feed. The harvest of rice and fish appears to have been excellent.

3.9.3 Water and farm inputs management

In the case of rice-cum-fish culture, it is mentioned that very careful management is required to watch watering, to avoid fish escape, and to prevent intrusion of ducks and carnivorous fish. Also, it is required to ensure the required water depth in the field and to prevent raising water temperature to above 31°C. It is said that irrigating with colder water achieves this end.

In so far as fertilizer application is concerned, it is said that the application of chemical fertilizer should be limited to 30 kg/ha (2 kg/mu) per day. Application of insecticide is handled carefully to avoid harmful effects on fish. Where heavy doses of insecticide are unavoidable, fish are collected before its application and are put back in the field after the insecticide toxicity comes within allowable limits.

In many instances, the shallower the water depth the higher the rice crop yield and less the water requirement. Very often paddy fields require intermittent drainage, particularly at the late tillering stage to avoid harmful consequences due to the reduction of organic substances promoted under prolonged waterlogged conditions. Shallow water intermittent drainage make fish culture in paddy fields difficult, if not impossible.

One possible solution that could be used is to enlarge the area and depth of fish ches, although this may result in less cropped area. Furthermore, the practice of wing irrigation to control water temperature often results in low irrigation efficiency. promoting fish culture in paddy fields, these points should not be overlooked.

0 Water lifting devices

The Mission observed a number of large-scale pumps. For example, at the Pai-Tan ping Station in Hupei Province there were four sets of axial flow pumps with a capacity $8 \text{ m}^3/\text{sec}/\text{pump}$ at 8 m per head. On the occasion of visiting the Agricultural Fair in nghai, the Mission learned that very large-scale pumps are installed in many water servancy projects.

The Mission was under the impression that the country is capable of manufacturing and talling all kinds of pumps now being used elsewhere. The Mission thought that small ps were manufactured locally and that they are widely used by farmers for on-farm and h-pond water supply.

Most fish culture in China today is carried out in low-lying delta plains. Here the er level of canals and creeks is often below the surrounding land level. Thus, water ting becomes indispensable for both irrigation and supply to the ponds. Water lifting ices are also needed when the ponds are drained.

Traditional water-lifting devices, such as the dragon wheel, were occasionally observed the Mission, but electric pumps are now used extensively. On the occasion of visiting Chen-tung People's Commune near Shanghai, the Mission was informed that the water ply in the area was done using animal-driven water-lifting devices with about 400 animals. se devices were replaced by 21 electric pumps in 1958; however, the Commune still keeps devices as well as cattle for an eventual energy crisis. During discussion with Commune icials, the Mission was under the impression that the Commune gives special attention to proper maintenance of pumps. The Mission was told that all 21 pumps were in good king condition and that spare parts were readily available. It should be noted that ctricity is available in every rural sector and is one of the key factors contributing the rapid development of pump irrigation and fish culture. Movable low-lift pumps are t commonly used. The lift varies from 1-3 m with an estimated discharge of $2-4 \text{ m}^3/\text{min}$. y often such a small pump is put on a boat and transported to the watering point. The p is either operated by electric power available on the spot or by a diesel engine ually 10 hp) used for the boat.

1 Land consolidation

The Mission was informed that the prime objective in land consolidation, including d grading, is to increase land and labour productivity. The work consists of land ding and reshaping (in most cases a rectangular shape) and provision of irrigation and inage networks as well as farm roads.

In main fish areas, such as the delta of the Pearl River in Kwangtung Province, ponds upy a considerable portion of the land, from 30 to 60 percent. Land consolidation, refore, includes ponds or the water area. In the Le Liu People's Commune in Shun-ta nty, for example, 50 percent of the land area is taken up by fish ponds, but the land water (fish pond) areas were consolidated. As a result the number of irregularly ped and scattered fish ponds had been sharply reduced and regularly shaped fish ponds rectangular blocks of 60 x 90 m had been constructed instead. Overall, the number of is were reduced from 9 743 to 4 877, but the total area of fish ponds remained the same.

Land between the fish ponds, used for cultivation, had also been made more regular, and an irrigation network was installed at the same time. This was an impressive display of integration.

Such land-cum-fish pond consolidation, coupled with water control works, clearly increase land, water and labour productivity since farming and fishing operations in regularly shaped plots are more efficient. A timely water supply and application is also assured. Equally important, efficient transportation of farm inputs and commodities through networks of farm roads and water courses is provided.

The techniques used in China are largely identical to those used in other countries. But what is so outstanding is the massive mobilization of labour for earthwork.

Obviously one major reason for China's ability to implement speedy and large-scale land consolidation is the ownership system. Since land and fish ponds are state or commune owned, decisions on reshaping and reallocating land and ponds do not run into legal snags as in most other countries.

3.12 Fishways

The Mission was informed that hydraulic structures built across rivers, such as weirs and headworks, are usually provided with fish ladders so as not to impede the migration of fish. Fish paths are also built within gate structures. The Mission noted that as far as major schemes are concerned, the Water Conservancy Department is responsible for the design and installation of such facilities in consultation with fisheries agencies. Mission members were told of the experience in the Hwai River to illustrate the importance of the provision of this facility. An estuary barrage was constructed there in 1956 and 1957 to control flood and seawater intrusion in the deltaic area of the Hwai River and to store fresh water. After completion of the work, migration of crab and mullet was impeded. Production inevitably dropped. In 1965 the Tung-kou Fishery Commune harvested only 100-150 kg (200-300 jin) of crab per day and 50 kg (100 jin) of mullet per boat - a big drop from the 3 000-4 000 kg (6 000-8 000 jin) of crab per day and 1 250 kg (2 500 jin) of mullet per boat recorded in 1955.

A special task force for fishways design was formed in 1965. It examined the location, structure, capacity, velocity and water depth of the fishway together with the operation of sluice gates.

A fishway was constructed in 1966, which restored smooth migration of fry. Furthermore, the operation of sluice gates was improved. These resulted in increasing crab and fish catches. More than 15 000 kg (30 000 jin) of crabs per day were harvested in 1972.

The Mission was not able to get technical information on the construction. The Mission considers that a coordinated approach toward the design and location of fishways built in hydraulic structures is often overlooked in FAO member countries and that a detailed study of experience in China merits attention.

3.13 Summary and recommendations

3.13.1 Summary

China places the greatest emphasis on comprehensive and intensive use of land and water resources for agriculture and fisheries. People at all levels met by the Mission pointed out that assured and controlled water supply and timely drainage are the key to successful agriculture and fisheries activities.

One of the major contributing factors is the availability of electric power in every rural area.

Most striking was the fact that techniques for effective and intensive use of land and water resources are practised at the farm level by farmers. The techniques are not very sophisticated, but they are indigenous and extremely practical.

The water bodies created or developed for irrigation and drainage purposes are invariably utilized for catching and breeding fish.

The bottom mud of ponds and water courses, excavated to maintain hydraulic capacities of these facilities, is returned to cultivated land to fertilize the soil. It is a pattern similar to nature's own cycles and appears to be ecologically sound.

Land consolidation projects cover both cultivated land and fish ponds.

Irrigation and drainage systems are installed to serve crop production and aquaculture, and also navigation.

In short, irrigation and drainage projects are planned and executed to ensure the fullest use of land and water resources.

3.13.2 Recommendations

No doubt other countries have achieved much by way of gigantic water resources development projects that require sophisticated technical knowledge of design and construction engineering and huge capital outlays. But developing countries may first benefit by studying closely:

- (i) small-scale water development projects in China being planned, built and managed by the farmers themselves at the commune and farm level at minimal cost using indigenous resources and materials;
- (ii) integrated and intensive management of land and water resources for agriculture and fish production at the farm (commune or brigade) level; and
- (iii) crop production, animal husbandry and fish culture/catching technologies adopted and performed by farmers in an integrated manner.

For this purpose the following courses of action are recommended:

- (a) A study tour of China for one month or more by key government officials of member countries with a view to obtaining a general idea of the Chinese way of thinking and performance, and to identifying the areas of detailed study and training by their colleagues.
- (b) In-service training of technicians, extension workers and farmers at the farm level (commune and brigade) for a period of three to six months.
- (c) Setting up pilot demonstration-cum-training projects in member countries to be managed by Chinese technicians and farmers.

4. LAKE AND RESERVOIR FISHERIES

4.1 Productivity

4.1.1 Reservoirs and lakes

Total area of fresh water in China is usually given as about 20 million ha. About one third of this consists of small lakes, reservoirs and ponds. This estimate, however, was made before 1956 (Solecki, 1966). Since then there have been increases in water area available for fish culture. Active programmes for the construction of ponds and small to medium-sized reservoirs have continued. Thus, the 6.7 million ha of water area considered suitable for aquaculture at the time have probably been increased to 10 million or more.

The traditional "five lakes" of China are: Tungting, Poyang, Hungtze, Taihu and Chao. Together they make up nearly 1.4 million ha, and yield in the order of 70 000 tons of fish annually (estimated by the Mission at 50 kg/ha).

There are reported to be about 130 lakes larger than 100 km². The 33 lakes over 100 km² in size listed in van der Leeden (1975) total over 4 million ha. Of this area, 670 000 ha are salty.

The largest of the salt lakes, Koko Nor, has an elevation of 3 200 m above sea level. It is about one percent salt and supports a significant fishery of yellowfish and pike (Anon., 1974).

In Hupei Province, lakes, rivers and reservoirs make up some 70 percent of the 270 000 ha of water. The Mission was told that the average yield of lakes over 10 000 ha in size is 60 kg/ha. Those of medium size reportedly yield 225 kg/ha. Small lakes and reservoirs under 500 ha generally yield 1 000 kg/ha under intensive management.

The Chinese assume that reservoirs will produce about one third less than natural lakes of the same size. For small reservoirs and lakes, the national average is given as "several dozen jin/mu". This is about one quarter to one third the figure given for Hupei.

Table 4 gives the reported productivity of some reservoirs and lakes of various sizes. Recent data on the deeper lakes and reservoirs of the hilly and mountainous areas are not available. It may be assumed that their productivity would be substantially less.

There are evidently still some parts of the country where the small reservoirs built for water storage are not used for fish production. The people in these areas have not been accustomed to eating fish. However, in most areas, the Mission was told, such reservoirs are now stocked and fished, following the national motto "wherever there is water there should be fish". The required fish fry and fingerlings seem to be readily available in most parts of the country where pond production is possible.

4.1.2 Rivers and canals

Larger rivers are also fished. However, little attention appears to be given to their management for fishery purposes. Fishing here is usually carried out with traditional gear. The Mission noted the use of large lift nets, with 5 to 20 m² of netting, in several places, and set nets and lines are reportedly also used.

Small rivers and canals in the delta regions of the Yangtse, the Pearl and other rivers are more intensively managed for fisheries. As at the Chen-tung Commune visited, some are divided off into sections (sometimes with guards whose duties are to maintain the fences and assist boats in passing). These areas are stocked (see section 5.3) and provided with additional food materials such as manure and grasses. Productivity reaches nearly 1 500 kg/ha.

Table 4

Productivity and Other Characteristics of Various Lakes and Reservoirs in China

| Name | Province | Surface Area (ha) | Average Depth (m) | Productivity (kg/ha/year) | Remarks |
|--|-----------|-------------------|-------------------|---------------------------|--|
| Ho Lung Reservoir | Kwangtung | 200 | 8.3 | 70 | (Present production; 200 kg/ha expected) |
| Tung Lake (East Lake) | Hupei | 1 467 | 4-5 | 278 | 167 ha not used for fish |
| Pai Tan Lake | Hupei | 400 | 2 | 730 | |
| Miyun Reservoir | Peking | 9 300 | ? | 150 | |
| Taihu Lake | Kiangsu | 226 000 | 3 | 52 | |
| Fan Li Lake (2 $\frac{1}{2}$ li Lake) | Kiangsu | 333 | 2 | 525 | Connected to Taihu Lake |
| Hsuan Wu Lake | Kiangsu | 450 | 1.5 | 1 100 | |
| Tin Shan Lake | Shanghai | 6 600 | ? | 151 | Also 450 kg/ha of snails and other molluscs |
| Lui Hwa Lake | Peking | 33 | 2 | 5 000 | (Report of Canadian Mission) |
| Liang tse Lake | Hupei | 4 330 | ? | 173 | 1953. In 1956 had been reduced to $\frac{1}{2}$ by excess fishing. Anon., 1958 |

4.2 Management

4.2.1 Principles

Management programmes developed for lake and reservoir fisheries are basically an extension of the polyculture system so successfully used in pond culture. Reservoirs or lakes under 100 ha in size are managed for intensive production with supplementary feeding as well as heavy stocking.

At the other end of the scale, the large lakes (over 10 000 ha) like Taihu Lake in the Yangtse Basin are managed by a combination of techniques: stocking; protection of natural spawning sites as well as creation of supplementary spawning sites; regulation of fishing seasons and gear; and enclosure of suitable bays and coves for conversion to intensive fish culture.

Much attention appears to be given to watershed management to increase lake fertility. Conversely, additional resources of the lakes (fertile bottom mud, aquatic vegetation, snails, etc.) are utilized to increase agricultural production in surrounding areas.

Certain of the natural lakes, such as Pai Tan and Hsuan Wu once underwent large-level fluctuations owing to the periodic droughts and floods. Pumping stations and other control devices have now been installed to control the water level (see section 3.5).

Special attention is given to the small and medium-sized lakes and reservoirs near cities where the local facilities for both fish production and recreation are especially needed. The Mission was told that grass clippings from the parks and vegetable waste from the markets are utilized for supplementary feeding. Dikes and causeways provide walkways and mid-lake pavilions; but they also serve to separate the lake into different kinds of production units, as at East Lake (Fig. 2).

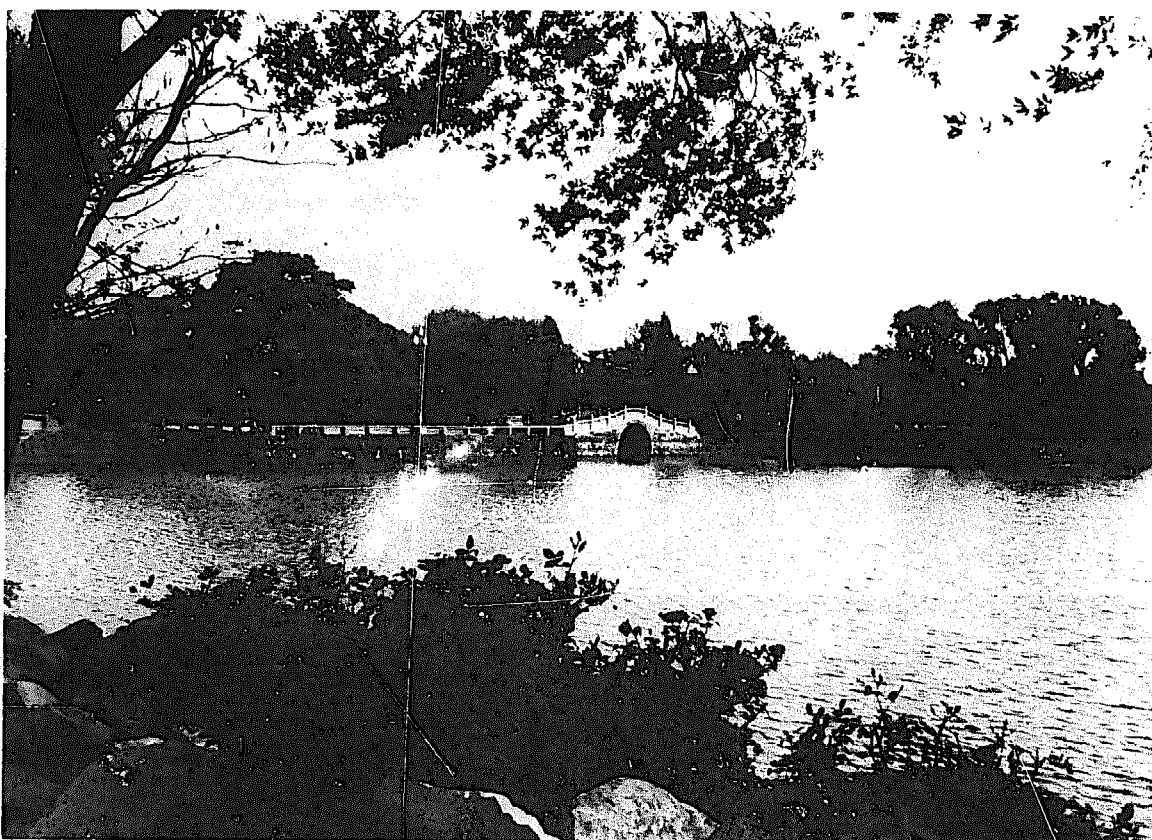


Fig. 2 Causeway on East Lake separating lake into different basins

4.2.2 Special methods

There are five unusual aspects of the Chinese approach to lake and reservoir fisheries that merit detailed comment. These are:

- (i) stocking
- (ii) fertilizing
- (iii) large-scale catching
- (iv) subdivision
- (v) bottom grading and clearing.

Such policies are not unique. They are also followed in the U.S.S.R. for instance, though with less consistency. Elsewhere, they have often been regarded as not worth the high cost. These aspects are discussed below in relation to the special conditions that exist in China.

4.2.2.1 Stocking

In Asia there are fewer native species of freshwater fishes than in North America, and many fewer than in South America or Africa. The Asian species are more typically riverine. Thus, the natural or spontaneous fish fauna of lakes and reservoirs does not encompass the variety of feeding habits that is typical, say, of the faunas of most African water bodies. Mollusc, detritus, phytoplankton and plant feeders, and even zooplankton feeders adapted to open water, are often missing.

Thus, the practice of stocking a combination of grass carp (herbivore), silver carp (phytoplankton), black carp (mollusc eater) and bighead (zooplankton), along with such bottom feeders as mud carp and common carp, utilizes more of the natural production of the system. These species, however, do not reproduce naturally in the still waters of lakes and ponds and therefore stocking must be regularly repeated ("catch and stock in rotation"). This requires extra work and facilities, but the system does allow close control of stock size. Thus catches need not fluctuate from year to year as they do when dependent on wild stocks.

The Mission feels that relatively low labour costs, and species that do not require high protein foods, are the most important factors in the success of this technique in China. It is also significant that bulk or large-scale harvesting of the stocks (see section 4.2.2.3) where this is practised, leaves time for other activities than fish catching. In China, it is the fishermen who usually also produce the fish to be stocked.

Usually, the Mission learned, about 1 500 individuals (10-15 cm in length) are stocked per hectare of lake (see section 5.3). These fingerlings are usually produced near the lake site (see sections 5.5 and 5.6).

4.2.2.2 Fertilization

Direct feeding of fish and fertilization of water are considered an essential part of small pond and reservoir management. It is often undertaken in lakes up to 100 or more hectares in size. Animal manures, especially pig, are used to stimulate plankton growth. The Chinese rule-of-thumb is to raise 15 or more pigs per hectare of water (see section 5.4.2). Green grass and vegetables are fed to grass carp, which, in turn, produce animal (fish) manure and food for other fishes. The Chinese say: "Feed one grass carp well and you feed three other fishes".

In most countries, fertilization of large lakes and reservoirs is not considered as a practical fish-management tool. The fish manager also has little influence on the overall development of the surrounding land. China, however, recognizes that its arable land must be fully utilized to feed its people. Thus, a high premium is placed on utilization of waters in the most efficient way possible. Fish management, the Mission found, is given full consideration in agricultural planning, especially at the commune level. The Chinese planner, it seems, would regard an attempt to improve a lake fishery without considering the surrounding land as incomplete and wasteful.

There is little discussion of the use of human sewage in water management. It is clear nonetheless that considerable effort is being put into improving methods to ferment and sterilize such wastes for both land and water fertilization (see section 5.4.2).

4.2.2.3 Bulk or large-scale harvesting

In large lakes and rivers, harvesting is accomplished in more or less conventional ways (e.g., gill nets and/or pair trawling). But in the smaller lakes and new reservoirs methods of obtaining a large percentage of the stock in a short time are emphasized. Seine nets up to 5 km long are common (e.g., East Lake, Wuhan). Encircling nets and seines up to 1 or 1.5 km are regularly used. Most of the work is done manually. Such seines may even be used as beach seines, with additional hauling ropes at regular intervals along the net (Solecki, 1966).

An interesting technique used is that of driving fish toward one end of the lake or large bay with boats, with the boatmen beating the water as they move forward together. After proceeding for some distance (100 m or so) a net is set behind the boats to prevent the fish from returning (Fig. 3). After repeating the process the first net is removed to be used for the next blocking. When the fish have thus been concentrated, they are fished from the remaining area with conventional gears such as encircling nets. In some cases (e.g., Ho Lung Reservoir) the last blocking net set incorporates a trap (Figs. 4a and 4b).



Fig. 3 Poster at East Lake showing successive positions of the blocking nets used to concentrate fish into one arm of the lake for harvest

The remaining fish are driven into this trap. Such an operation requires 20 to 50 persons, and for big lakes it may extend for 20 or more days.



Fig. 4a Lifting the trap portion of a large blocking net used in reservoir harvest (Ho lung Reservoir, Kwangtung Province)



Fig. 4b Emptying the trap, Ho lung Reservoir

The method seemed very efficient to the Mission. But the investment in fishing equipment is high. Permanent dikes are sometimes built to reduce the length of nets needed for concentrating the fish. The system is primarily effective for the grass, silver and bighead carps, which remain in the upper part of the water column. Obviously the system is only practical where it is possible to market large catches all at once.

4.2.2.4 Subdivision

Lakes and reservoirs are frequently subdivided to increase the efficiency of production and harvest. On reservoirs such as Ho Lung, visited by the Mission, dikes have been built across several bays. These shorten the length of the roads needed to give access to various parts of the lake shore. In addition, they form protected ponds in which to raise fry to a size at which they may escape from predators when moved into the lake itself. These nursery areas are small and shallow, so that systematic removal of unwanted fish is possible and their subsequent re-entry from the lake unlikely.

Subdivision is used also to separate sections where water plants like lotus are grown from the fishery areas, to partition recreational facilities from the main lake, and to facilitate harvest (see section 4.2.2.3).

In Taihu Lake, Mission members were shown a dike constructed across a large bay. The enclosed portion of about 150 ha was converted into fish ponds for intensive fish culture. Built in three months by 2 200 workers with only small tools, this dike will increase the fish production of that bay from about 7 tons/year to perhaps 700. It seems likely that subdivisions of lakes and reservoirs will be used increasingly in China to convert parts of such bodies to intensive fish culture.

4.2.2.5 Bottom grading and clearing

Prior to 1958, the reservoirs built in China were rarely or only partly cleared of trees before flooding. In other parts of the world, clearing is discouraged as dead trees and other such left-over structures enhance the productivity of reservoirs, making more fish available. However, the Chinese practice of stocking and feeding in small reservoirs may reduce the importance of this effect. The advantage of leaving trees, therefore, appears correspondingly small. On the other hand, the trees hamper fishing operations, preventing the use of moving gear, an important harvest method in China. Therefore after 1960, all areas to be flooded in small reservoirs were not only cleared, but also all stumps and other potential snags were removed and the bottom graded to an even contour to make fish harvesting as easy as possible.

It is much less practical to attempt to clear the bottoms of medium and large reservoirs. The Chinese, therefore, attempt only to clear natural coves, and other areas about 10 ha in size (2 li in circumference) where this would facilitate fishing operations. As supplementary feeding is generally not done in these larger water bodies, the extra biological productivity of uncleared bottom is likely to be more important.

4.3 Environmental problems

China's handling of environmental problems is like that of the ancient Chinese artisans carefully carving a block of jade into a work of great detail still preserving its basic form. Mountains are levelled and swamplands are converted to manageable lakes with regulated water level, ponds and croplands, with a massive application of manpower. But at the same time, large programmes of reforestation and erosion control are under way, in an attempt to reverse the long over-use of Chinese hillsides and mountainsides and restore the ancient landscape.

China attempts to use resources to the fullest but the ecological implications of such development are considered. Waste, of any kind, is reduced as much as possible and the range of fishculture practices seen and discussed by this Mission provides good examples of how wastes are recycled back into productivity.

Substantial development of industry has created noticeable air and water pollution problems. The Mission was informed that government departments for environment problems have been recently created at both national and provincial level. Standards for air and water quality have been written into law. New factories are required to meet these standards, but most of the older ones are not, unless special local problems exist.

A severe drop in fish production of the Nun-chiang River, Tsitsihon, in 1969, resulted from discharge of waste water. The waters of a large reservoir near Peking became polluted with industrial effluents resulting in bad taste of the fish. These incidents helped show the Chinese the importance of such legislation. Both of the above problems have now been corrected.

However, a different kind of concern arises from the large-scale efforts to domesticate production. The conversion of swamplands, especially in large lakes, to fish ponds and fields is seen elsewhere as a potential threat to water quality. It reduces the natural filtration of water. Wild birds as well as fish require such areas for breeding and sometimes food.

The Chinese seem aware of such problems though they were not discussed with the Mission. In Taihu Lake, shallow marshy and swampy areas needed for natural reproduction of several kinds of fishes have been set aside as reserves and cannot be destroyed or even fished.

It seems likely, however, that the Chinese will prefer to find alternative ways of fulfilling the ecological roles played by wetlands and swamps (e.g., the anchored clumps of grass put out in Taihu Lake). Large-scale conversion of swamps to fish ponds or other uses of high utility will probably continue.

4.4 Summary and recommendations

The management systems for lakes and reservoirs that have evolved in China merit close study and even emulation by some of FAO's Member Governments. It is characteristic of Chinese development that such methods evolve in place. In general the approaches fit her own social and economic system. It is impressive to note that specific local conditions and constraints are well provided for and projects, like pieces in a jig-saw puzzle, fit into place with each element matched to the local resources and setting.

It is thus necessary to view their programme of stocking, fertilizing, and fishing all available waters in the context of China's emphasis on agriculture as the key to development and of the whole programme of agricultural production that reflects that policy. It is a system in which, when needed, industry can be expected to - and does - provide capital for agricultural investments.

Even more significantly, cost/benefit ratios appear to be evaluated in terms of overall development rather than on an individual project basis. Thus, the cost of clearing a reservoir near a city may not be evaluated against the return from sale of extra fish but rather by such factors as equalizing fish consumption, stimulating pig production, and so on.

The concept of controlling fish stocks through replenishment with artificially-raised fingerlings warrants reconsideration in the light of Chinese experience. It is worth noting that such stocking of lakes and reservoirs is also widely practised in India, and other areas of Asia. Special attention should be given, in cases where such stocking is proposed, to the feasibility of constructing predator-free subareas for fingerlings and adjacent facilities for fry production.

It is particularly important for other countries to note the advantages of all-round integrated management of water resources. This is a very recent development in Chinese practice but a very impressive one. In those countries where expansion of freshwater fish production is a significant element in development plans, special efforts should be made to ensure that fish and farm go hand in hand, in planning and in practice.

5. FISH CULTURE SYSTEMS

5.1 General

Freshwater aquaculture is an integral part of the overall agriculture production system in China. It is practised either as a primary occupation supplemented by other crops, a secondary activity or a sideline occupation depending on the resources available. Such integration of aquaculture with agriculture is practised in other countries to a lesser extent (i.e., duck-cum-fish culture in Nepal and Hungary). It is only in China where aquaculture is undertaken on a fully-integrated, nationwide scale.

Integration promotes the full use of raw materials produced in the farm for food production. Animals provide organic manure that fertilizes the ponds and the croplands; the land, in turn, produces crops and plants for food for animals, fish and man; the wastes of fish accumulated in the pond humus go back to the soil where land crops are grown. This inter-relationship illustrates the practicality of China's approach to diversified agriculture and integrated rural development.

The Mission was informed that there are about 20 million ha of freshwater areas available in China, of which about 6.7 million ha can be used for aquaculture (see section 2.3). This is made up of 60 percent under pond culture, including irrigation water reservoirs and village ponds, and 40 percent in natural or artificial water areas (lakes, dams and reservoirs) utilized for aquaculture.

Fish rearing in China has a long history. It used to depend on natural stocks of fry collected from the Yangtse River. However, as a result of the development of artificial spawning techniques in 1953, it became possible to produce black carp fry on a large scale for aquaculture use. By 1958, other species of the Chinese carps (grass, silver and bighead carps) were also successfully induced to spawn and this marked the end of the dependence on natural fish seed sources. Induced spawning has become a routine farm activity in the communes since 1958 and most farms produce their own fry and fingerlings. Fish breeding centres that were established in certain communes soon after artificial spawning was developed now take care of the fish seed requirements of farms where there are not adequate facilities for artificial spawning.

5.2 Aquaculture development

A key factor that has influenced aquaculture development in China is to be found in the national policy on land and water development, wherein top priority has been given to water conservation measures in the overall development programme. This has led to the nationwide construction of water control structures for flood prevention and stabilization of river flows. Lake levels have been likewise controlled by the construction of hydraulic structures and sluices at the main river connexions, and new water bodies have been developed such as dams and reservoirs (see section 3). These efforts gave tangible benefits in agriculture production, including aquaculture, that China now enjoys. All water surfaces thus created in land and water development, as well as natural lakes and ponds, are utilized for fish production. The use of these areas for aquaculture is a manifestation of the slogan "Wherever there is water, there must be fish".

5.2.1 Ponds

Some existing fish ponds appeared to have been developed as a result of land consolidation and farmland amelioration for agricultural crop production. Many are traditional ponds in which fish have been cultivated for many years. In low-lying deltaic areas, ponds came into existence as a result of projects for development of "raised fields", constructed by excavating soil from adjacent areas of land or by digging drainage ditches around rectangular plots to elevate the fields and lower the water table. This, in effect, corrects waterlogging problems in farmlands and creates ponds. In Nan Huei County, Shanghai, ponds were created out of the diggings made for the manufacture of bricks.

Marginal lands along river deltas, shallow margins and adjoining waterlogged areas are reclaimed for agriculture, including fish-pond development. One example of this is the reclamation of 2 400 ha near Taihu Lake, which was completed in 1975. This area used to be under water most of the year and produced mainly aquatic plants. It was reclaimed primarily for fish production.

The size of newly constructed ponds is usually about 4 000-5 300 m² (6-8 mu) with a depth of 2-3 m. Movement of water in and out of the ponds is usually accomplished by pumping as the land used for construction of ponds is generally low-lying.

5.2.2 Lakes, dams and reservoirs

Lakes, dams and reservoirs are developed and used in aquaculture by applying the principles of polyculture in ponds (see section 5.3). Shallow bays are blocked off by netting or screens to serve as nurseries or fish-breeding areas and for rearing fry and fingerlings to stock the water bodies. Some lakes, such as the East Lake and Fan Li Lake, not only serve as aquaculture areas but also for recreational purposes.

5.2.3 Paddy fields

Paddy fields used for aquaculture are those which have adequate water supply and drainage systems.

There are two methods used, namely "deep water" and "shallow water". The former uses up to 0.5 m of water while the latter uses a minimum of 5-10 cm depth of water. For both techniques trenches are constructed in the paddy for fish retention. For details of paddy-cum-fish culture see section 3.9.2.

5.2.4 Canals and ditches

Drainage canals and ditches within the farm are also utilized for aquaculture. In some instances, aquatic plants are raised in these areas to provide feeds and fodder for the livestock and other animals raised on the farm. While the Mission was not told the total area of irrigation sector canals and ditches in China, it must be substantial.

5.3 Fish culture techniques

Freshwater fish culture in China is mainly polyculture of the "family fish", the Chinese major carps, in combination with other species with complementary feeding habits, to utilize all the available food materials in the water. Monospecies culture is used only for fry and fingerlings up to 3 cm size.

In ponds, the main species raised is the grass carp in combination with bighead, silver carp, black carp, mud carp, common carp and bream. The proportion of each species varies according to prevailing pond conditions and raw materials available for fish rearing.

There are two types of polyculture practised in China, namely multigrade and mixed-age fish culture.

Multigrade fish culture is a technique whereby fish are reared in a series of ponds from fingerlings to marketable size, with fish sorted in the ponds according to size. This method takes advantage of the maximum growth potential of the fish as their density in the ponds can be adjusted for the size of fish as well as for productive capacities of ponds. This enables the farmer to undertake a continuous cycle of stocking and harvesting, increasing the output. The rearing period is also shortened and production of the desired size of fish for market facilitated. This technique, however, can only be practised in communes that have several pond units for large-scale production.

As shown in Table 5 the stocking density decreases as fish become larger.

Table 5

Stocking Density for Multigrade Polyculture

| Grade | Size of Fish (g) | Stocking Density/ <u>ma</u> (per ha) | | | | Rearing Period (days) |
|-------|--------------------------------|--------------------------------------|-------------|-------------|-----------------|-----------------------|
| | | Bighead | Grass Carp | Silver Carp | Mud Carp | |
| 1 | 14-65 14-80 5-20 | 450 (6 750) | 100 (1 500) | 250 (3 750) | 7 500 (112 500) | 40 |
| 2 | 65-225 80-500 20-60 | 140 (2 100) | 450 (6 750) | 40 (600) | 2 500 (37 500) | 150 |
| 3 | 225-500 500-1 000 60-270 | 60 (900) | 200 (3 000) | 20 (300) | 850 (12 750) | 150 |
| 4 | 500-1 200 | 25 (375) | 70 (1 050) | | | |

The mixed-age or size polyculture is a traditional method where fish of different species of varying sizes are reared in the same pond from fingerling to marketable size. The stocking density and combination of species vary from place to place. Selective harvesting is used to remove the larger individuals during the rearing period. Subsequently, the pond is restocked with small-size fish to replace the ones removed. In this method it is common to find a total stocking density of 15 000 fish/ha (1 000/mu). Stocking combinations used in polyculture in China are shown in Table 6.

Both techniques, multigrade and mixed-age polyculture, apply a principle of stock manipulation also used in the monoculture of milkfish in Taiwan and the Philippines. Here, different sizes of fish seeds are initially stocked and the larger ones are harvested earlier in the rearing period with subsequent stocking of small fish after each partial harvest. In effect, there are three to four croppings and stockings carried out during a rearing cycle of 10 to 12 months.

In lakes and reservoirs where management is less intensive, silver carp and bighead carp form the major species and a density of 4 860 fish/ha (325/mu) is used. This figure also varies according to the ecological conditions and natural productivity of the water areas concerned. An example of stocking combinations used in reservoirs (Ho Lung Reservoir) is as follows:

| | |
|--------------|-----|
| Silver carp | 46% |
| Bighead carp | 16% |
| Grass carp | 10% |
| Mud carp | 21% |
| Common carp | 8% |

Table 6

Various Combinations of Species used in Polyculture in China

| Species | % composition |
|--|---------------|
| (In ponds visited in the Pearl River Delta) | |
| 1. <u>Where major species is grass carp:</u> | |
| Grass carp | 55 |
| Silver carp | 16 |
| Bighead carp | 10 |
| Others | 19 |
| 2. <u>Black carp as major species:</u> | |
| Black carp | 42 |
| Grass carp | 24.2 |
| Silver carp | 12.4 |
| Bighead carp | 7.4 |
| Wuchan fish | 7.4 |
| Common carp | 3.4 |
| Golden carp | 3.2 |
| 3. <u>Silver carp as main species:</u> | |
| Silver carp | 65 |
| Bighead carp | 10 |
| Grass carp | 12 |
| Common carp | 5.2 |
| Wuchan fish | 7.8 |

Fish culture in canals and ditches observed in Chen-tung People's Commune uses a combination of the following species:

| | |
|--|-----|
| Bighead and silver carp | 30% |
| Grass carp | 15% |
| Black carp | 5% |
| Wuchan fish (bream) and other bottom-feeding species | 50% |

5.4 Aquaculture management

5.4.1 Eradication ("sterilization") of pond pests and nuisances

As normally practised in most managed fish culture operations, ponds are treated to eradicate obnoxious pests and nuisance organisms prior to stocking with fry or fingerlings. Tea-seed cake and quicklime are commonly used for this purpose in China. The former is applied at the rate of 525-675 kg/ha (35-45 kg/mu) and the latter at 900-1 050 kg/ha (60-75 kg/mu) in the case of dry ponds, and 1 875-2 250 kg/ha (125-150 kg/mu) in wet ponds, with 1.0 m depth of water.

5.4.2 Application of fertilizers

Organic manure is the main fertilizer used in ponds, lakes or reservoirs. No inorganic fertilizers are applied for fish rearing. This is the main reason why all farms undertake animal husbandry - to supply the necessary fertilizers for fish farming and at the same time to diversify the economy.

The Mission was informed that two to three pigs are raised to supply adequate organic manure for each mu of pond (30-45 pigs/ha). Manure of cows and chickens is also utilized as fertilizer mixed with plant materials and soft mud. These are put together in a composting pit and allowed to ferment for ten days, after which the resulting compost is transported to the ponds or fields.

In some places composting tanks are constructed in such a way that the liquid product of fermentation flows directly into the water supply canals to the fish ponds (Figs. 5-7).

The use of human waste as fertilizer is a traditional practice in China and is continued today. The system of utilizing such wastes, however, has been improved by the use of anaerobic treatment for several weeks. Of still greater importance to the continuing decline in intestinal disease has been the great increase in rural health care through the "barefoot doctor" programme and massive programmes in rural health such as the campaign to eradicate snail fever (schistosomiasis). It is estimated that "night soil" constitutes as much as one third of the total fertilizer resources of the nation (McGarry, 1976).

The rate of organic manure application in ponds as practised in the southern part of China (Kwangtung) varies from 5 625-10 125 kg/ha (750-1 250 jin/mu) applied in three portions with the first application more than the last two.

Fertilization of lakes and reservoirs is indirectly undertaken through intensification of agriculture and animal husbandry along water areas and low-lying lands close to the shores. Chicken, cattle, pigs, sheep, ducks and geese are raised in these areas to increase the fertility of water bodies. This is widely practised in China in compliance with the national policy of an all-round development of a diversified economy (see also section 4.2.2.2).

It is interesting to note, as mentioned to the Mission, that 50 kg of fish produce enough pond humus to fertilize 6 670 m² (10 mu) of crop land. This is the practical reason for locating the ponds between croplands. The pond humus is collected four to five times a year and applied to vegetables and land areas where other crops are grown (Fig. 8). Removal of pond humus also helps to increase O₂ in the water due to the removal of organic materials.

5.4.3 Feeds and feeding of cultivated fish

Fish culture in China makes use of plant materials as feeds which are produced on the farm. Usually supplementary feeding with high protein of animal origin is not practised, except that the black carp may be fed with snails and clams gathered from lakes. The latter practice was seen only in the lower Yangtse region in Wushi and Shanghai, where black carp are raised as a major species because of the abundance of snails and clams in nearby Taihu Lake.

In most other places grass carp is the major species cultivated and this is fed mainly with various grasses and vegetables which are grown along the slope of the pond dikes. Silk-worm pupae and faeces are also utilized as feeds where they are produced in considerable quantities. In the silk-producing areas mulberry is often cultivated in between the fish ponds (Fig. 9).



Fig. 5 Pig manure composting tanks with canals to convey the liquid product to the water supply system leading to the fish ponds, Pai-tan Lake, Fish Cultivation Station, Hupei Province

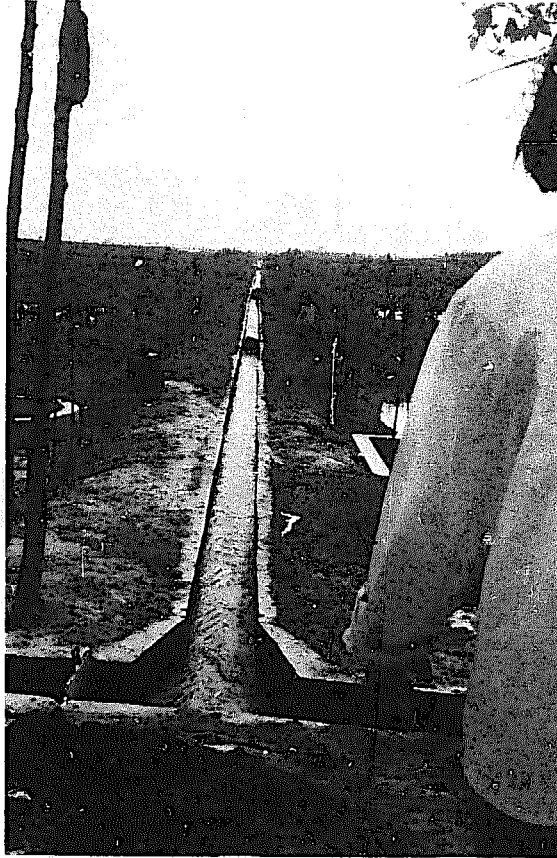


Fig. 6 Water supply system fed with pig manure,
Pai-tan Lake Fish Cultivation Station



Fig. 7 Water control structure along the water supply canal,
Pai-tan Lake Fish Cultivation Station



Fig. 8 Collection of pond humus and its application to crops grown near the pond, Shia-Kia People's Commune, Kwangtung Province



Fig. 9 Mulberry trees planted between ponds, Le Liu People's Commune, Kwangtung Province

The Mission was informed that feeds given to fish usually consist of 99.6 percent of rough plant material (grass and vegetable tops) and only 0.4 percent fine food consisting of residues of fermented products (soybean curd, soybean and peanut cake, rice and wheat bran). The natural fertility of the water is also enhanced by the application of organic manure which promotes the growth of plankton feeders, such as the silver carp and bighead. Other species such as the common carp and Wuchan fish are bottom and detritus feeders, while black carp feeds on snails. Based on the availability of these feed materials, the ponds, lakes and reservoirs are stocked with appropriate combinations of different species of polyculture.

According to information given to the Mission members, 60-70 kg of grass and vegetable tops produce 1 kg of grass carp; 50 kg of snails and clams produce 1 kg of black carp; 100 kg (200 jin) of fertile water^{1/} produce 1 kg of silver carp. Fish excrement accumulates in the pond bottom and serves as organic manure which helps fertilize the water for plankton growth. It was mentioned that 500 g (1 jin) of fish waste produce 0.8 kg of silver carp or bighead; 25 kg of animal manure produce 500 g of silver carp and bighead.

Grass and vegetables being the main feed materials for fish, the pond dikes are usually wide - providing enough land space for the production of these items. Information obtained in this regard was that 66.7 m² (0.1 mu) of land is needed to provide 667 m² (1 mu) of fish pond with plants as feed materials (Fig. 10).



Fig. 10 Pond slopes planted with grass to serve as food for grass carp, Shia-Kia People's Commune, Kwangtung Province

^{1/} Fertile water consists of 77 percent residues of bean curd and 23 percent residues of fermented products

It is common practice in China to utilize the slopes and both sides of the crown of the pond dikes for planting elephant grass, oil seed plants and vegetables to feed the fish and other animals raised on the farm. Elephant grass is particularly useful as the roots strengthen the dike and prevent soil erosion. It may be harvested every ten days.

As with other aspects of Chinese fish culture, the feeding practices are not unique to China. The Mission was much impressed, however, by the simple and practical approaches seen. It seemed particularly significant that all of the major inputs, such as feed, fertilizer and fish seed, are produced within the farm. In other countries, some or all of these are produced at a distance, adding transport costs and uncertainties of supply and delivery. The use of organic fertilizers and locally-produced feed materials is especially to be recommended for most of the developing countries. Unfortunately, the latter have often elected to adopt commercial fertilizers and feeds simply because it is the practice in the developed countries.

5.5 Artificial spawning of fish

Almost all of the farms visited by the Mission produce their own fry by artificial spawning methods. This is a common practice among the farmers in China, a situation that is not yet found in other countries. Although induced spawning techniques are well known outside China, their practice is limited to specialized workers in research institutions engaged in artificial spawning studies and to stations specialized in fry production. The practical application of several such techniques developed in research institutions has yet to find its way to the fish farmers at the farm level in many developing countries.

The main reason for this slow transfer of technology elsewhere is often that research workers keep to themselves and do not try to simplify the techniques enough for the use of farmers themselves. Extension workers must fill the gap to bring the technology to the farm level. Unfortunately, trained practical aquacultural and extension workers are not available in most developing countries to undertake intensive farm extension work.

The Chinese have familiarized themselves with the reproductive behaviour and the physical requirements of their species. They have developed practical techniques of artificial fish spawning using simple facilities that the farmers can construct and operate. This apparently came about as a result of the farmer-researcher-soldier or "three-in-one" work combination and their "open-door" research policy (see sections 7.1 and 8.6).

5.5.1 Facilities for spawning

The design and construction of the fish spawning facilities include spawning ponds and incubation pools. These are located close to the broodstock ponds.

5.5.1.1 Spawning pools

These are usually circular cement tanks, 8-9 m in diameter and 1.2-1.5 m deep. Water capacity is 50 m³ (Fig. 11a). Some spawning ponds are rectangular or oval in shape, but the circular shape has been found to be the most effective. The design of spawning pools is shown in Fig. 11b.

The bottom of the pool slopes toward the centre where there is an outlet pipe leading to the egg-collection chamber. The walls of the tank are provided with water inlet pipes installed in a diagonal position to create a circular water flow during the spawning period (Fig. 12).

Each spawning pond is provided with a collection chamber where the fertilized eggs are gathered for counting and transfer to the incubation pools. The outlet pipe from the spawning pond is fitted with a net to facilitate collection of eggs for counting (Fig. 13).

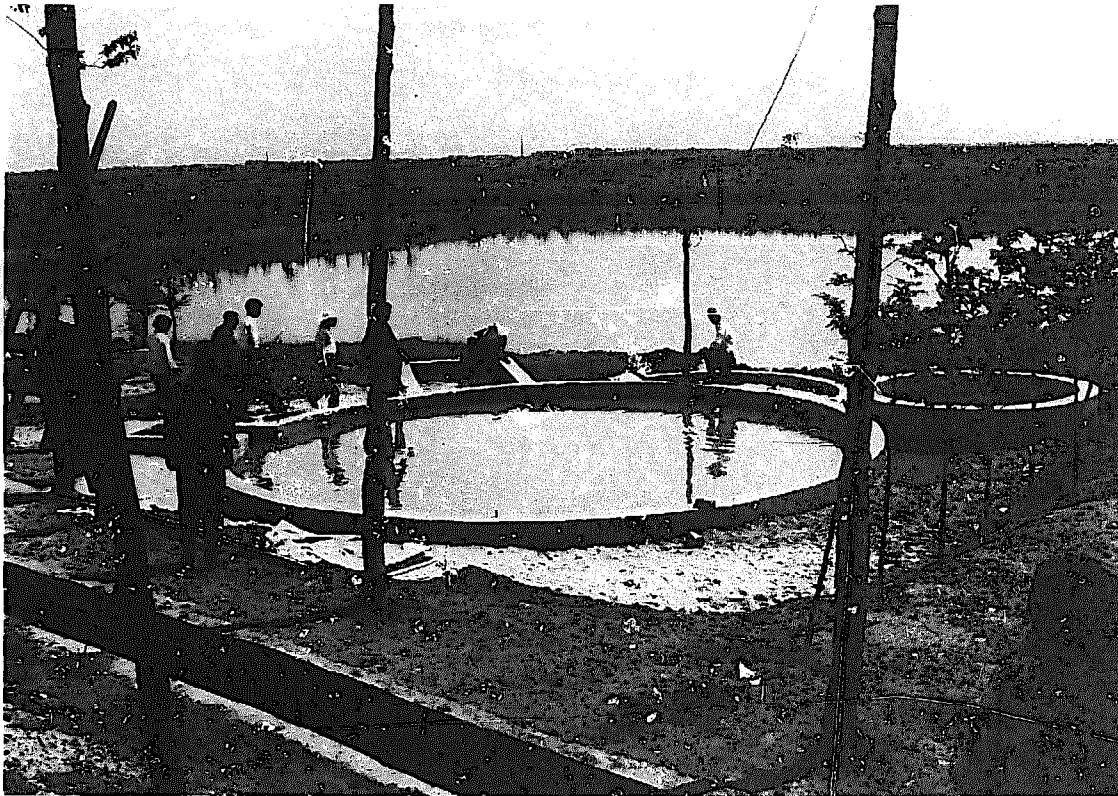
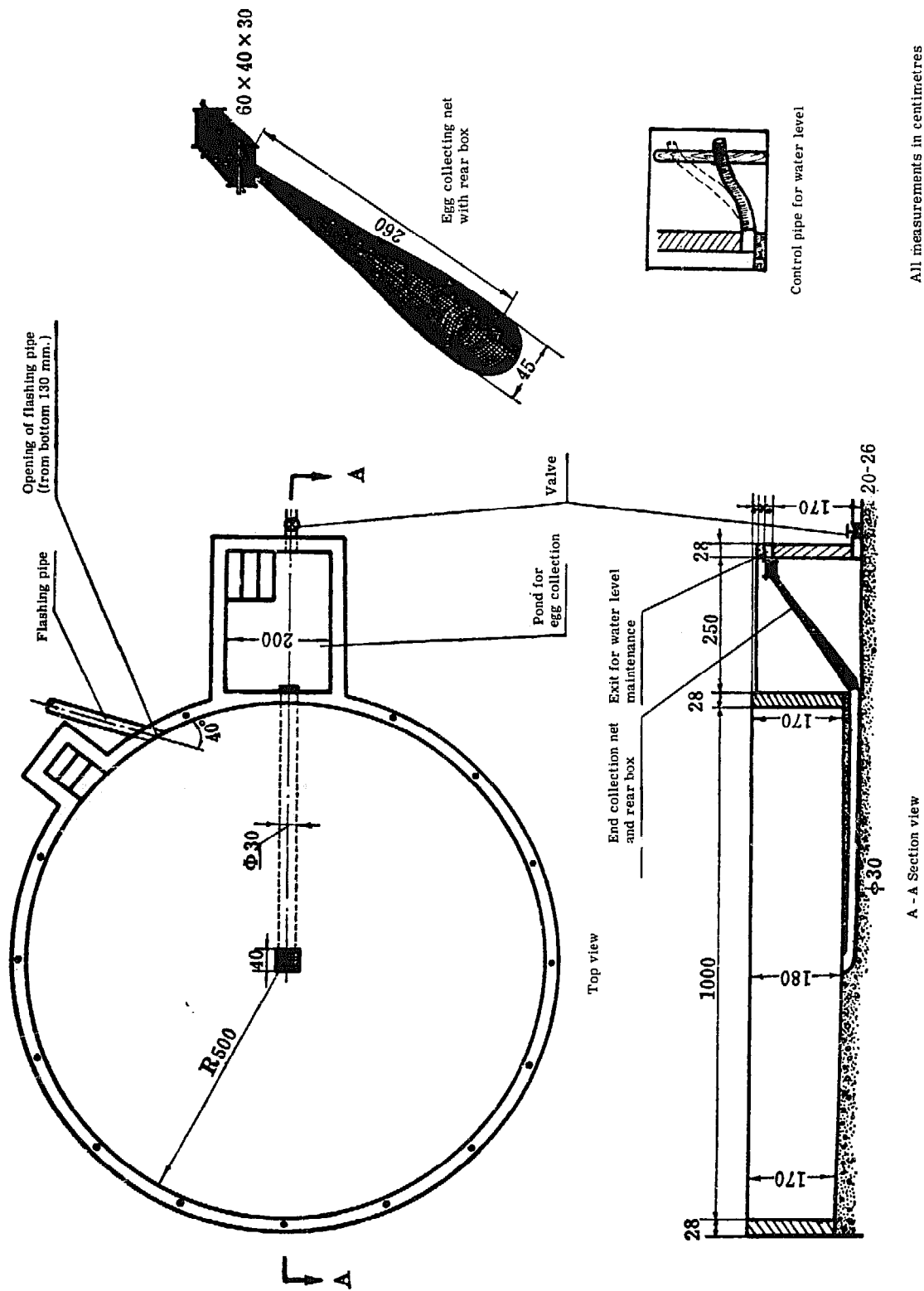


Fig. 11a A circular spawning pool and hatching facility,
Pai-tan Lake Fish Cultivation Station, Hupei Province



All measurements in centimetres

Fig. 11b Design of the circular spawning pool (dimensions in centimetres)



Fig. 12 Water inlet installed in a diagonal position on the wall of a spawning tank to circulate water, Pai-tan Lake Fish Cultivation Station



Fig. 13 Rectangular collection chamber between a large spawning pool (lower right) and two circular hatching pools, Nan-hai Station, Kwangtung Province

5.5.1.2 Incubation and hatching pools

These are also circular in shape with one or more chambers for incubation. A single-chambered hatching pool (Fig. 14) has an inside diameter of 3.5 m, and a depth of 1.0 m with a water capacity of 9.0 m³; multi-chambered hatching pools are also used (Figs. 15a and 15b). Water circulation is very important in the incubation and hatching period. For this purpose there are several diagonally-installed pipes at the bottom of the pool. Paddle wheels are used where there is inadequate running water supply to circulate the eggs in the pool.

Portable hatching jars are also used when unusually large numbers of eggs are obtained (Figs. 16a and 16b). These jars are also very practical for small-scale spawning activities.

5.5.2 Methods and procedure of artificial fish spawning

The success of artificial spawning of fish is dependent on the condition of the brood fish. Particular attention is given in this regard to ensure better results.

5.5.2.1 Broodfish rearing

The sizes of brood ponds vary from place to place but a size of 2 000-4 000 m² (3-6 mu) with a depth of 2-3 m is commonly used. Meticulous pond preparation is carried out by treatment with tea-seed cake, quicklime and green manure.

The rearing of brood fish also uses polyculture techniques with species combinations varying according to the major species desired. In Kwangtung Province broodfish stock density is 1 500-2 250 kg/ha (100-150 kg/mu) composed as shown in Table 7 below.

Table 7

Stocking Combination for Broodstock Rearing in Kwangtung Province

| Species | No. of fish/ha | Average Weight (kg/fish) |
|--|-------------------|--------------------------|
| 1. <u>Grass carp as major species:</u> | | |
| Grass carp | 150-200 | 8-12 |
| Silver carp | 60-90 | 2 |
| Mud carp | 600-960 | 20-50 g each |
| 2. <u>Bighead as main species:</u> | | |
| Bighead | 80-96 | 7-12 |
| Grass carp | 96-128 | 5 |
| Silver carp | 32-48 | 2 |
| Common carp | 320-480 (monosex) | 0.25 |
| 3. <u>Silver carp as major species:</u> | | |
| Silver carp | 150-240 | 3-6 |
| Grass carp | 96-128 | 2 |
| Mud carp | 480-640 | 20-50 g |
| 4. <u>Mud carp as major species:</u> | | |
| Mud carp | 1 600-2 240 | 0.8-1.45 |
| Bighead | 32-48 | 5-6 |
| Silver carp | 64-92 | 2-3 |



Fig. 14 Another type of hatching pool from the Hwa Chung Agriculture Academy, Wuhan

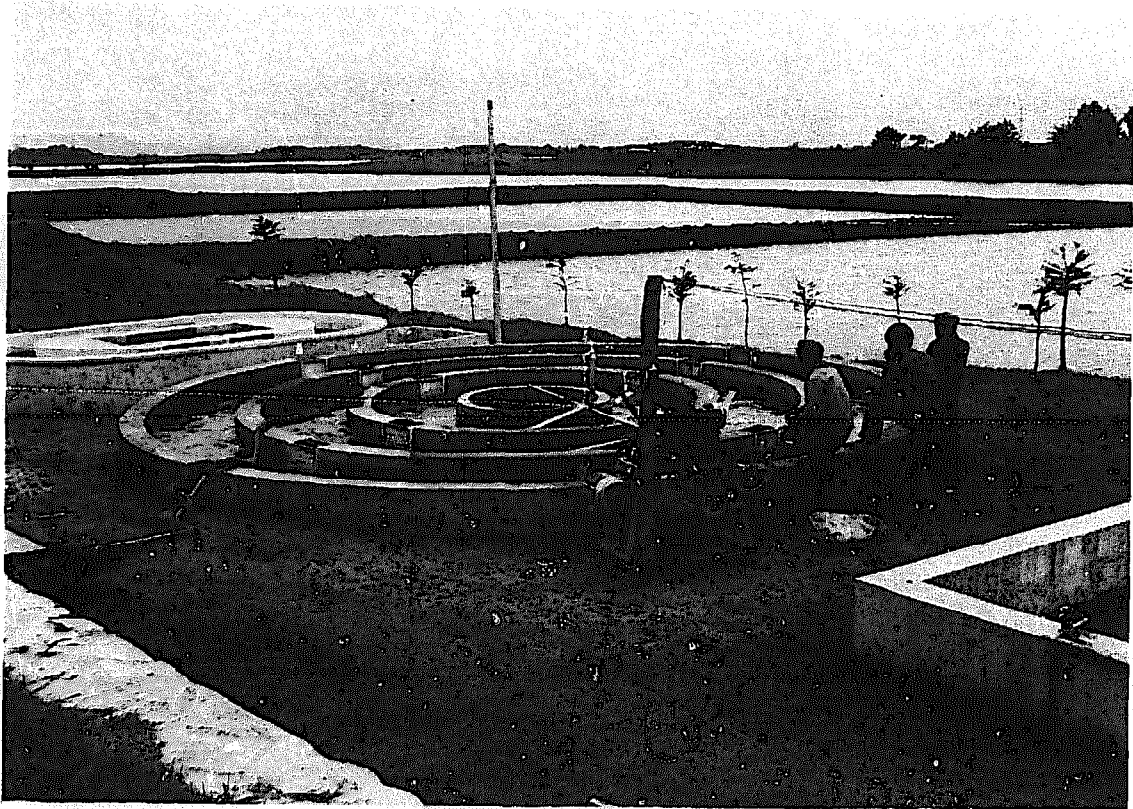
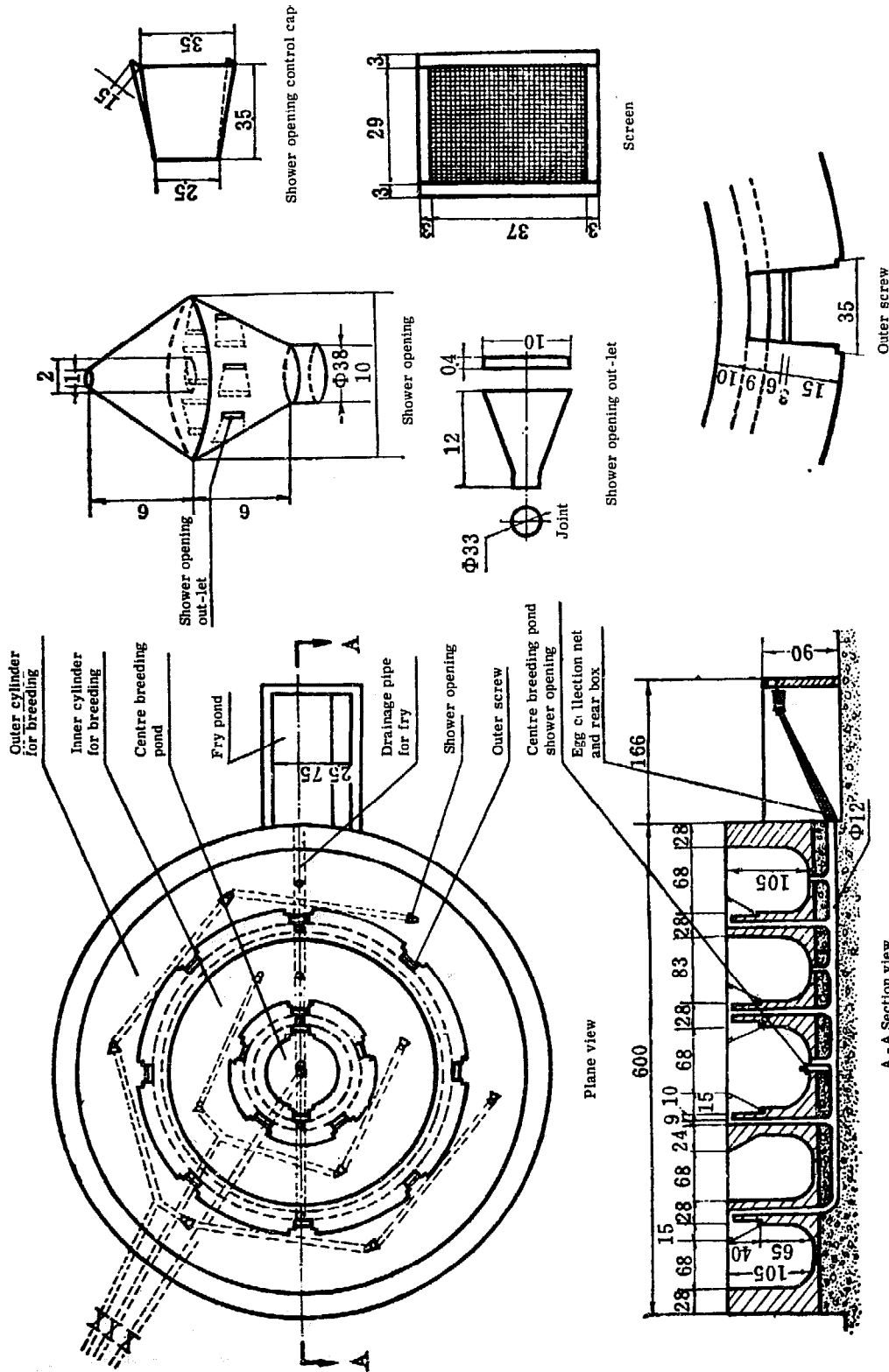


Fig. 15a A multiple-chambered hatching pool with paddle wheels for water circulation in locations where there is insufficient water for continuous circulation, Hwa Chung Agriculture Academy

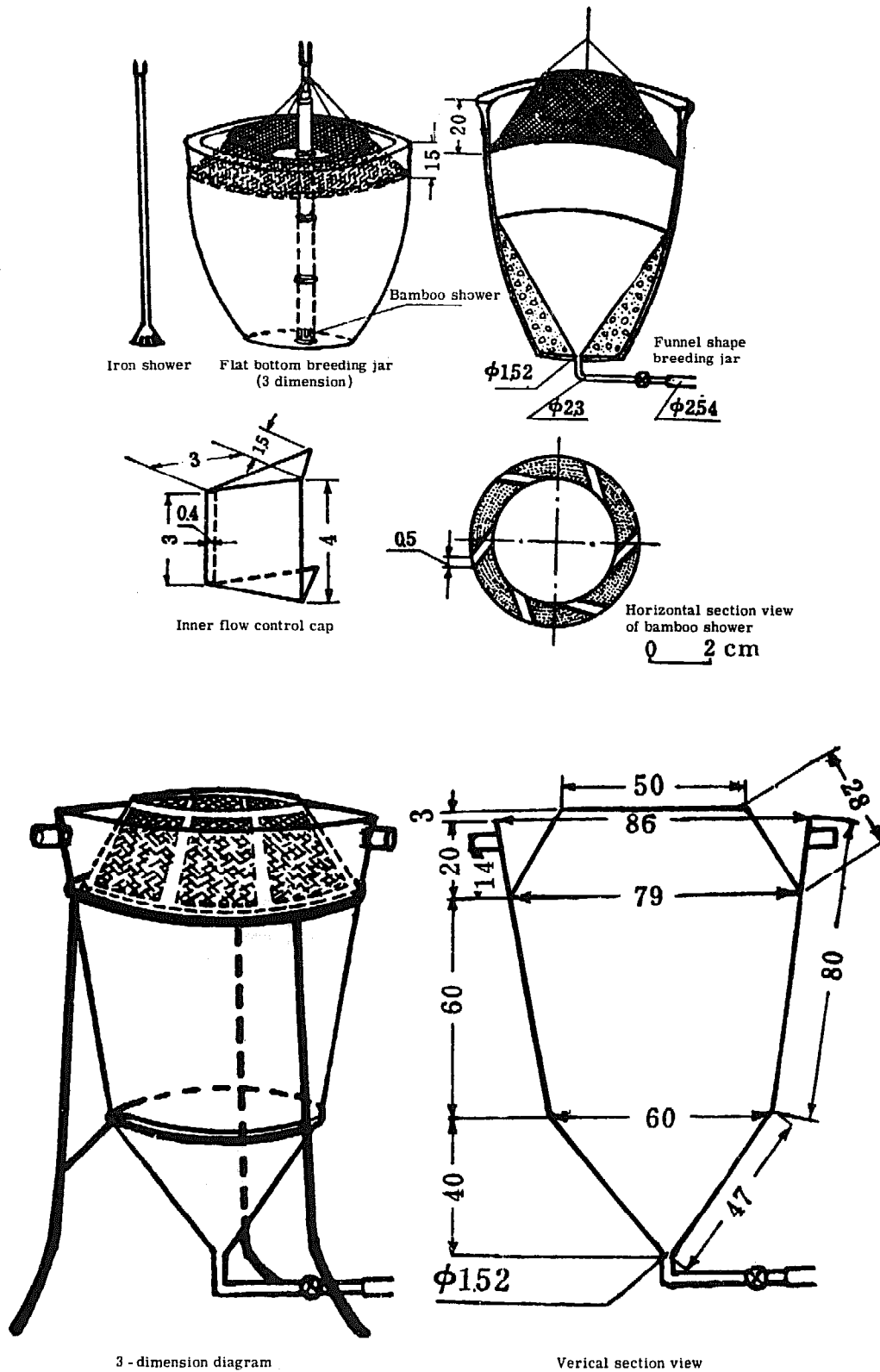


All measurements in centimetres

Fig. 15b Design of a three-chambered hatching pool (dimensions given in centimetres)



Fig. 16a Portable hatching jars installed
below a concrete water reservoir,
Hwa Chung Agriculture Academy



All measurements in centimetres

Fig. 16b Design of portable hatching jars as used at Hwa Chung Agriculture Academy

Water in the broodstock ponds is renewed in spring, once or twice a month, with water flowing two to three hours at a time. This simulates flooding and promotes spawning. The depth of water in the pond is maintained at 2-3 m.

Brood fish attain sexual maturity in ponds from two to five years. Silver carp mature in two or three years; grass carp four to five years; bighead three to four years, and mud carp three to four years. The males mature a year earlier than the females.

5.5.2.2 Induced spawning technique

Mature fish are selected by seining from the broodstock ponds and confined for a short period of time in a crowded condition, either blocked off by nets in one corner of the pond or suspended in the seine. This operation is carried out once or twice before treatment with hormones, to acclimatize the fish to handling and transport. It also excites the fish and facilitates removal of wastes from their system before actual injection is made so that no waste products are excreted in actual spawning or release of eggs. In this manner, the spawning ponds are kept clean.

After the desired species of brood fish have been duly selected, they are injected with human chorionic gonadotropin (HCG), 800-1 100 IU per kg of body weight (Fig. 17). Hormone injection is given twice, with an interval of eight hours, the first dose being 10-15 percent more than the second. The first is usually given in the evening and the last at daybreak. Males are injected once, usually at the same time as the females are given their second dose. Treated fish are kept in the spawning pools with a sex ratio of two males to one female for natural fertilization. The dry method of fertilization is known to the Chinese but they prefer the wet method or natural fertilization in the spawning pools as this prevents injury of the brood fish. The same brood fish can be used for as long as ten years by using this method, and they are able to obtain more complete fertilization of the eggs.



Fig. 17 Injection of hormone to induce spawning at Nan-hai Station, Kwangtung Province

Fish normally spawn after a few hours from the time the second injection is given. It is not uncommon to have fertilization even an hour or less from this period, which is very good. During the whole period when the treated brood fish are kept in the spawning pools, water flows at the rate of 0.2-0.4 m³/second. Water temperature may range from 20 to 30°C, with the optimum 26°C.

5.5.2.3 Incubation and hatching

After the fish have spawned, eggs are collected by opening the outlet of the spawning pond leading to the egg-collection chamber (Fig. 18). This is fitted with a net with which the eggs are concentrated for counting and transfer to the hatching pools. The eggs are stocked at the rate of 1 500 to 2 000/m² of water volume.

During the incubation period, a constant flow of water is maintained at 0.2-0.3 m/sec velocity to keep the eggs rolling in the water and simulating the riverine conditions under which natural incubation and hatching takes place. Hatching occurs after 36-48 hours, depending on water temperature.

Optimum water quality conditions for hatching are a temperature of 26.5°C, pH between 7.4 and 8.5, and dissolved oxygen concentration greater than 4 mg/l. Satisfactory hatching is obtained with temperatures ranging from 24°C to 30°C.

The newly-hatched fry are then transferred to fry nets (Fig. 19) installed in a nearby pond until the egg yolk is absorbed and the swim bladders have developed. They are then transferred to nursery ponds for growing or are sent to other fish farms.

5.6 Rearing of fry and fingerlings

5.6.1 Fry rearing

Prior to stocking of fry in the nursery ponds, treatment with 900-1 125 kg/ha (60-75 kg/mu) of quicklime in case of dry ponds and 1 875-2 250 kg/ha (125-150 kg/mu) for wet ponds (with 1 m of water) is made to eliminate unwanted species and pests. Tea-seed cake is also applied at the rate of 325-365 kg/ha·m (35-45 kg/mu·m) depth of water. Application of lime and tea-seed cake is done alternatively to maintain the normal pH of the water. Organic fertilizer or base manure (compost) is applied at the rate of 11 250-18 750 kg/ha·m (750-1 250 kg/mu·m) depth of water, 10-15 days before stocking of fry. This is divided into two to three applications, with the first dose more than the second and third. Water quality is observed prior to seeding the fry in nursery ponds. Bighead carp ("testing bighead") are used for this purpose. For the test, fingerlings 14-18 cm in length, stocked at a rate of about 5 000/ha, and adults, at a rate of 7 500/ha, are used. If dissolved oxygen is low, the bighead will surface, particularly in the early morning before sunrise. The Chinese associate low oxygen with over-fertility of water. This testing method is rather crude but perhaps the farmers have observed this through long years of practice. Certainly, the use of portable chemical kits for water quality analysis would be a simple thing to apply in this respect, and the techniques are well within the capability of the farmers.

The test fish are removed and fry are stocked at the following rates:

Low density stocking:

| | | |
|-------------|---|---|
| Grass carp | } | 1.6-2.4 million/ha (100 000-150 000/mu) |
| Bighead | | |
| Silver carp | | |
| Mud carp | | 4.8-6.4 million/ha (300 000-400 000/mu) |

High density stocking:

| | |
|-------------|---|
| Grass carp | 3.2-4.0 million/ha (200 000-250 000/mu) |
| Bighead | 2.4-3.2 million/ha (150 000-200 000/mu) |
| Silver carp | 3.2-4.0 million/ha (200 000-250 000/mu) |
| Mud carp | 4.6-6.4 million/ha (350 000-400 000/mu) |



Fig. 18 Egg collection net installed in the egg-collection chamber, also used for collecting fry from the hatching pool

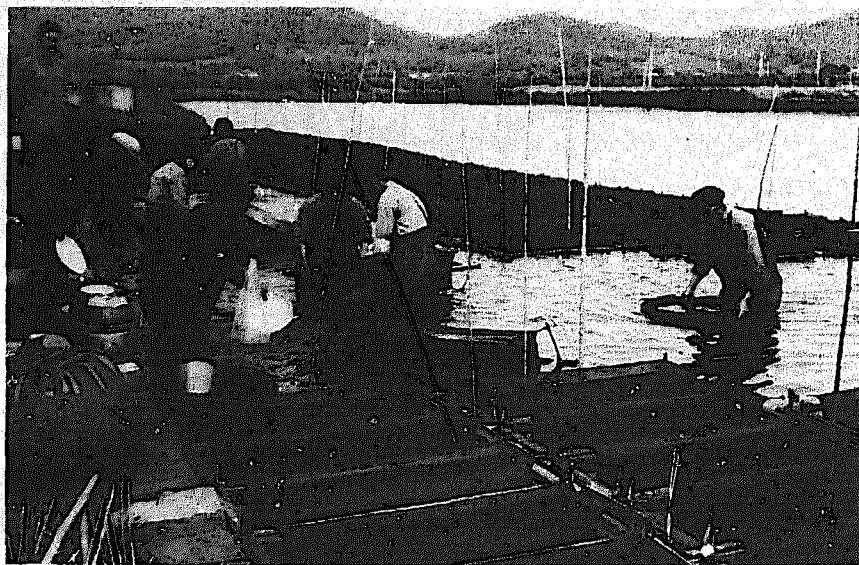


Fig. 19 Transferring fry from holding nets to plastic bags for transport, Nan-hai Station, Kwangtung Province

Feeding: elephant grass and vegetables at the rate of 13 tons/ha (875-900 kg/mu) is given in addition to fine food (wheat bran, rice bran) at the rate of 0.56 percent of total weight of fish during the rearing period of 30 days. The fry are 3.0 cm at the initial stage of rearing. Fry rearing is monoculture.

5.6.2 Rearing of fingerlings

Pond preparation for rearing fingerlings is similar to that undertaken in fry-rearing ponds. A uniform size of fingerlings, 3-3.5 cm long, is used.

Polyculture is adopted at this stage, depending on the plans of production. The fingerlings are reared in two stages. In the first they are grown from a length of 3.5 to 6 cm. This requires about 30 days. Grass carp, bighead and silver carp are all stocked at a rate of 4 500 000/ha (300 000/mu).

For the second stage they are transferred to another pond where they grow to a size of 12 cm. The following stocking rates were given for three different combinations:

| | | |
|---|---|---|
| 45 000/ha (3 000/ <u>mu</u>) - grass carp | } | 1 |
| 30 000/ha (2 000/ <u>mu</u>) - bighead | | |
| 45 000/ha (3 000/ <u>mu</u>) - silver carp | } | 2 |
| 90 000/ha (6 000/ <u>mu</u>) - bighead | | |
| 45 000/ha (3 000/ <u>mu</u>) - grass carp | } | 3 |
| 135 000/ha (9 000/ <u>mu</u>) - mud carp | | |

The fish are fed at the rate of 150-300 kg/ha (10-20 kg/mu) of duckweed, and 3 000-4 500 kg/ha (200-300 kg/mu) of green manure every ten days; 30 kg/ha (2 kg/mu) of peanut cake daily and 45 kg/ha (3 kg/mu) of vegetable tops daily are given as supplement. During the first month 30 kg/ha of vegetables are used daily while in the second month 30-50 kg/ha of grass are added to green manure daily.

5.7 Fish diseases

The Mission was told repeatedly that prevention of fish diseases was emphasized rather than treatment. Nevertheless, studies on treatment of disease also continue energetically. The Aquatic Biological Research Institute of Hupei Province is one centre for such work. It gives particular emphasis to treatment with locally available herbaceous materials.

The diseases being studied include bacterial gill rot, white-head and mouth disease, enteritis, white blood disease (Ichthyophthirius multifiliis), Myxosporidae (Myxobolus sp.), Lerneae and Cestodes, gill lice (mussel glochidia) and fungus diseases.

Plants that have proven efficacious for treatment include Platycarya strobilacea, Rhus chinensis, Carpatia japonica and various Euphorbia. These are all used in combatting diseases caused by slime bacteria, i.e., gill rot, white-head and mouth disease.

5.8 Fish-farm design

In view of the integration of fish farming into the overall agriculture farming system, fish ponds are designed in such a way that a close link between fish pond and crop land is realized. In places where fish is a primary crop, ponds are constructed in rectangular sizes of 4 000-5 336 m² (6-8 mu) each with pond dikes of a width varying from 1.2-1.8 m and a slope of 1:1 ratio.

On the other hand, in places where agriculture (i.e., soybean, sugar cane, mulberry) is the main activity and fish farming is a secondary crop, the size of ponds may be the same but the land area in between the ponds is much wider. This latter design was observed at the Shia-Kia People's Commune, where a ratio of water to land of 40:60 is used in farm development (Fig. 20). The technical details of farmland/fish pond layout are also discussed in section 3.8.

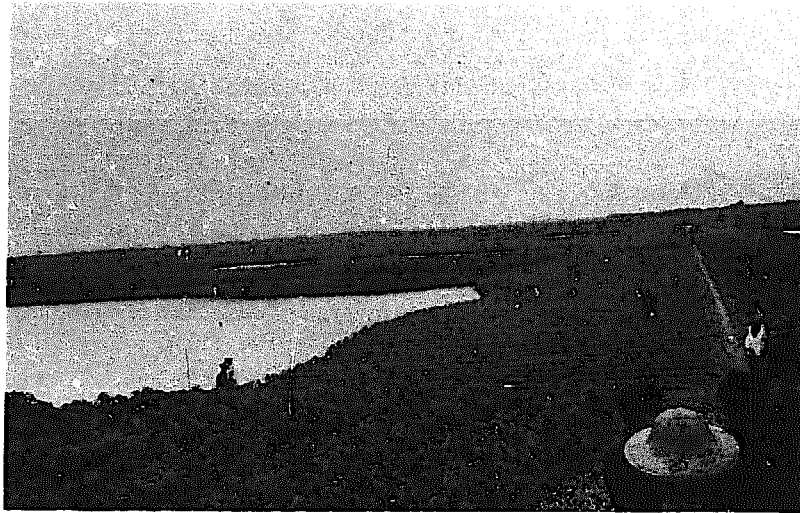


Fig. 20 A section of the fishpond/farmland layout of the Shia-Kia People's Commune, Kwangtung Province (see also Fig. 10)

The water supply is, in most cases, obtained through small canals constructed on top of the dikes. Drainage is almost always accomplished by pumping (Fig. 21). In the areas visited water for the ponds is obtained from nearby rivers, lakes or reservoirs through canals and ditches which, in many cases, were constructed primarily to provide irrigation water. The pumping stations usually include screens to prevent wild fish and other nuisance organisms from entering the canals and ponds (see also section 3.6).

5.9 Aquaculture production

The productivity of Chinese aquaculture is high. In Peking, the Mission was given the following figures used in national planning for production in fish ponds:

| | | |
|----------------------------|---|-------------|
| North of the Great Wall | - | 1 500 kg/ha |
| North of the Yangtse River | - | 3 000 kg/ha |
| South of the Yangtse River | - | 3 750 kg/ha |

The average productivity of the places visited was generally higher than these target levels, in some cases much higher. Data for the fish farms visited are given in Table 8. In the irrigation ditches near Shanghai about 1 300 kg/ha/year are obtained, even though these ditches are also used for boat traffic. The productivity per hectare of water surface is, of course, much less in lakes and reservoirs where intensive feeding and fertilizing is more difficult (see section 4.1.1).

Total production figures were not available. It is nevertheless clear from the figures given to the Mission on the water area used for fish culture that intensive culture is a major, if not the major source of fish in China.

5.10 Aquaculture devices and equipment

5.10.1 Aerators

The use of mechanical aerators to improve the output of ponds has been recently developed. These devices are mounted on floats installed at the centre of the ponds. Their use was observed in Shanghai at the Jie-fang Commune and at Ho Sung People's Commune in Nanking where a factory manufacturing the equipment was visited.

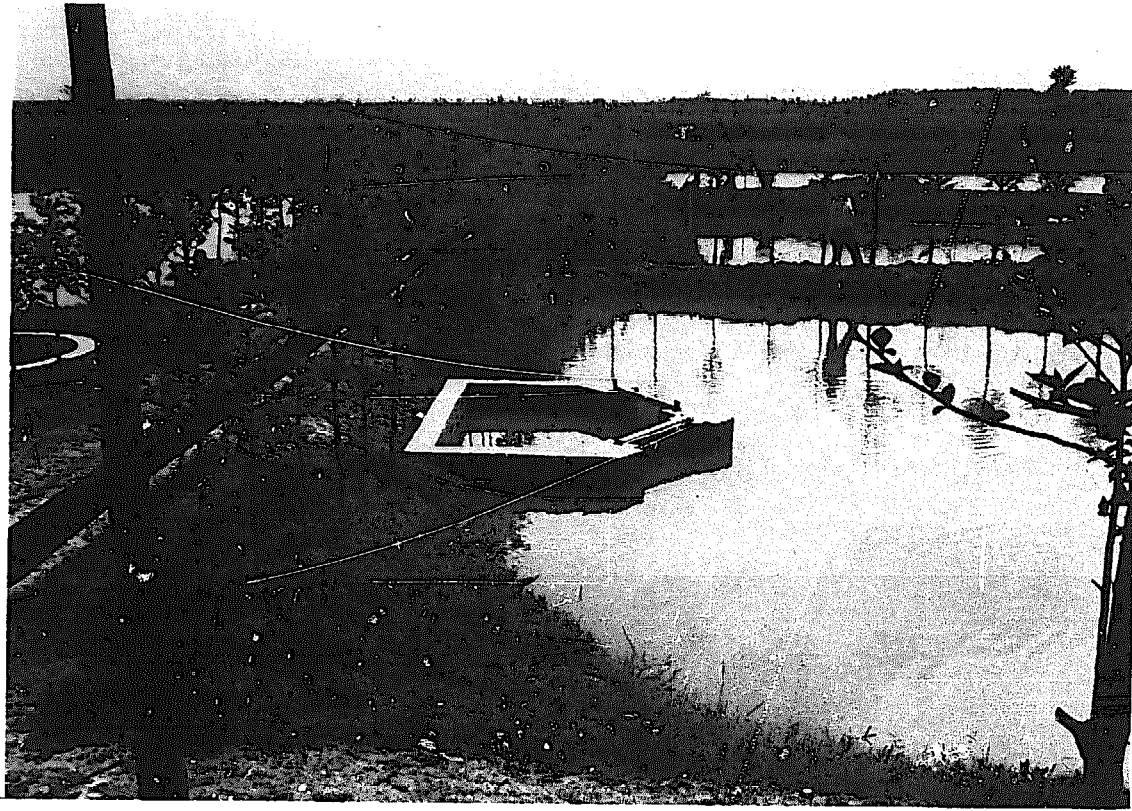


Fig. 21 Pond layout at Pai-tan Lake Fish Cultivation Station. Structure in foreground is used as a holding area for fry before release and pumping well. An electric water pump used to empty the ponds can be seen in the background

Table 8

Production in Intensive Culture

| Location | Province | Total Pond Area (ha) | Average Productivity (kg/ha) | Maximum Productivity (kg/ha) | Remarks |
|--------------------------------|-----------|----------------------|------------------------------|------------------------------|---|
| Fang tsun Experimental Station | Kwangtung | 13 | 4 500 | 7 500 | Research |
| Le Liu Commune | Kwangtung | 2 400 | 3 000 | - | |
| Shia-Kia Commune | Kwangtung | 80 | 2 235 | - | |
| Ho Law Commune | Kiangsu | 170 | 11 430 | - | Increased to 12 750 in ponds with aerators |
| Nan Huei Breeding Farm | Shanghai | 23 | 6 225 (1975) | 15 000 | Adult fish. Aerators used with supplementary feeding of crushed snails. |
| Jie-fang Commune | Shanghai | 900 | 4 000 | 8 000 | Aerators used with supplementary feeding of crushed snails. |

The farm machinery factories of both communes produce aerators. The machines consist of an impeller, with air tubes, which is rapidly rotated, throwing aerated water up and away from the unit. They are supported by floats and anchored in position with lines extending to the banks of the pond. One unit (7.5 kW) is adequate for a pond of about 0.5 ha (8-10 mu) in size.

These communes were using aerators in their fish ponds quite extensively. Previously, when the oxygen level in the ponds became too low, water had to be pumped into the pond, at first by hand and later by power pumps. Such pumping, however, was observed to reduce the fertility of the ponds by dilution. The aerator, by stirring the water, increases oxygen without water exchange. Aerators were operated for two to three hours around noon, or in the morning on overcast days. Frequent operation (once a day for an hour) has been shown to increase yields by about 14 percent (28 percent for silver and bighead carp). This is presumably brought about by the circulation of nutrients, stimulating plankton growth and by increasing the feeding activity and metabolic rate of the fish. The machine is now called a "yield-increasing machine" instead of a "fish-saving machine" (Fig. 22).



Fig. 22 Floating aerator as used at the Jie-fang People's Commune, Shanghai

5.10.2 Dredging machine

For deepening and excavating ponds, a hydraulic dredging machine has been developed by the farmers in Nan Huei County, Shanghai. The machine has a high pressure pump (20 kW), tube and nozzle to produce the jet stream used for digging. A suction pump and tube transports muddy water to the embankment site. Excess water is removed from the embankment with a vacuum pump, sand filter and suction pipe (see Figs. 23 and 24).



Fig. 23 Operation of the dredging machine, Jie-fang People's Commune. The suction pump at the centre transports the mud formed to the site of dike construction

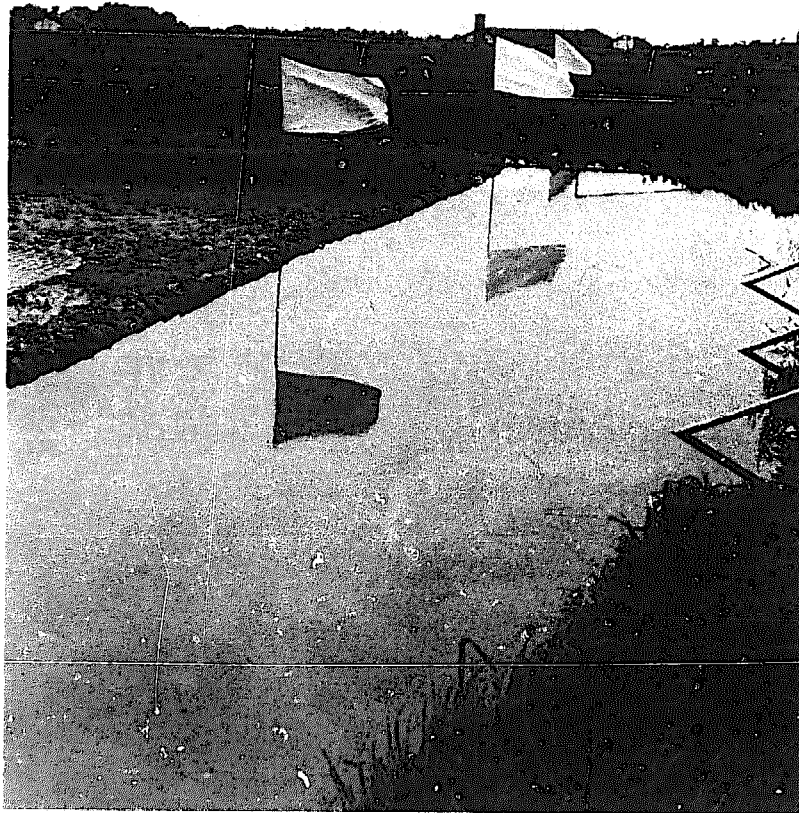


Fig. 24 Settling of mud from the dredging operation to form a pond dike. Pipes at right pump excess water from sand filters embedded in dike

5.10.3 Harvesting equipment

Harvesting of fish is done mainly by the use of seine nets dragged from end to end of the pond. The net may be operated with the use of flat boats at both ends to drag the seine or simply by pulling the net by hand through the length or a section of the pond. The fish are concentrated in a small portion of the net where they are scooped and loaded in baskets for transport to market. One unusual feature of the operation, seen at the Ho Law Commune, was the use of inflated automobile tires as floats to support the head rope. Wooden frames about 0.5 m high were mounted on top of the rubber tires. The top of the seine could be hooked on these floats (Fig. 25). These devices hold the float line about 0.25 m above the water surface reducing the escape of jumping fish. As the fish-catching operation neared completion the floats were removed from the net. This is a very practical innovation as the nets are less heavy and more convenient to store when not in use. The floats can also be used in other fishing operations within the farm without necessarily hauling the whole net assembly to another place. After using such floats, the rubber tires can be deflated for storage. Not all communes use the same type of float in the seine. This is an indication of local innovation in harvesting equipment.

No mechanical equipment for fish transport on the farm was seen. Such transport is usually accomplished by shoulder pole from pond to pond or from the pond to the live fish boat that brings fish to the market place (Fig. 26).

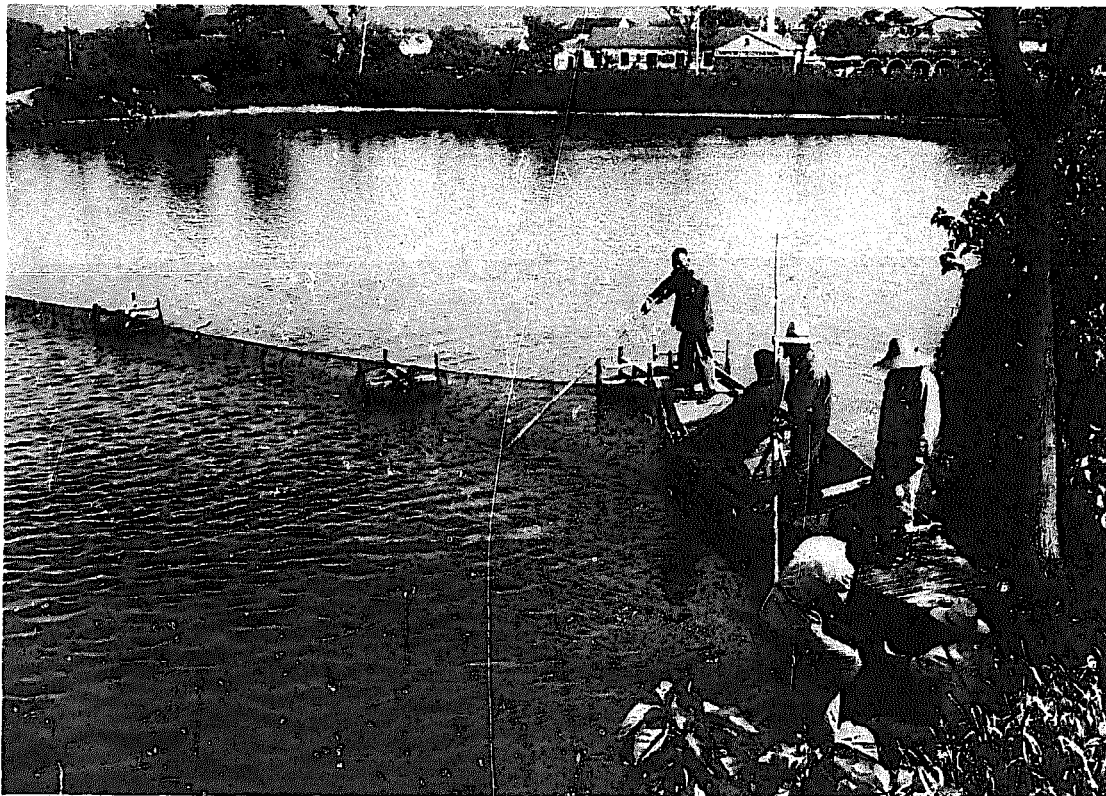


Fig. 25 Seining a pond using rubber tire floats to hold net above water, Ho Law People's Commune, Wushi

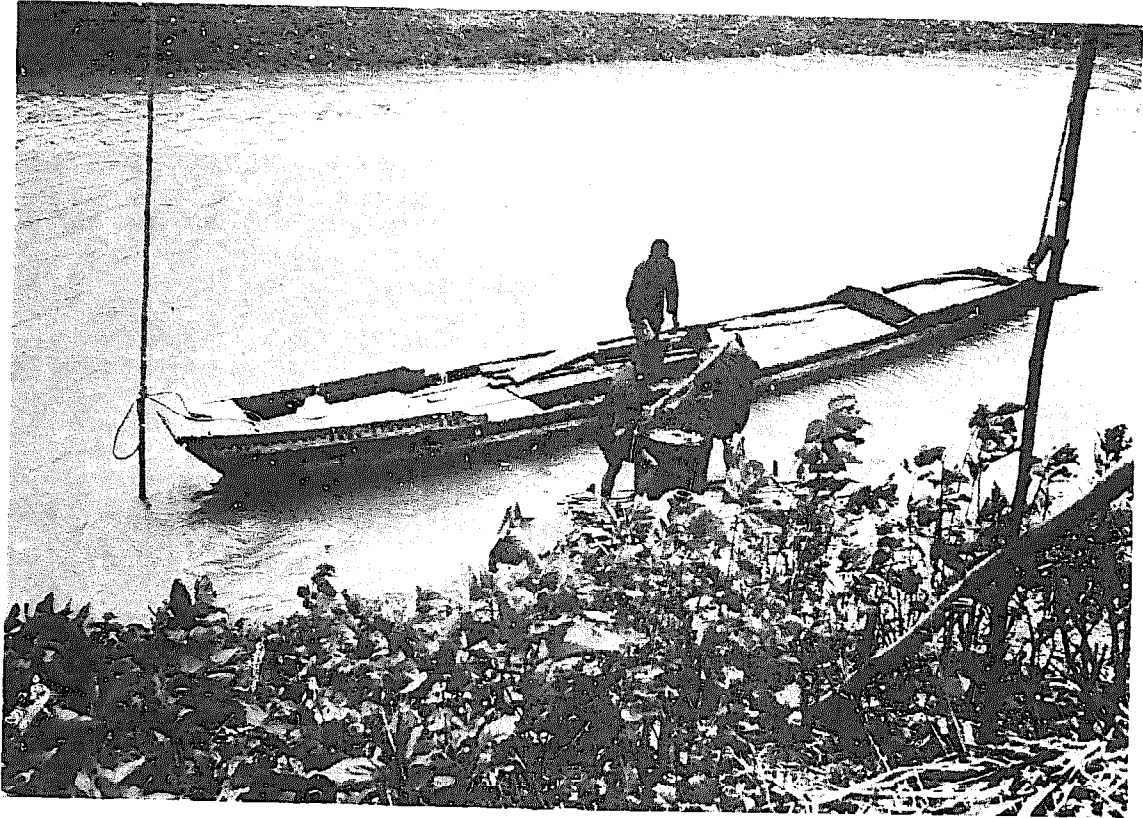


Fig. 26 Fish transport at Le Liu People's Commune:
(a) shoulder pole, (b) live fish boat in canal

5.11 Other aquaculture activities

5.11.1 Pearl culture

Freshwater mussel culture is undertaken in some ponds, lakes and reservoirs (Fig. 27). The species used are Anodonta woodiana (Lea) and Hyriopsis cumingi (Lea).



Fig. 27 Pond for culture of the freshwater mussel for pearl production, Chen-tung People's Commune, Shanghai

These mussels are used for pearl culture. The technique of pearl production is similar to that used in Japan. However, because the pearls are produced for medicinal purposes, the shape and quality of the pearls are not so important to the Chinese fish farmer. Pearls are obtained in one or two years of rearing, usually two. A mussel can be made to produce from 20-40 pearls (Figs. 28a and 28b), depending on the number of nuclei implanted in it.

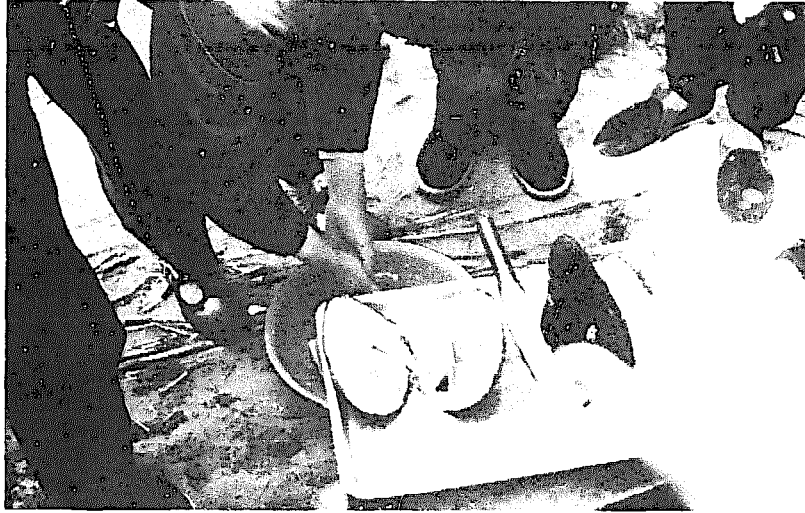


Fig. 28a Freshwater mussel opened for the removal of pearls,
Chen Tung Commune

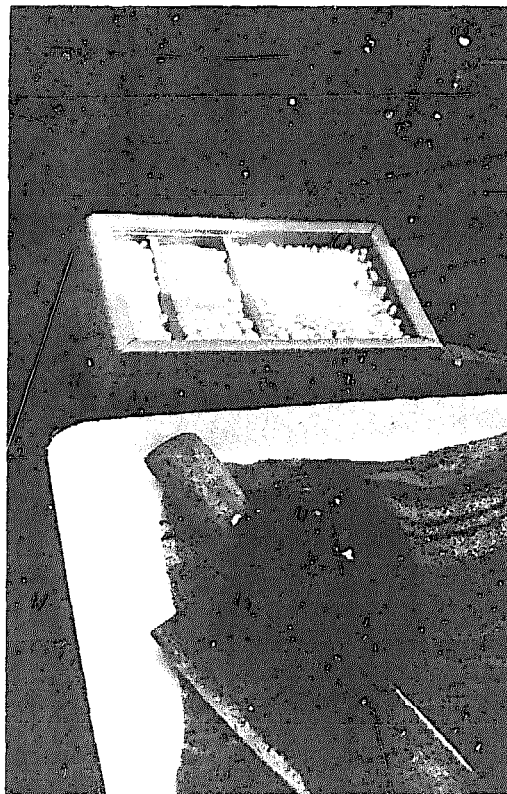


Fig. 28b Pearls produced at Chen Tung Commune

The culture of freshwater pearls might well be introduced in other countries in lakes and reservoirs as a productive sideline occupation for artisanal fishermen. It does not require a big space nor sophisticated equipment and farm implements. However, skill is required in implanting the nucleic material for pearl formation, and further research is needed to improve the shape of the pearls for most markets.

5.11.2 Mink production

Mink are raised as a sideline occupation in some fish farms in Shanghai. The Chinese call it a precious water animal because its skin is made into coats. Mink are fed with trash fish collected from the ponds or nearby lakes and reservoirs, or from marine waters. The feed consists of 0.4 kg of fish, 0.01 kg of grain and 0.01 kg of vegetables daily. Mink produce a litter every year, normally two to three young per female, but some individuals can give birth to six to eight young. The animal attains full growth in a year at which time it is slaughtered for its fur and the meat is fed to pigs. The skin is valued at Yuan 18 (U.S.\$ 9.00) per piece.

5.12 Fish genetics

Cross-breeding of the mirror carp and common carp has been carried out at the Freshwater Research Institute at Wuhan. The hybrid was found to have a much faster growth rate than the parents. A hybrid fingerling of 10 cm grows to 1.0-1.5 kg in six months rearing period. Tests in the use of the hybrids in polyculture, at a stocking density of 10 000 normal "family fish" species plus 10-20 hybrids, showed that the hybrids would attain 1.5 kg in six months.

Silver carp and bighead have also been cross-bred but the characteristics of the hybrids are still under evaluation.

5.13 Summary and recommendations

5.13.1 Summary

Aquaculture in China is a part of the overall agricultural farming system. It is either carried out as a primary farm occupation, a secondary or sideline activity depending on the extent and nature of land and water resources available. This integration of farming activities provides a vivid demonstration of how the full use of all raw materials available in the farm can be cycled into the production of food. Animal manures are used to fertilize the ponds and croplands; the land, in turn, produces crops for food of animals, fish and man; the wastes of fish accumulated in the pond and/or lake muds are recycled back to the soil where land crops are grown. This illustrates the practical reasons for integration and diversification of land and water farming.

Integration of aquaculture with agriculture is carried out only on a limited scale in other countries, unlike the full integration that is found in China. A major reason for this is the difference in the control of the means of production, and in the ownership of resources used for production. Most countries have private land ownership systems where it is difficult to implement a unified development strategy. In China, land is state-owned and development programmes are centrally directed even though implementation is highly decentralized. This gives flexibility at the local level in undertaking their respective production activities but at the same time maintains central control over the resources decisive for nationwide development. Local needs and experience are the basis of planning which provide a strong motivation for rural production and development. Innovation in methods and equipment is encouraged.

Generally, agricultural development plans and programmes elsewhere overlook aquaculture simply because aquaculture has not gained recognition as an integral part of farming activities. It would, perhaps, be beneficial to FAO member countries and to FAO itself to re-examine their approaches to agriculture development to include the development of aquaculture to effect the maximum use of resources, such as land, water, manpower and raw materials of production.

While the polyculture technique of freshwater aquaculture is known in other countries, its practice elsewhere, except in India, is not as wide and extensive as is found in China. The reasons for this may be:

- (a) the lack of organizational and statutory arrangements to promote aquaculture in general and polyculture in particular;
- (b) the lack of suitable species of fish for polyculture;
- (c) the lack of readily available fish seeds for aquaculture use;
- (d) the lack of demonstration activities by which polyculture of locally-available species may be brought to the attention of farmers and local planners;
- (e) the lack of adequate research activities to back up the development of freshwater aquaculture;
- (f) the lack of an effective mechanism for extension work to transfer aquaculture technology at the farm level;
- (g) the lack of financial support for small-scale aquaculture operators.

One important feature of the recent development of Chinese fish culture is that research activities are undertaken with the combined participation of fish farmers and technicians. Scientists work in the farms, which facilitates rapid transfer of technical information and practical experience among the workers. The rapid dissemination of technical information and any new innovations in fish-farming techniques take place through regular sessions of summing-up farm experiences among the production teams from different locations. Improvements in farming methods therefore take place quickly, even before the research results and experiences have been written down in printed form. Extension workers, such as those being trained in other countries, are less necessary in China. The problem of communication gaps between farmers and technicians, so typical in other developing countries, does not exist in China on account of the work system that prevails in the country.

5.13.2 Recommendations

The role of aquaculture in integrated rural development was vividly demonstrated to the Mission. While such development has been the goal in most developing countries, it has remained an elusive one due in large part to problems of organization and institutions which somehow preclude the attainment of successful results.

There is a great potential for aquaculture development in the developing world on sites which are still in the public domain. There is also an abundant supply of human resources, the majority of which are made up of subsistence farmers who do not own the land they till. Aquaculture technology is already developed and different methods of production are known, including those practised in China. Species used for aquaculture in China are also found in other countries. There are also similar species which could be used for polyculture.

With the above resources, the developing countries might greatly benefit from the Chinese experience with the help of FAO by:

- (i) organizing study tours to China composed of government officials and others concerned with decision-making in aquaculture, agriculture and water resource development policies and planning;
- (ii) establishing pilot projects to demonstrate the feasibility of a fully integrated aquaculture development in developing countries. A project proposal of this nature is already in the pipeline prepared with the collaboration of the Department of Fisheries.

Furthermore:

- (i) FAO should promote and encourage the development of integrated aquaculture by examining its own procedures and approach to providing technical assistance to member countries on agriculture development. The involvement of farmers in the actual project planning and implementation should be looked into as a means of reaching the grass-root level as directly as possible.
- (ii) FAO should assist in the documentation of the Chinese aquaculture systems. A documentary film, which could be used in the dissemination of information through seminars and training of farmers, would be specially useful. Such a film, if produced in different languages, would educate and inform as many people as possible at one time in many places around the world, particularly in developing countries where food production is more urgently needed. As an initial step, the commentary of the Chinese film on artificial spawning of fish should be translated into English and perhaps Spanish and French for use in the training of fish farmers in developing countries.
- (iii) The Mission brought back to Headquarters various practical manuals on aquaculture in China. Some of these documents should be translated for the use of FAO and FAO member countries. A list of this material is given in Appendix II.

6. FISH DISTRIBUTION AND MARKETING

Fish distribution and marketing are major problems in most developing countries. While the Mission did not examine these questions in detail, there seemed to be few problems in China.

The Chinese like fresh fish and most of the freshwater fish is sold this way. Ice is seldom used as the fish are not transported over long distances. A considerable portion is marketed live, especially in southern China.

Most people's communes produce and supply their own fish requirements. Special efforts are now being made to intensify fish production near the cities to minimize transport and supply problems. The Mission was told that city authorities know the daily requirements of their populations and only enough fish are harvested to meet these requirements.

A similar principle appears to govern the harvesting of vegetables. They are gathered usually the day or night before being carted into the city.

Around the cities and towns, the full fishery potential of small and medium-sized lakes is realized by combining fish production with animal husbandry and vegetable crops.

The State has purchasing centres which handle fish marketing. In Le Liu People's Commune in Kwangtung Province, which the Mission visited, there are three State Fish Purchasing Centres. Fish produced in the Commune are generally transported live from the production area in small boats (3-5 tons) with fish compartments in the perforated hull. On arrival at the Fish Purchasing Centre, the fish are sorted according to species, weighed and transferred to a bigger (30-ton) transport boat, also with a perforated hull to supply water to fish compartments. This boat carries fish to the market areas in Canton. Some fish are subsequently exported, still alive, to Hong Kong markets.

The market size of the fish is at least 1.0-1.5 kg. Prices are fixed by the State and the average price is about Yuan 0.76 (U.S.\$ 0.38) per kg.

A comparison of the retail price of fish in the Shanghai area, with other basic food commodities is as follows:

| <u>Food Item</u> | <u>Retail Price</u> (in Yuan per kg) |
|--------------------|---|
| Pork (first grade) | 2.4 |
| Pork (third grade) | 1.60-1.80 |
| Vegetables | 0.04 |
| Fish | 0.60-0.80 |
| Chicken | 2.40-2.60-3.00 |
| Duck | (a little cheaper than chicken) |

The Mission was informed that there is very little processing of freshwater fish, at least of the culture species. Such processing as is done is negligible, usually limited to small and/or wild fishes from capture fisheries.

At the Canton Trade Fair, the Mission did see samples of canned freshwater fish. These were silver carp with meat filling, silver carp in tomato sauce, and fried carp with scallions.

7. RESEARCH, EDUCATION AND TRAINING

7.1 Introduction

The policy adopted in China is that research, education and training should serve production. In putting this into practice, they have adopted what they call an open-door policy of research and teaching.

These policies are being achieved through "three-in-one" combinations. Leaders, researchers and worker/farmers identify production problems together and work together to solve the problems. Teachers, researchers and worker/farmers teach each other and learn from each other.

Furthermore, the combination of "theory with practice" is more than just talk. In the Mission's view it seems to be a hard and fast rule at all levels of research, education and training.

A practical effect of these working policies has been that even artificial fish propagation is now commonly and widely practised by ordinary fish farmers in the countryside. In contrast this is a highly specialized field in most other countries, usually only done by government scientists/technicians.

7.2 Research

The Mission visited several research institutes in Shanghai Municipality and in Kwangtung, Hupei and Kiangsu Provinces. Everywhere the "open-door" method of carrying out scientific research was evident.

Research institutes have organized "three-in-one" groups composed of workers, technicians and scientists. Together these groups identify problems of production; together they plan and carry out research, not only in the laboratory but more often in the field at actual site operations.

Production units themselves also develop scientific research through the "three-in-one" combination.

The institutes have adopted a basic pattern by which researchers go to the production field to learn from fishery workers and fishermen, while assisting them in production and in practical research. Thus, the fishery workers and fishermen play a very significant role in the scientific research effort; the researchers, on the other hand, combine the generalization of scientific work with production.

In Shanghai there are ten counties. A network system of collecting all problems of production, views and experiences from these counties has been organized by the Fisheries Research Institute of Shanghai. It is a "Science Technique Exchange Group" and seeks to increase the level of science and technique of the fishery production workers.

The Group collects all problems in the field which have to be solved. Research workers take part in this job. Through this "Science Technique Exchange Group" and the "three-in-one" combination, the research workers combine their scientific knowledge and discuss possible avenues for solution. Meetings are held once a year for one to three days with about 200-300 people participating.

7.3 Education and training

Like the research institutes, the educational and training institutions of China have also adopted the "open-door" policy.

Teachers themselves must go to the field, especially to the more advanced production units, not only to teach but also to learn from the worker/farmers. They join the peasants and workers and participate in physical labour in the communes.

For the students, the result of an entrance examination is no longer the criterion for entering an educational training institution. Colleges and universities admit students in accordance with Chairman Mao's instructions that "Students should be selected from among workers and peasants with practical experience". They must have a minimum of two years', preferably five years', working experience in the field. They are also selected from, among and by the commune members. On completion of their education the graduates usually return to their respective production units in their commune.

A few graduates, who have to further their education and training for specialized and advanced scientific research, are assigned by the State to research institutes.

Teachers and students often go together to fish breeding farms in the communes, combining production with scientific education and research.

Since students have practical experience before entering an educational institution, they also take part in management of the schools. Together with the teachers, they comment on teaching methods and materials and help in raising the quality of teaching.

University technical education has now been reduced to three years from the former four to five-year programme. The number of subjects taught has been reduced. The courses retained are those most directly related to actual production.

Educational institutions and even communes organize short-term training courses periodically. In at least two communes visited by the Mission there were special buildings to house and provide laboratory space for research. These were called "peasant universities".

Such training courses for peasants are usually organized during the slack labour season or during evenings. Parts of training courses are, however, also held during the actual fish-breeding season. Throughout the whole educational and training process, emphasis is laid on combining theory with practice.

Workers, students and farmers with political consciousness and practical experience take to such a university type of education and short training courses "like fish to water". Another educational policy is the so-called "ups and downs" system of college teaching. "Up" means the students combine work with study within the college. "Down" means the students return temporarily to production teams to put what they have learned into practice. The activities, duration of periods, and number of "ups and downs" vary according to different specialities and grades.

8. SOCIO-ECONOMIC ASPECTS OF THE DEVELOPMENT OF AQUACULTURE

8.1 Introduction

The success of aquaculture in China stems partly, of course, from historical, resource and technological factors. The Mission believes, however, that a large measure of this success has come from the close linking of fish culture with agriculture and with other sectors of production, and from various other characteristics of the Chinese social and economic system. As background for considering how China's experience might be put to use in other countries, these characteristics are summarized in this section.

8.2 Integration of productive activities

"Comprehensive integrated development", and especially "integrated rural development" are popular concepts in development planning. However, such integration remains a somewhat elusive goal in most developing countries. In China it is happening - and on a large scale.

8.3 The organization of the communes

It was not until 18 years ago that the communes became the accepted major unit of social and economic organization. They are large enough (in the order of tens of thousands of persons) to undertake major supporting projects such as road and reservoir construction, industry and merchandizing. But they are also small enough to ensure that local experience and local needs are the basis of planning.

Individual income is also distributed from this level by sharing communal proceeds. Thus integration of production is beneficial to everyone, provided it leads to an overall gain in communal income, even if some kinds of productive activity are reduced. An improvement in fish production is as much concern to the farmer or factory worker as to the fisherman. Cost/benefit ratios are calculated on a community, not a project basis, and not on strictly monetary grounds.

8.4 "Take agriculture as the base"

Following the difficulties of the Great Leap Forward in 1958, and particularly since the Cultural Revolution (1969), China has given development of agriculture first priority. China intends to achieve self-sufficiency in grain with a sound rural economic base. Irrational growth of cities is to be prevented. Hence, industry must grow on the purchasing power of the countryside, that is, of the farmer. Fish culture has benefited greatly from this emphasis. Accelerated development of irrigation and electrification of grain farms provides water and power for fish farms. Fish make efficient use of waste agricultural products and are useful in maintaining soil fertility. In many areas fish culture is as traditionally a part of farming as the raising of pigs and ducks.

8.5 Simple but effective promotional campaigns

The Chinese have traditionally used proverbs and slogans as a major tool of social instruction. Such instructions are repeated everywhere and convey national policy to the farthest villages. These directives are repeated in every explanation. They appear on signs and posters, in meetings for criticism and meetings for planning, in the education of small children as well as of fishery technicians and workers.

Among the sayings are:

"Take grain as the key link, and ensure an all-round development of agriculture, industry, animal husbandry, forestry, sideline occupations and fisheries"

"In fisheries do stocking and catching in rotation"

"Freshwater fishery is the side-line of agriculture"

"Lay stress on culture and simultaneous development of culture and capture"

"Wherever there is water there should be fish"

8.6 The "three-in-one" combination and "open-door" research and education

The Chinese Revolution sought to curb the gross economic inequalities of the landlord system of old China. The Great Proletarian Cultural Revolution aimed, among other things, at curbing elitism specially among officials and intellectuals. The result is that working experience is put ahead of education as a qualification of the individual, and practice (experience) is seen to precede theory (summing up of experience). There is full recognition given to the special experience of all. Thus work and planning are done by "three-in-one" combinations such as: "young, middle-aged, and old"; "researcher, technician, and peasant-farmer".

Universities are now open to the farmer, not only to learn, but also to teach. The fisherman now has access to the research laboratory not only so he may get new ideas but also so that he may give his own ideas. Conversely, the teacher and the research scientist spend time in the field, on the fish farms or on the fishing boats in order to share experiences and to learn what the problems really are. Similarly, management is opened to all (though there appears to be an emphasis on political and production experience). "Three-in-one" combinations are also a part of the structure of the Revolutionary Committees of communes as well as of production brigades and teams.

The benefits of emphasis on practice and experience, and the frequent movement of people from production to education and research and back to production, carrying the experience from one place to the other, were seen by the Mission in the relatively rapid spread of techniques in artificial propagation of fish, large-scale fish catching and the design and use of aerators in fish ponds. A proven idea is rapidly put into practice.

8.7 Production-oriented motivation

Interpersonal competition and rivalry have not disappeared from Chinese life. Yet the currency by which achievement is judged seems to have been effectively changed from consumption to production. Prestige is not earned by individual possessions. (In fact, they seem to be something of a liability, if not shared by others.) Nor is it earned by purely intellectual achievement. One succeeds by producing individually, and more importantly as member of a group. "Learn from Tachai" is one of the most common mottoes seen and heard. Such groups as the "Iron Girls" are praised and emulated. The ease with which large volunteer work teams are mobilized to build dams, or dikes or fish ponds is difficult to understand for an outsider. This kind of motivation also makes it relatively easy to assign people to work at jobs which are needed by the community rather than those corresponding to the individual's interest or even previous experience. Over-fishing of lakes in China is, for example, no longer a difficult problem to correct owing to this communal perspective on production.

8.8 Other factors

There are other social and economic factors that have helped stimulate the development of fish culture. These include: movement of fishermen from their boats to the shore for housing; the needs and special characteristics of the planned economy; provision of parks and other recreational facilities for the workers, and also the traditional appreciation of fish as food.

8.9 Moving fishermen to the land

Until recently, Chinese fishermen of lakes, rivers, and sea lived on their fishing boats. The 1949 Revolution freed them of the worst of the economic abuses of the "fishery despots". It was not until some time later that their special problems were considered. First, cooperatives were formed to help them buy gear, share labour and market their fish.

But the cooperatives were unable to cope with larger problems. The formation of communes from cooperatives provided a structure to cope with these problems. A policy decision to emphasize fish culture rather than capture then followed. This policy sought to increase productivity and settle fishermen on the land. Fishermen were encouraged to farm as well as fish. In the communes formed from fish cooperatives, such as Chen-Tung Commune, many persons are no longer solely engaged in fishing at all but have diversified their economic base. The first fishermen's village was built in Shanghai Municipality, a traditional fishery area, in 1965. Now fishermen all over the country are settled in such fishing villages or in other kinds of housing units such as Ten-Shan Workers Village Complex visited by the Mission. These changes have spurred fish culture.

8.10 A planned economy

The socialist economic system attempts to produce only those things for which there is need and only in the amount required. It was difficult for Mission members to understand such responses as: "No, we are not planning to expand fry production facilities. We are already producing all that are required". Certainly this approach facilitates planning. It can stabilize prices and encourage diversified development. It stimulates fish stocking in lakes and canals to curb fluctuation in catch.

It also produces some peculiar problems for fisheries. The Mission, for example, was not quite sure how the three or four large catches per year, which comprise most of the harvest in Pai Tan Lake or Ho Lung Reservoir, are coordinated with harvests in other places to ensure a steady supply of fish in the markets. As most of the fish sold in the south is fresh or live, there is little flexibility in distributing fish once harvested.

8.11 Provision of recreational facilities

Water resources near cities have received extra attention in China as sites for recreation as well as fishing. Recreational use places some constraints on fish production (e.g., distribution of feeding sites) but the overall relationship seems beneficial. Recreational use is an additional stimulus to lake and reservoir improvements.

8.12 Fish as food

In most of China, freshwater fish is a highly appreciated food item. The Chinese have developed many ways of preparing fish for the table. In some places, per caput consumption is high, as in the Le Liu People's Commune (48 kg/year). In other areas, however, fish has not been a traditional item in the diet. This is the case in Shansi and Kansu Provinces, or in the Inner Mongolian or Ningxia Autonomous Regions, though there are fishery resources there. This is now changing. But fish consumption, for the country as a whole, is still relatively low. And the need for fish for domestic consumption has certainly not yet been satisfied. This need and desire for fish will continue to encourage the expansion of fish culture for some time.

8.13 Summary

The Mission believes that the kind and rate of expansion of aquaculture which has occurred recently is linked to China's socialist economic and social system. The Mission is not fully convinced that such socio-economic organization is, however, essential or pre-requisite to the rapid development of aquaculture and freshwater fisheries elsewhere. But it does believe that such development will occur only when careful attention is paid, as it is in China, to the simultaneous development of all local resources, as well as to the technology of fish culture, and above all when the details of aquaculture are planned and evolved at the level of the fisherman or fish worker. The Mission further thinks that it is essential to strengthen motivation conducive to real "integrated rural development", and to the development of practice along with theory in all developing countries.

9. GENERAL OBSERVATIONS AND RECOMMENDATIONS

9.1 Impressions

Certain key impressions stand out in the Mission's initial observations. These include:

- (a) In many Asian countries, aquaculture tends to be an "elite craft". Artificial spawning is a highly specialized field limited to technicians and scientists. In China, ordinary farmers throughout the countryside practise this craft.
- (b) Concepts in integrating agriculture and fisheries are well known (worldwide), but China puts these concepts into practice. Integration is realized to an effective degree.
- (c) The Chinese have broken away from the traditional monoculture pattern and rely on polyculture. In this practice, there is effective use of indigenous materials and simple technology.

9.2 Conclusions

The Mission feels that the potential for production of fish by intensive culture is more fully developed in China than in any other country.

- (a) There is full integration of fishery and fish culture with water conservancy, agriculture, forestry, animal husbandry, sideline occupations and intensive use of land and water resources, specially at farm level.

Throughout the trip, the emphasis China places on comprehensive and intensive use of land and water resources was evident to Mission members. Water bodies for drainage or irrigation were also used for fish breeding and catching. Fish reared in these areas convert agricultural wastes to fertile water and the humus-enriched bottom mud of ponds is used as fertilizer for crops.

Watershed management seeks not merely to control erosion but also to increase water fertility. Pigs, dairy herds, manure crops and orchards are actively promoted to benefit fish production. Land consolidation includes fish ponds as well. This multi-faceted approach was impressive.

- (b) Fish polyculture is practised within the same body of water

Mixed species cultivation or polyculture is the general practice. The Mission was told that wherever there is water - in ponds, lakes, reservoirs, ditches or paddy fields - fish are being raised. Major Chinese carp species are raised in combination with other species. Monoculture is practised only in the rearing of fry.

Management of water for aquaculture consists of organic manure application and feeding. Inorganic fertilizers or commercially prepared feeds are not used. Fodder grown along dikes is the main supplementary feed. Thus, fish do not compete with people for food.

Aerators are used to increase productivity by 20 percent or more. There is stress on disease prevention. Since 1958, artificial spawning produces a reliable source of fry and fingerlings for both pond culture and for stocking lakes and reservoirs.

- (c) Lakes and reservoirs are effectively managed for all-round development.

Extension of polyculture principles in ponds to these bodies of water results in full use of natural foods in lakes and wastes from surrounding land.

Effective use of direct management methods like fertilization and systematic stocking or indirect methods like watershed management raises productivity. Generally, shallow lakes and reservoirs of the heavily populated lowlands like Taihu Lake in Kiangsu Province produce about 50-70 kg/ha in large bodies. Yields of 1 000 kg/ha were reported in lakes smaller than 1 000 ha.

- (d) The policy of "open-door" research, education and training translates itself into productivity increases.

As in other agricultural sectors, research in fisheries is problem-oriented and combines theory with practice. Researchers and farmers teach and learn from each other. At least two years' production experience is required of those who enter university or technical school. Teachers must work in the field too.

- (e) Programme planning is decentralized and enables popular participation. This results in effective implementation.

The commune structure enables farmers to plan their programmes to meet local needs. The commune, at the same time, has enough resources and skills to meet those needs. Planning and implementation are done at local level and therefore achieve effective integration and parallel development of related sectors.

- (f) Efforts to sustain community consciousness and collective action are unremitting.

At all levels of Chinese society, emphasis is given to motivating people to work for the benefit of all. The rapid development of fish production appears partly due to this mobilization of people and to their pride in their own contributions to communal production.

9.3 Recommendations

The Mission believes that FAO and many of its Member Nations may gain considerable benefit from knowledge of China's experiences in fish culture and its development. The particular forms of fish culture practised in China may not be directly applicable in many countries, particularly outside Asia. But the perspectives of Chinese fish farmers on self-reliance and on the inter-dependence of aquaculture, agriculture and animal husbandry, and their familiarity with fish and fish behaviour under conditions of intensive culture, make their experience most valuable elsewhere.

The Chinese insistence on adopting the living standards of the localities in which they work, especially their insistence on doing so in their programmes of aid to others, make it difficult to fit individual Chinese experts into the usual FAO-managed projects. Provisions must also be made for the problems of language.

Considering the above, the Mission recommends that FAO encourages the use of Chinese expertise and experience in some or all of the following ways:

- (1) Projects and sub-projects in small-scale water development, irrigation, and reservoir management, especially where fish production is one of the objectives.
- (2) Projects for the development of medium to large-scale culture of Chinese carps.
- (3) Combination pilot, demonstration and training projects in intensive culture of fish and/or in the management of the fisheries of small reservoirs (less than 1 000 ha).
- (4) Exchange programmes and/or study tours for fish farmers (groups of 10 to 20) for both Chinese groups visiting other member countries and vice versa (a group should have common language).
- (5) Study tours for inland fishery administrators and planners to provide them with new or different perspectives on their own problems.

- (6) Preparation of manuals and training materials on the polyculture of Chinese carps, management of small reservoirs for multiple use, irrigation works and water management. These should be prepared, in the official languages of FAO, by sending to China experts in the respective fields whose language is that of the manual to be prepared. Periods of two to six months are appropriate.
- (7) Research and practical training for FAO staff in China for periods of one to three months under the Refresher Training Programme in such topics as induced breeding of fish, pond productivity, culture of freshwater mussels.
- (8) Preparation of a documentary film on integrated agriculture-aquaculture in China for the use of FAO in promoting integration of land and water use in developing countries.

Finally, the Mission was impressed by the degree to which individuals and local groups participate in the planning and management of China's development. The Mission felt strongly that FAO and its member countries should re-examine ways in which development projects of all kinds can be identified, planned and executed at the local or village level. Particularly for the rapid development of fish culture in rural development everywhere, such emphasis on "grass roots" activities and projects seems essential.

10. LIST OF REFERENCES

- Bardach, J.E., J.H. Ryther and W.O. McLarney, Aquaculture: the farming and husbandry of
1972 freshwater and marine organisms. New York, Wiley-Interscience, 868 p.
- Borutskiy, Ye.Y., Biological study of reservoirs of China. Vestn.Akad.Nauk SSSR, 1960(2):
1960 74-6
- Canada, Department of the Environment, Aquaculture in China. In Final report of the visit
1976 of the Canadian Fisheries Mission to the People's Republic of China, 22 November -
9 December, 1974. Ottawa, Fisheries and Marine Service, pp. 1-21
- Galtung, J. and F. Nishimura, The farmer-worker, student-militiaman. Ceres, May-June:40-3
1976
- Gu-San Dun, Editorial notes and news. Fish biology in China. Copeia, 1975(2):404-12
1975
- Jamayaha, D.E.S. et al., Report to FAO on the training of D.E.S. Jayamaha, et al.,
1975 (12 Sri Lanka Fellows) in the People's Republic of China on freshwater fish
culture, 1 April - 24 September, 1975. Colombo, FAO/UNDEVPRO, 30 p. (mimeo)
- Leeden, F. van der (ed.), Water resources of the world: selected statistics. Port
1975 Washington, New York, Water Information Center, 568 p.
- McGarry, M.A., The taboo resource: the use of human excreta in Chinese agriculture.
1976 Ecologist, 6(4):150-4
- Roberts, T.R., C in-Ho Park and R. Straus, Book review of: Chinese freshwater fish culture,
1973 by Fourteen Members of the Committee to summarize experience on freshwater fish
raising (a quasi-official Committee of the Chinese Academy of Sciences). Trans.
Am.Fish.Soc., 102(3):668-9
- Solecki, J.J., Economic aspects of the fishing industry in mainland China. Vancouver,
1966 University of British Columbia, Institute of Fisheries, 172 p.
- Stavis, B., How China is solving its food problem. Bull.Concerned Asian Sch., 7(3):22-38
1975 (July-Sept. issue)
- Anon., Fresh water fisheries. China News Anal., Hong Kong, (243):5-6
1958
- Anon., China: a geographical sketch. Peking, Foreign Language Press, 130 p.
1974

Appendix I

ITINERARY AND PERSONS MET

21 April 1976 (Wednesday)

09.30 hours Depart Hong Kong by train
10.45 hours (09.45 local time) Arrive Lowu (Hong Kong border side)
13.00 hours Depart Schumchung (China border)
14.50 hours Arrive Kwangchow, checked in Tung Frang Hotel
Afternoon Briefing given by Chinese officials
Evening Dinner given by Mr. Yang, Deputy Director, Fisheries Bureau, Kwangtung Provincial Government

People met

Mr. Chang Shih-jang Ministry of Agriculture and Forestry (MAF), Peking
Ms. Chu Tsung-hsian Interpreter, Ministry of Agriculture and Forestry, Peking
Ms. Kung Chien-ying Interpreter, Ministry of Agriculture and Forestry, Peking
Mr. Yang Tsue-sheng Deputy Director, Fisheries Bureau, Kwangtung Province
Mr. Lue Ou-feng Chief, Fisheries Research Institute, Kwangtung Province
Mr. Tsung Tse-sung Staff Fisheries Bureau, Kwangtung Province
Mr. Cheng Chia-yi Staff Fisheries Bureau, Kwangtung Province
Mr. Tsai Fu-chun Interpreter

22 April 1976 (Thursday)

Morning Visit Kwangtung Freshwater Culture Experimental Station - Kwangtung Provincial Government
Discussion and observation of the station
Afternoon Visit to Canton Trade Fair
Evening Visit to Song and Dance Performance

People met - Freshwater Culture Experimental Station

Mr. Tsung Chu-pien Chairman of Revolutionary Committee
Mr. Liu Chia-chao Deputy Chairman of Revolutionary Committee
Mr. Chung Lin Professor
Ms. Tsung Mei-ti Technical Staff

23 April 1976 (Friday)

Morning Le Liu People's Commune in Shun-Ta County
Field visit and discussion
Lunch at the Commune
Afternoon Proceeded to Nanhai County
Evening Stay overnight at Su chao Shan Hotel

People met - Le Liu People's Commune

Mr. Lu Hwei-yuan Chief, Commune Office
Mr. Su Chuo Deputy Chief, Commune Office
Mr. Wu Kung-sheng Deputy Director, Fisheries, Shun-ta County

24 April 1976 (Saturday)

Morning Visit Nan-hai County Aquaculture Station
 Discussion, observation and lunch
Afternoon Shia-Kia People's Commune, Shun-ta County
 Field observation and discussion
 Return to Hotel Tung Fang in Kwangchow

People met - Nan-hai County Aquaculture Station

Mr. Tao Tien-jung Deputy Chairman of Revolutionary Committee
Mr. Tsen Chi-chiang Technician

People met - Shia-Kia People's Commune

Mr. Kuo Pun Deputy Chairman of Revolutionary Committee
Mr. Ho Shun-fa Deputy Chief of Commune Office
Mr. Lu Kang-ming Cadre of Shun-ta County Revolutionary Committee

25 April 1976 (Sunday)

Morning Visit Ho Lung Reservoir of Tai-ho Commune
 Discussion and fish catching observation
Afternoon Final discussion with the Provincial Government officials

People met - Tai-ho Commune

Mr. Hwang Wan Deputy Chief of the Commune
Mr. Yan Chen-feng Chief, Ho Lung Production Brigade
Mr. Yang Sheh-you Deputy Chief, Ho Lung Production Brigade

Final discussion

Messrs. Lue, Tsung, Chen, Tsai and Chu from Fisheries Department of Kwangtung Provincial Government^{1/}

Messrs. Liu, Chung and Tsung from Kwangtung Freshwater Culture Experimental Station^{2/}

Mr. Cheng and Ms. Chu and Kung from MAF Peking^{1/}

1/ See record of 21 April 1976

2/ See record of 22 April 1976

26 April 1976 (Monday)

08.30 hours Leave Kwangchow by air
11.30 hours Arrive Wuhan, met by Hupei Provincial Government Officials
Afternoon Programme briefing and the introduction of fisheries in the Hupei Province
Evening Dinner given by Mr. Liu, Director of Water Conservancy Bureau of the Province, at the Hotel Victory

People met - Hupei Provincial Government

Mr. Liu Chen-Hsia Director, Water Conservancy Bureau
*Mr. Lee Chen-Sheng Leader, Fisheries Division
*Mr. Chiu Chi-chuan Staff, Fisheries Division
*Mr. Wang Chin Staff, Fisheries Division
*Mr. Liu Wan-Han Staff, Foreign Affairs Office

27 April 1976 (Tuesday)

Morning Visit Aquatic Biological Research Institute, Hupei Province
 Discussion and observation
 Lunch and observation of Tung Lake (East Lake)
Afternoon Visit the East Lake Fish Breeding Farm
Evening Film, "Chin Miao", story of girl barefoot doctor

People met - Aquatic Biological Research Institute

Mr. Chen Tin-chu Chairman, Revolutionary Committee
**Mr. Liu Chien-Kiang Director, Fish Research Office
Mr. Cheng Sung-chuan Deputy Director, Fish Research Office
Mr. Chen Ying-dia Staff, Fish Research Office
Mr. Peng Che-bei Staff, Fish Research Office
Mr. Yu Chi-tang Staff, Fish Research Office
Ms. Wu Chin-chiang Staff, Fish Research Office

People met - East Lake Fish Breeding Farm

Mr. Hsia Chang-sung Director, Revolutionary Committee

28 April 1976 (Wednesday)

08.00 hours Depart Hotel in Wuhan
11.00 hours Arrive Wang Kong County, Office of Revolutionary Committee
Afternoon Pai Tan Lake Fish Cultivation Station - Provincial - Field observation and discussion
Evening Films: (i) "Artificial Fish Propagation"; (ii) "Sunflower"
 Stay overnight at Wang Kong County

* Accompanied Mission throughout Mission's stay in Wuhan

** English-speaking

People met - Revolutionary Committee of Wang Kong County, Hupei Province

Mr. Ting Yun-Ron Deputy Director of the Committee
Mr. Liu Ji-cheng Director of the Office of the Committee
Mr. Wang Te-chiang

Persons met - Revolutionary Committee of Pai Tan Fish Breeding Farm

Mr. Tsao Pieng-Shan Director of the Committee
Mr. Wu Pai-Lian Engineer
Mr. Liu tsu-fa Deputy Director of the Committee

29 April 1976 (Thursday)

08.00 hours Depart Wang Kong County Revolutionary Committee Office
Morning Visit Pai Tan Pumping Station
 Observation and discussion
12.00 hours Arrive Wuhan, Victory Hotel
Afternoon Visit Hwa Chung Agriculture Academy

People met - Pai Tan Pumping Station

Mr. Cheng Chi-yuan Director of the Station

People met - Hwa Chung Agriculture Academy

Mr. Kan Te-chien Deputy Chairman, Revolutionary Committee
Mr. Hsiu Cu-ying Director, Academy Office
Mr. Wang Hung Director, Aquaculture Department
Mr. Wu An-le Chief, Workers Propaganda Team
Mr. Chou-Hung-liang Worker-peasant-soldier Teacher
Mr. Cheng Ching-lan Worker-peasant-soldier Student

30 April 1976 (Friday)

Morning Discussion about water conservancy programme in Hupei Province,
 with Mr. Chang, Engineer Water Conservancy Bureau, Hupei Provincial
 Government
16.00 hours Depart Wuhan by air
21.00 hours Arrive Peking met by Mr. Lee Yung-Kai. Stay in Peking Hotel

1 May 1976 (Saturday)

Observation of International Labour Day festival. Visit to the
Summer Palace in the morning and Sun Yat Sen Park in the afternoon.
Fireworks in the evening.

2 May 1976 (Sunday)

Visit to the Great Wall, Ming's tomb and 13 tombs reservoir,
accompanied by Mr. Li Yung-Kai

People met

Mr. Li Yung-Kai Director, Foreign Affairs Bureau, MAF
Mr. Kung Ming-shan Deputy Director, Aquaculture Bureau, MAF
Mr. Cheng Yang-chung Leader, Freshwater Fisheries Division, MAF
Mr. Yi Chen-par Deputy Leader, International Department, Ministry of Foreign Affairs
Mr. Tung Chieng-sung Foreign Affairs Office Bureau, MAF

3 May 1976 (Monday)

Morning Briefing of freshwater fisheries in China by Mr. Cheng Yang-chung, Division Leader, Freshwater Fisheries Division, MAF and discussion
Afternoon Report writing and rest

4 May 1976 (Tuesday)

Morning Tour to the Forbidden City
Afternoon Study tour to China Agriculture Exhibition
20.07 hours Depart Peking for Nanking by train

5 May 1976 (Wednesday)

14.30 hours Arrive Nanking. Stay in Nanking Hotel
Afternoon Visit to the Nanking Yangtse River Bridge
Evening Dinner given by Mr. Tang, Director of Agriculture, Kiangsu Provincial Government

People met

Mr. Tang Lu-yu Director of Agriculture, Revolutionary Committee of Kiangsu Province
Mr. Ou Chiang Leader, Aquaculture Division, Agriculture Department, Revolutionary Committee of Kiangsu Province
Mr. Li Wen-che Technical Officer, Aquaculture Division
Mr. Ma Yun-tan Technical Officer, Aquaculture Division
Mr. Wang Kuang-shiang Foreign Affairs Office, Revolutionary Committee

6 May 1976 (Thursday)

Morning Visit to the Hsuan Wu Lake, observation and discussion
Afternoon Visits to historic places
17.40 hours Depart Nanking by train
20.50 hours Arrive Wushi (Wuxi). Short briefing on arrival. Stay at Taihu Hotel

People met - Revolutionary Committee of the Hsuan Wu Lake Office

Mr. Wang Te-niang Deputy Chairman
Mr. Hsin How Chief, Fisheries Brigade
Mr. Chu Chau-jung Technical staff

People met - Wushi Municipality

| | |
|-------------------|---|
| Mr. Wu Chen | Deputy Director, Agriculture and Water Conservancy Department |
| Mr. Kuo Chiu-ping | Deputy Chief, Agriculture and Fisheries Division |
| Mr. Ma Wen-nen | Secretary, Fisheries Office |
| Mr. Tang Sung-nen | Technician, Agriculture and Water Conservancy Department |

7 May 1976 (Friday)

| | |
|-----------|---|
| Morning | Visit to Ho Law People's Commune |
| Afternoon | Visit to Taihu Lake |
| Evening | Dinner given by Mr. Wu, Deputy Director, Agriculture and Water Conservancy Department, Wushi Municipality |

People met - Ho Law People's Commune

| | |
|--------------------|-----------------------------------|
| Mr. Liu Wei-ping | Chairman, Revolutionary Committee |
| Mr. Shen Chung-lun | Aquaculture Technician |
| Mr. Wang Wu | Aquaculture Technician |
| Mr. Cho Yung-Kuo | Fisherman, Production Brigade |

8 May 1976 (Saturday)

| | |
|-------------|---|
| Morning | Visit Fan Li Lake |
| 09.50 hours | Depart Wushi by train |
| 12.25 hours | Arrive Shanghai. Stay at Ching Chiang Hotel |
| Afternoon | Programme discussion of visit to Shanghai |
| Evening | Film show "Unforgettable Fighting" |

People met - Shanghai Municipality

| | |
|--------------------|---|
| Mr. Hsiao Lin | Director, Revolutionary Committee of Fisheries Department |
| *Mr. Wu Lan | Leader, Office of Fisheries Department |
| *Mr. Hsui Shong-ta | Technician, Freshwater Fisheries Division |
| *Mr. Tsao Pin-mei | Technician, Freshwater Fisheries Division |
| *Mr. Liu Te-pei | Working staff, Freshwater Fisheries Division |

9 May 1976 (Sunday)

| | |
|-----------|---|
| Morning | Visit Shanghai Industrial Exhibition |
| Afternoon | Visit Fish Breeding Farm of Nan Hwei County Government |
| Evening | Dinner given by Director Hsiao of Shanghai Municipality, Fisheries Department |

People met - Nan Hwei County Fish Breeding Farm

| | |
|---------------------|---|
| Mr. Ni Ya-ping | Director, Revolutionary Committee |
| Mr. Song Lung-Kuang | Member, Revolutionary Committee |
| Mr. Ting Yung-liang | Research staff, Shanghai Fisheries Machinery Research Institute |

* Accompanied Mission throughout their stay in Shanghai

10 May 1976 (Monday)

Morning Visit to Jie-fang (Liberation) People's Commune in Qing-pu County
Afternoon Discussion with Fisheries Research Institute of Shanghai
Evening Opera "White-Haired Girl"

People met - Jie-fang People's Commune

Mr. Li Lian-pin Deputy Director, Revolutionary Committee
Mr. Wu Kung-wang Chief, Office of the Commune
Mr. Chu Jin-Ken Chairman, Revolutionary Committee of Fish Breeding Farm
Mr. Ku Yu-ming Chairman, Revolutionary Committee of Fisheries Machinery Factory

People met - Fisheries Research Institute of Shanghai

Mr. Wang Ke-fu Chairman, Revolutionary Committee
Mr. Ching Lung Chief, Freshwater Aquaculture Laboratory
Mr. Wang Hsin Ching Staff, Freshwater Aquaculture Laboratory
Mr. Chang Cheng-pian Staff, Freshwater Aquaculture Laboratory
Mr. Ting Jen-fu Chief, Marine Resources Laboratory

11 May 1976 (Tuesday)

Morning Visit Ten-shan Workers Village Complex (new village for factory workers)
Afternoon Visit Chen-tung People's Commune in Cha Ding County

People met - Chen-tung People's Commune

Mr. Chen Chih-lung Director, Commune Office
Mr. Kan Shih-chang Staff, Commune Office
Mr. Chu Ken-shan Staff, Commune Office

12 May 1976 (Wednesday)

07.20 hours Depart Shanghai by air
09.40 hours Arrive Kwangchow. Stay at Tung Fang Hotel
Afternoon Visit Kwangtung Exhibition of Aquatic Products
Evening Dinner given by the Mission

People met

Same as those on 21 April 1976

13 May 1976 (Thursday)

08.30 hours Depart Kwangchow by train
14.30 hours Arrive Hong Kong

14 May 1976 (Friday)

15.25 hours Depart Hong Kong by air
17.30 hours Arrive Bangkok. Met by Dr. D.L. Umali, Mr. P. Mengin and Chinese Embassy Staff (Mr. Chang, First Secretary and Interpreter)

Appendix II

LIST OF PUBLICATIONS BROUGHT FROM CHINA

1. "Building of small sluice gate"
Published by Shanghai People's Publishing House
2. "Building of small reservoir"
Published by Shanghai People's Publishing House
3. "Control of flood and water-logging, reclamation of saline and alkaline land, and water and soil conservation"
Published by Shanghai People's Publishing House
4. "Raising fish in reservoirs"
Published by Agricultural Publishing House
5. "How to raise fish"
Published by Shanghai People's Publishing House
6. "Raising fish in fresh water"
Published by Agricultural Publishing House
7. "Irrigating farmland with sewage water"
Published by Liaoning Provincial New China Bookstore
8. "Compilation of experiences on the management of water conservancy facilities"
Published by Water Conservancy and Electricity Publishing House
9. "Diverting flood to bring water and silt to crop field"
Published by Water Conservancy and Electricity Publishing House
10. "Levelling sloping land in reverse order"
Published by Water Conservancy and Electricity Publishing House
11. "On water management"
Published by Shanghai People's Publishing House
12. "Knowledge on manures and fertilizers"
Published by Shanghai People's Publishing House
13. "Do well the work of capital construction on the farmland, volume 2"
Published by Agricultural Publishing House
14. "Various kinds of manures and fertilizers and their rational application"
Published by Shanghai People's Publishing House
15. "A county of fish and rice by the side of the Pearl River"
Published by Agricultural Publishing House
16. "Cultivation of water plants"
Published by Shanghai People's Publishing House
17. "A bumper harvest of foodgrain and fish"
Published by Agricultural Publishing House
18. "Fish farming in Inner Mongolian Autonomous Region"
Published by People's Publishing House in Inner Mongolian Autonomous Region

19. "Growing of red duckweed"
Published by Kwangtung Provincial People's Publishing House
20. "Raising African silver carp"
Published by Agricultural Publishing House
21. "Control of common diseases of grass carp (Ctenopharyngodon idellus)"
Published by Hunan Provincial People's Publishing House
22. "Raising African silver carp"
Published by Scientific Publishing House
23. "Techniques of artificial propagation of family fishes"
Published by Agricultural Publishing House
24. "The work on methane gas should be done well and seriously"
Published by Agricultural Publishing House
25. "The stories of taming the rivers"
Published by Water Conservancy and Electricity Publishing House
26. "Raising crab"
Published by Agricultural Publishing House
27. "Afforestation for the conservation of soil and water"
Published by Water Conservancy and Electricity Publishing House
28. "Management of water for irrigation"
Published by Water Conservancy and Electricity Publishing House
29. "Production and application of methane gas in rural areas"
Published by Agricultural Publishing House
30. "Five small farm machines"
Published by Kwangtung Provincial People's Publishing House
31. "State farms are advancing forward"
Published by Agricultural Publishing House
32. "A tour of 5 000 kilometres along the Yellow River"
Published by Water Conservancy and Electricity Publishing House
33. "To grope for the law of raising pigs"
Published by Shanghai People's Publishing House
34. "To protect irrigation canal from seepage"
Published by Kwangtung Provincial People's Publishing House
35. "Preparation of soil map in big scale"
Published by Scientific Publishing House
36. "On fish sieve"
Published by Agricultural Publishing House
37. "Questions and answers of techniques on pig husbandry"
Published by Shanghai People's Publishing House
38. "Making horizontal terraced field on gradient surface of land"
Published by Water Conservancy and Electricity Publishing House

39. "Artificial propagation of seaweed, Undaria and Porphyra"
Published by Scientific Publishing House
40. "Artificial propagation of shells in the sea"
Published by Shantung Provincial People's Publishing House
41. "Excavation of wells for agriculture"
Published by Water Conservancy and Power Publishing House
42. "Radial wells"
Published by Water Conservancy and Power Publishing House
43. "Well installation techniques"
Published by Water Conservancy and Power Publishing House

