# RESEARCH REINFORCEMENT IN AQUACULTURE FOR COUNTRIES OF SOUTH AND SOUTHEAST ASIA

Report of a Visiting Consultant Mission January-April, 1978

for

The Southeast Asia Fishery Development Center

and

The Technical Advisory Committee

International Development Research Centre

Vancouver

21 April 1978

REPORT TO TAC; SEAFDEC

# Report of the Consultative Mission On Asian Aquacultural Research


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## CHAPTER 1

## INTRODUCTION

The urgent food needs of the poorer tropical developing countries and the vast increase in food supplies needed to feed their rapidly increasing populations within the next two decades, have focussed attention on the possible use of domesticated fish as a large-scale source of cheap animal protein for the "poor majority" in these countries.

As the Consultative Group for International Agricultural Research will be aware from earlier debates of the Technical Advisory Committee, aquaculture is already an important source of food in the most heavily populated tropical areas of South and East Asia, from India to China. Magellan described in the 16th century the coastal ponds for production of salt and of fish in the Philippines. In recent years, industrial pollution and siltation of rivers and estuaries, together with decreasing of supplies of juvenile fish, have diminished the production of milkfish in both Indonesia and the Philippines. At the same time, the centuries-old tradition of culturing fish with low-yielding forms of rice production has been overtaken by the need to use pesticides to protect the higher yielding varieties of rice produced by recent research-based technology in Indonesia and the Philippines. These trends have coincided with a dwindling of sea-catches from over-fished waters of the region as hunting effort has increased. Production of wild-caught freshwater fish has also declined as wetlands have been developed into agricultural irrigation areas. All these influences have increased the interest of the governments of the region in the potential for increased production from aquaculture, and this is now included in the published priorities for rural development by the Governments of India, Thailand, Malaysia, Indonesia, Singapore and the Philippines.

It did not prove possible to include the People's Republic of China or Taiwan in this tour, but authentic information, both from tour reports and translations of Chinese texts, have provided, we hope, an adequate background. It is hoped, and strongly recommended by this Committee, that in future organised regional

cooperation will include these major sources of experience and research in aquaculture.

The part now played by marine and inland capture fisheries, and by aquaculture in the production of fish as food in South and East Asia is summarised in Appendix 1, and the vital statistics of the developing countries in South and East Asia are summarised in Appendix 2.

Appendix 1 gives the most recent data for fisheries production and shows that the South and East Asia region produces 70% of world aquacultural outputs, but this is still only some 4 million out of the total fish production of 31 million from this region, or 13.4%.

## Chapter 2. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS:

### Conclusions

#### 1. Technical aid

That the existing support for development, provided both by bilateral aid and by UN regional and global liaison networks, is an essential factor in the expansion of regional production in aquaculture. In particular, the FAO/UNDP Aquacultural Development Team, which was set-up on recommendations of the TAC Working Party at Spoletto in 1973, should be supported in its program of meetings and short term technical aid, while the FAO South China Seas Development Program should continue to receive support for general fisheries development aid. Neither of these organisations, however, can provide the research support which requires continuity of effort for the scientific targets of five years to ten years ahead and which is the vital role of the CGIAR in agriculture.

#### 2. The viable alternatives for research support

The Mission concluded that there were only two viable courses which could be recommended to TAC. The first is that the present provision of international aid be accepted as adequate and the subject of aquaculture be taken off the agenda. There is indeed a lively interest among donor organisations and an abundance of technical aid on offer, both from bilateral and multilateral sources, through a confusing multiplicity of aid channels. With so complex a pattern of production systems and farmed species, the applicability of the CGIAR system of research support is less immediately evident in aquaculture than it has been in agriculture.

The second effective course would be to undertake an organisation designed to meet the unique character of the problem, in the form of a regional network of active research units outposted from a regional support and training centre, in order to undertake the type of research in tropical fish species which is necessary for the success of the many technical aid

programs. This new type of support was recommended by the conference of national leaders of research services at Bellagio in December 1977.

3. The choice recommended

The Mission concludes that no intermediate course would be effective, and has no hesitation in recommending the second of the two alternatives.

Recommendations

1. That the SEAFDEC Council should build on the success already achieved by its Aquaculture Department and should seek to develop it into a Regional Organization for Aquacultural Research in Asia (ROARA) to serve the whole region.

2. That the main objective of the new Regional Organization should be the increased production of food fish and of shellfish for consumption by the majority of the populations of the region.

3. That the Regional Organization should make full use of the national laboratories and university departments throughout the region, both by outposting divisions to major laboratories and by subcontracting highly specialized tasks to universities. In university contracts, the essentially applied and problem solving objectives should determine the programs, so that the work of the ROARA should fill the present gap between academic work properly supported by the educational vote and the development supported by Technical Aid programs.

4. That the facilities at Iloilo should be developed into the headquarter's support and training organisation for this network. Although the current program on prawn research lies outside the food production objectives of CGIAR, the potential economic advantages are such that these studies should continue to be pursued, under separate funding, but under the integral research direction and management of the new organisation.

5. That an independent international Board of Governors, with supporting technical committees, drawn from both Government Departments and academic institutions, should include the Directors of Fisheries of the participating countries, so that the views and policies of SEAFDEC would continue to carry full weight in the Regional Organisation.

6. That TAC should invite SEAFDEC to study these proposals with a view to making formal application for recognition and support by the CGIAR: this should be in the form of an agreement between CGIAR and SEAFDEC for the operation and management of the laboratories at Tigbauan as the support and training centre for the regional network.

7. If SEAFDEC agrees in principle to these proposals and expresses a request for such support, then TAC should call a meeting, in the region, for definitive discussions both with the present members of SEAFDEC and with other interested countries in order to make firm recommendations to CGIAR.

8. If such a meeting were to be called by TAC in October, then it may be possible to present at least a progress report, giving outlines of probable costs and timetable, to the annual meeting of CGIAR in November 1978 in order to be guided as to what further steps should be taken in 1979.

## Chapter 3. ORIGIN OF THE CONSULTANT MISSION

### (a) Summary of Action by the TAC on Aquaculture

(N.B. The first meeting of TAC was held in 1971.)

1. 1973 (Feb.) An early discussion recognized the importance of aquaculture for expanding tropical food production and resulted in the formation of an authoritative expert Working Group.

2. 1973 (July) The Working Group met for 4 days at Spoletto in Italy.

3. 1973 (Sept.) Prof. John Bardach, as Chairman of the Working Group, reported progress to TAC.

4. 1974 (Feb.) Prof. Bardach presented the completed report. This recommended:

   (i) A task force permanently available to advise on aquacultural development. (This was subsequently funded by UNDP and set up as a component of FAO HQ staff in Rome.)

   (ii) Further strengthening of ongoing work; also that no single centre could cope with the ecological diversity of aquaculture, so that a chain of regional centres should be set up.

5. 1975 A 3-man sub-committee (Prof. John Bardach, Dr. W.H.L. Allsopp and Dr. T.V.R. Pillay) recommended sites for the regional centres and proposed a program of U.S. $15 million over 5 years. TAC could not discover in those proposals a role requiring priority over current agricultural projects

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| | 1975 (cont'd.) | but the subject remained on the agenda for later consideration. |
| 6. | 1975/76 | IDRC mounted a small team consisting of Dr. Halver and Dr. Gorbman, assisted by Dr. Allsopp, to study the specific research requirements for aquacultural nutrition and physiology of reproduction in South and East Asia. The SEAFDEC laboratories were selected for reinforcement and an equipment list was recommended. The Philippine Government has provided a new building, and the Japanese Government has provided the equipment at the SEAFDEC Aquacultural Department Laboratories at Iloilo. |
| 7. | 1977 (Sept.) | TAC again expressed recognition of the importance of aquaculture for the future expansion of tropical food supplies, but did not accept the proposals thus far presented. In response to the request by the Council of SEAFDEC, IDRC offered to mount and fund a regional study on international support for aquacultural research in the South and East Asia region where some 70% of the world's aquacultural production occurs, and where food supplies for increasing populations are of major concern. This proposal was welcomed by TAC at the 15th meeting, and the report of the study was placed on the agenda for the 17th meeting in June 1978. |
| 8. | 1977 (Dec.) | The Chairman of the Mission visited the Executive Secretary of TAC in Rome and discussed plans for the Mission. He also discussed plans for this study with the ADG (Agriculture), Dr. Bommer, the ADG (Fisheries), Mr. Watzinger, and the leader of the FAO Task Force, Dr. Pillay. |

(b) Action by SEAFDEC

1. 1976 — At its Ninth Meeting in Tokyo, December 1976, the SEAFDEC Council of Directors discussed the establishment of an independent Secretariat for the Center. The Council decided to continue the present structure of the Secretariat until a thorough evaluation of the structure, functions, and operation of the Center had been made, while instructing the Secretary-General to prepare a suitable proposal to interested donor agencies for funding support to finance an international management study group to undertake the evaluation.

2. 1977 — The Secretary-General approached both US AID and IDRC. Only the latter expressed interest. The Chief of the Aquaculture Department of SEAFDEC requested IDRC to look into the structure and the program of activity of its Department.

3. 1977 (Jan.) — In January 1977 this request was discussed during a visit to the Philippines by Mr. J. Hulse, AFNS Director of IDRC, with Mr. Felix Gonzales (a member of SEAFDEC Council and its Chairman-designate), and Dr. Q.F. Miravite, Executive Director of SEAFDEC's Aquaculture Department. Mr. Hulse recommended that the request be referred to the TAC for CGIAR support.

4. 1977 (Feb.) — In February 1977 Dr. Madamba, Director-General of the Philippine Council of Agricultural Resources Research reported, as a member of TAC, the request of the Secretary-General of SEAFDEC for assistance in the proposed review. Dr. Hopper, then both President of IDRC and a member of TAC, reported the willingness of IDRC to respond to the SEAFDEC

1977 (Feb.) (cont'd.) request by mounting and funding a review of the Aquaculture Dept., but that IDRC felt unable to undertake the study of marine fisheries necessary for a review of all three SEAFDEC Departments. TAC welcomed the suggestion of support by IDRC.

5. 1977 (March) In March 1977, the Council of IDRC approved funds to meet the aquacultural side of the SEAFDEC request, but did not offer to fund the full study of all three Departments.

6. 1977 (Dec.) This offer by IDRC was formally reported to the SEAFDEC Council at its meeting in Tokyo in December 1977, and was welcomed by the Council.

While expressing appreciation and cooperation for the proposed study program, the Council at that Meeting expressed the desire that the consultative group "would, in particular, consider and recommend complementary programs and projects in aquaculture research in member countries".

(c) Recruitment of the Consultant Mission

In view of their substantial investments in aquacultural aid in South and East Asia, three leading donors, the Government of Japan, UNDP and US AID were invited to nominate members for the technical review mission. The Government of Japan nominated Prof. Kuronuma, President Emeritus of the Tokyo Fisheries University, the UNDP, US AID and SEAFDEC made a number of suggestions, including both Dr. J. Bardach and Dr. W.E. Ripley. SEAFDEC Council agreed that its Secretary-General, Dr. Deb Menasveta, should serve on the Mission, and IDRC provided Dr. W.H.L. Allsopp and Dr. F.B. Davy. Prof. J. Bardach of Hawaii University and the East-West Centre, agreed to serve part-time because of other commitments, and Sir Charles Pereira, F.R.S., then Chief Scientist of the U.K. Ministry

of Agriculture, Fisheries & Food, and a long-service member of TAC, agreed to Chair the Mission. Dr. Bardach and Dr. Ripley participated in the discussions at the beginning and end of the Mission, but were prevented by other commitments from undertaking the tour.

(d) Advice of the Bellagio Conference of Leaders of National Research Organisations - October 1977

At this "International Conference on Potentials for Cooperation among National Agricultural Research Systems" specific recommendations were made to CGIAR. Under the heading, "Regional Collaborative Networks Among Research Systems of Developing Countries", the report recommends, "Initiatives in this respect should come from national research systems, but the CGIAR and the international donor community should consider funding them after examination by TAC". Among three specific examples listed is "Aquaculture ... on a regional basis".

## Chapter 4. TERMS OF REFERENCE OF THE MISSION

IDRC Statement Describing this Study:

Consultant Mission on Asian Aquacultural Research

The International Development Research Centre (IDRC) has invited a team of experts to undertake a detailed study of ongoing aquacultural research programs in Southeast Asia and to recommend a program of aquacultural research priorities for reinforcement by international funding in a pattern which would be consistent with the policies and methods of the Consultative Group for International Agricultural Research (CGIAR). The terms of reference for the international consultant mission and the proposed itinerary are attached.

The Composition of the Mission is as Follows:

Full-time members:

| | | |
|---|---|---|
| Sir Charles Pereira, F.R.S. | - | Chairman, Chief Scientist (1972-77), Ministry of Agriculture, Fisheries & Food, U.K. |
| Prof. K. Kuronuma | - | Emeritus President, Tokyo University of Fisheries |
| Dr. D. Menasveta | - | Secretary-General SEAFDEC, Thailand |
| Dr. W.H.L. Allsopp | - | IDRC, Associate Director (Fisheries), Secretary to the Mission |

Part-time members:

| | | |
|---|---|---|
| Prof. J. Bardach | - | Research Associate of the East-West Centre and Adjunct Professor of the University of Hawaii |
| Dr. W.E. Ripley | - | UNDP Fisheries Advisor (Regional & Global Programs) |
| Dr. F.B. Davy | - | IDRC Fisheries Program Officer Southeast Asia, Assistant Secretary to the Mission |

Terms of Reference

1. The Consultant Mission will make a study tour to discuss with both research workers and administrators the ongoing programs of research and the critical subjects in which further research can best assist in the increasing of food production from aquacultural development.

2. The purpose of this study will be to recommend whether internationally funded reinforcement of research on a regional basis is necessary in order to achieve the collective aims of the countries of the region to increase food production from their marine, brackishwater and freshwater resources.

3. The Consultant Mission will study as much as is practicable of the ongoing aquacultural research programs and projects and will consult recent reports of conferences, workshops, seminars, and consultancies.

4. In studying reinforcement on a regional basis the Consultant Mission will, of course, be giving attention to the regional cooperative organization already set up and operated by several of the countries concerned, i.e. the Southeast Asian Fisheries Development Center (SEAFDEC), and especially to the Aquacultural Department of SEAFDEC at Iloilo, for which the Mission is asked to make specific recommendations as to organization and program. The research-training and information needs of the region as a whole will be studied.

5. The Report of the Consultant Mission will be presented in June 1978 to the Technical Advisory Committee of the CGIAR and to the Council of SEAFDEC. It will be available to all institutions or organizations contributing to or participating in the aquacultural research of the region.

## Chapter 5. SCIENTIFIC POLICY ADOPTED BY THE MISSION

In our initial discussions, the guidelines to be used in following the terms of reference were agreed as follows:

(i) To explore whether there exists in aquaculture the same type of gap between the academic programs of UNESCO/UNDP and the development programs of FAO/UNDP which has been so successfully filled in agriculture by the CGIAR system.

(ii) To apply science to improve the production of captive food-fish.

(iii) To support research to the extent needed to solve problems over the spectrum from explicit background studies to technologies of practical application.

(iv) To support research in preparation for aquacultural problems foreseen in 5 to 10 years' time.

(v) To give priority to technologies which make the maximum use of environmental resources of water and sunlight, and involve the minimum inputs of money and of energy.

(vi) To seek a pattern of reinforcement which minimises unproductive repetition of research work and maximises regional sharing of advances.

(vii) To include training provisions only for techniques of applied, problem-solving research. Both academic training and training of technicians for production schemes are outside our remit.

## Chapter 6. THE STUDY TOUR

The Mission undertook a total of 12 weeks of travel to study and discuss with people of a wide range of interests the opportunities for increased aquacultural production. The research needs, the extent to which these needs are being currently met, and the most suitable forms of reinforcement, were discussed during visits to Canada, U.S.A. (Hawaii), Hong Kong, India, Thailand, Malaysia, Singapore, Indonesia, the Philippines, Japan and U.S.A. (Washington, D.C.).

An itinerary is given in Appendix 3, a summary of observations is made in Appendix 4, and a list of many of the people who helped us with discussions is set out in Appendix 5. It proved to be quite impractical to list all of the many people who assisted us in various ways and we assure the many not so listed that their contributions to our discussions were noted and considered.

## Chapter 7: EXAMPLES OF FOOD PRODUCTION BY AQUACULTURAL SYSTEMS OBSERVED DURING THE TOUR

The term "aquaculture" covers many types of fish production. Some species of finfish, of crustaceans and of shellfish can now be selected, bred, reared, harvested and marketed under controlled conditions, as for all species of agricultural livestock. Others are captured at the fingerling stage, confined in enclosed coastal bays or in coastal ponds and grow on the natural flora and fauna. There are various stages of intensification, involving feeding of one species (monocultures) or of species combinations of complementary feeders. Many of the intensive cultural methods compete directly with agriculture for plant foods (manures and fertilizers), for animal foods (cut grass, rice-bran, groundnut cake) and for land with an irrigation potential. Where carnivorous species are fed "trash fish" the energy budget of the aquacultural production may be extremely adverse. In terms of food production it may also be extremely wasteful. The term "trash fish" is misleading: much of the fish seen to be used as feed was of the type and quality suitable for direct human consumption and widely used by the low-income sector. While the culture of carnivores generates cash income it thus decreases the net supply of fish for the "poor majority".

Where, however, phytoplankton feeders are raised in eutrophic natural waters, e.g. in cages in canals, reservoirs, rivers or lakes, there can be economic production of high-value protein with low inputs. In considering food production by aquaculture, there is so large a number of species with different ecological and feeding requirements that generalisations on productivity are dangerous. Relations between certain output and inputs can however be demonstrated by quoting some quantitative examples of techniques encountered by the Consultant Mission (Table 1).

In pond cultures we observed a regrettable tendency to express the results of short term experiments, lasting three or four months, conducted in small ponds of 1/20th to 1/10th ha, in terms of tonnes per hectare per annum. This has little relevance to the actual or even to the potential production, since limitations of water supply, water quality, nutrient availability and

above all production of fingerlings usually preclude continuous year-round production involving three or four successive crops. Where large ponds are used, and the fish are harvested annually, the results are, of course, directly meaningful in these terms.

Table 1 EXAMPLES OF THE PRODUCTIVITY OF AQUACULTURAL SYSTEMS

| LOCATION | SPECIES USED | CULTURE METHOD | STOCKING RATE | FISH FEED | ADDED FERTILIZERS | AREA IN PRODUCTION | AVERAGE PRODUCTION | PUBLISHED * REFERENCE |
|---|---|---|---|---|---|---|---|---|
| A) WITHOUT FEED INPUTS | | | | | | | | |
| 1)LAGUNA DE BAY, PHILIPPINES | MILKFISH (Chanos chanos) | FRESHWATER FISH PENS | 15,000-40,000 per Ha. | NONE OR SOME RICE BRAN | INADVERTENT BY RUNOFF | 5,800 ha. | 5,200 kg/ha /yr | Sergio, F.S. (1974) |
| 2)LAKE BUNOT, PHILIPPINES | Tilapia nilotica | FRESHWATER FISH CAGE | 40,000 per Ha. | SOME RICE BRAN SEASONALLY | NONE | (Approx. 5 Ha.) | 9-16 tons/ha/ 10 mo. | Personal Communication |
| 3)SELETAR RESERVOIR SINGAPORE | BIGHEAD CARP (Aristichthys nobilis) | FRESHWATER FISH CAGE | 300/cage (12.5/$m^2$) | NONE | NONE | 150 cages 0.3 ha. area | 25 kg/$m^2$/10 mo. | Personal Communication 1978 |
| 4)CIANJUR, INDONESIA | COMMON CARP (Cyprinus carpio) | FRESHWATER FISH CAGE IN RIVER | 0.5-2 kg/$m^2$ | SMALL AM'T RICE BRAN, KITCHEN SCRAPS, ETC. | NONE | 6,700 $m^2$ 0.67 ha. | EXTRAPOLATED 12 kg/$m^2$/yr | Fisheries Statistics Indonesia, 1975 |
| B) INPUT OF ANIMAL WASTES-BRACKISHWATER | | | | | | | | |
| 5)INDONESIA | MILKFISH (Chanos chanos) | POND (TAMBAK) | 500 fingerlings per hectare | NONE | MANURE 2600 kg/ha | 183,000 ha. | 350 kg/ha/yr | Fisheries Statistics Indonesia 1975 |
| 6)PHILIPPINES | MILKFISH (Chanos chanos) | POND | 30,000 per Ha. | NONE | MANURE 2000-2,600 kg | 170,000 ha | 250-2000 kg/ha/yr. | de Los Santos (1977) SCSDP 1973 |
| INPUT OF ANIMAL WASTES - FRESHWATER | | | | | | | | |
| 7)MALAYSIA | CHINESE CARP & DUCKS | POND | Ducks - 2,500/ha. Fish - 1,000/ha. | AQUATIC WEEDS, RICE BRAN | ADDITIONAL MAY BE ADDED | DATA NOT AVAILABLE | 3,000-4,000 kg/ha | Bardach et al., 1972 |
| 8)HONG KONG | CHINESE CARP & PIGS | POND | 3000 kg of pigs/ha. 1000 fish/ ha. | AQUATIC WEEDS, RICE BRAN | ADDITIONAL MAY BE ADDED | " | 4000 kg/ha | Bardach et al., 1972 |

Table 1 (cont'd)

| LOCATION | SPECIES USED | CULTURE METHOD | STOCKING RATE | FISH FEED | ADDED FERTILIZERS | AREA IN PRODUCTION | AVERAGE PRODUCTION | PUBLISHED* REFERENCE |
|---|---|---|---|---|---|---|---|---|
| C) RICE AND FISH CULTURE | | | | | | | | |
| 9) PHILIPPINES (CLSU) | RICE AND TALAPIA MOSSAMBICA | PADI FIELD | 25-50 kg/ha. | NONE | NONE | EXPERIMENTAL | 44-94 kg/ha | Kyoto Conference (Grover) 1976 |
| 10) INDONESIA | RICE AND COMMON CARP SOME TAWES, TILAPIA | PADI | INFORMATION NOT AVAILABLE | NONE | NONE | INFORMATION NOT AVAILABLE | Estimated 30,000 tons total production | Fisheries Statistics Indonesia, 1975 |
| INPUT OF AGRICULTURAL FEED AND FERTILIZER | | | | | | | | |
| 11) INDIA | 3 INDIAN CARPS 3 EXOTIC CARPS | FRESHWATER POND | 8000/ha. | AQUATIC WEEDS 40 t/ha/yr RICE BRAN & OILSEED CAKE 15 t/kg/ha/yr | COWDUNG 3 t/ha/yr 425 kg/ha TSP 188 " urea 125 " $NH_4SO_2$ | EXPERIMENTAL | EXTRAPOLATED 9088 kg/ha/yr | Chaudhuri et al., 1975 |
| 12) INDIA | " | " | 5000 per hectare | OIL CAKE 500 kg RICE BRAN - 600 kg kg. weed 13 tons | COWDUNG 700 kg MAHUA OIL CAKE 900 kg | VILLAGE PONDS IN N.E. INDIA | 600 kg/ha/yr to 5000 kg/ha/yr | CIFRI Reports. 1977 |
| 13) CHINA | GRASS CARP SILVER CARP BIGHEAD CARP BLACK CARP MUD CARP AND BREAM | FRESHWATER | 15,000/ha. | AQUATIC PLANTS & FERMENTED AGRICULTURAL PRODUCTS | VARIABLE AMOUNTS OF ORGANIC MANURE | AREA LARGE BUT EXACT INFORMATION NOT AVAILABLE | 3,750 to 4,500 kg/ha/yr | FAO Mission to China (1976) |
| INPUT OF TRASH FISH OR OTHER HIGH PROTEIN RATION | | | | | | | | |
| 14) THAILAND | *Clarias batrachus* *C. macrocephalus* | FRESHWATER POND | Greater than 500,000 fingerlings/ha | 5% BODY WT. DAILY (90% TRASH FISH 10% RICE BRAN) | NONE | 25-30 hectares | 100,000 kg/ha | Ariya Sidthimunka (1972) |

Table 1 (cont'd)

| LOCATION | SPECIES USED | CULTURE METHOD | STOCKING RATE | FISH FEED | ADDED FERTILIZERS | AREA IN PRODUCTION | AVERAGE PRODUCTION | PUBLISHED * REFERENCE |
|---|---|---|---|---|---|---|---|---|
| 15)HAWAII | Macrobrachium rosenbergii | FRESHWATER POND | 10/$m^2$ | COMMERCIAL CHICKEN FEED OR SCRAP FISH | NONE | 32 acres | 3,100 kg/ha/ yr | Fujimura 1974 |
| 16)THAILAND | Penaeus monodon | FRESHWATER POND | 600,000/ ha | TRASH FISH TWICE DAILY, MUSSEL, CRABS, RICE BRAN (10%) | NONE | 9,000 ha. | 109 kg/ha/yr to 7,656 kg/ha/ yr | Asean 1977 Pongsuwana, U., & T. Bhukaswan |
| 17)HONG KONG | GROUPER (Epinephelus) SEA BREAM (Chrysophys) SNAPPER (Lutjanus) | SALTWATER CAGE | 35 kg/$m^2$ | 10% BODY WT. DAILY | NONE | 7.6 ha | 7800 | Personal Communication, 1978 |
| 18)JAPAN | YELLOWTAIL (Seriola quinqueradiata) | SALTWATER FLOATING CAGE | 80-200 fish/$m^3$ | COMMERCIAL DIET OR TRASH FISH | NONE | 4687 $km^2$ | 280 tons/ha | Fujiya 1976 |

MOLLUSCS

Data from many countries in Southeast Asia have indicated a very high and efficient production of shellfish protein. Data from raft, rack, pole and longline culture are difficult to compare accurately with the foregoing examples but extrapolated production values of 2-20 tons of meat excluding shell per hectare per year are being achieved. The latter rely on particularly favorable local hydrographic conditions.

* References to be found in Appendix 7.

Table 1 illustrates the range and sometimes the surprisingly high yield per unit surface or volume of aquaculture in tropical Asia; it does, however not illustrate relations of cost to output or to the amount of energy needed to produce a unit weight of protein. It is germane here to draw attention to the work of Shang (1973) who compared for several types of aquaculture and hog culture in Taiwan kg/ha and cost/kg only to find that aquatic animal husbandry in fresh brackish and shallow sea water has various advantages over pig rearing. Milkfish culture in brackish water, by the way was made relatively costly by the scarcity of fry that needed to be collected from the wild (Table 2).

When assessing in a comparative fashion the amount of energy needed directly and indirectly to produce a unit weight of unprocessed protein, we learn from Rawitscher and Mayer (1977) and from as yet unpublished research of Prof. Bardach that sewage based cage culture of fishes compares very favorably, in K cal input/g protein output, with hog culture in Asia and with various other types of animal husbandry or with sea fishing. For instance in Israeli polyculture which is however more mechanized and therefore more energy intensive than that practiced in most of tropical Asia, 65 Kcal representing all inputs expressed in energy terms, produce one gram of silver carp, common carp,mullet or tilapia while U.S. broiler production (the most efficient animal production technique established in the advanced countries) require about 149 Kcal for one gram of unprocessed chicken. For marine trawl fisheries of various food fishes in Canada and the U.S. such values in energy terms lie between 79 and 93 Kcal/g protein. Comparison of energetics and of labor or money cost accounting both establish the potential of aquaculture.

Table 2: PRODUCTIVITY AND PRODUCTION COST PER HECTARE FOR DIFFERENT TYPES OF WATER AND LAND ANIMAL HUSBANDRY

| Type of husbandry | kg/man-year | | kg/hectare | | Cost/kg (U.S. $) | |
|---|---|---|---|---|---|---|
| | Average*** | High+ | Average*** | High+ | Average*** | Low+ |
| Brackish water* | 5,098 | 11,022 | 2,112 | 2,687 | 0.37 | 0.29 |
| Fresh water* | 10,453 | 70,607 | 1,537 | 2,413 | 0.31 | 0.20 |
| Shallow sea* | 45,575 | - | 1,292 | 2,096 | 0.16 | 0.10 |
| Hog* | 12,000 | - | - | - | 0.43 | - |

* Derived from Taiwan Fisheries Bureau (1966) Report on the Sampling Survey of Production Cost of Private Fisheries in Taiwan, Taipei, Taiwan.

** Derived from Taiwan Sugar Co. (1968) Annual Report of Livestock Operation, Taipei, Taiwan.

*** Under average management. +Under superior management.

## Chapter 8. THE AVAILABILITY OF TECHNICAL AID FOR AQUACULTURAL RESEARCH AND DEVELOPMENT

### Bilateral Aid

There appears to be no lack of bilateral aid available for production-oriented viable projects. Even so, all of the national Fisheries Departments contacted said that they could use more money. As for research, however, they do not as yet have experienced staff in sufficient numbers to be able to undertake rapid expansion. There is already spare capacity in modern laboratories in Thailand (at Bangkok) as well as the prospect of such capacity when buildings currently under construction are completed in India (at Dhauli). Similar space will be available when construction plans are implemented in Indonesia (at Bogor).

At present, the fragmentation and the intensely competitive nature of bilateral aid is causing delay and confusion and much time of the few available senior experienced staff in each country appears to be taken-up with such negotiations, which are often concerned only with transient advisory visits from individual specialists. While the U. N. General Council has allotted the UNDP the responsibility for the coordination of multilateral and bilateral aid, this is not sufficiently effective in fisheries and in some countries, any such coordination is actively opposed by the ministries concerned.

### Multilateral Technical Aid

The regional and global programmes of FAO/UNDP have been active in promoting exchanges of information through conferences and workshops, in providing fellowships and in supporting development schemes with technical aid staff. Although there is a tendency to use the term "research" rather freely in

describing technical aid schemes, these in fact supply short-term staff for the testing and local adaptation of overseas technologies. This is useful and necessary and is rightly popular with governments seeking rapid, practical results. These programs should continue to receive donor support. This type of aid, however, involves short-term visits of specialists whose effective spell of practical work rarely exceeds two years. The lack of continuity virtually precludes progress on the longer-term studies of the type outlined in Chapter 5. The Mission sees no need for conflict between the aims of the technical aid organizations such as the South China Seas Program or the FAO Global Program on Aquaculture, and the longer term research programs of the type sponsored by CGIAR. Effective liaison will have to be established between the research reinforcement organization here proposed and the development activities in the region, especially with the South China Seas Program and the Global Program of FAO.

## Chapter 9. THE CASE FOR REINFORCEMENT OF RESEARCH AND THE PRIORITIES RECOMMENDED

### Research Support

1. The question on which the Mission has concentrated its attention is as to whether there exists in this South and East Asian Region, which produces some 70% of the world's aquacultural output, an opportunity to improve tropical food supplies by the type of support which has been found important in agriculture.

2. This support would narrow the gap between the academic field of university research, as supported by educational aid funds of both bilateral and UNESCO organizations, and the development of production by application and adaptation of known technology, which is supported both by technical aid organizations of bilateral donors and by FAO/UNDP funding of regional and global programs.

3. In the agricultural sciences this gap has been well demonstrated by the contributions which the International Agricultural Research Centres have already made throughout the tropical world. The Mission did not, however, start by assuming that this research gap existed in Fisheries or that the agricultural model would apply to aquaculture. Previous studies reported to TAC, (which are summarised in Chapter 3 of our Report) had already emphasised the complexity and the ecological location specificity of aquacultural production, and suggested that a new pattern of support might well be needed.

### Food Production

4. Over the region of South and East Asia, from India to China, we have found convincing evidence that aquaculture presents a very important opportunity to increase the production of food supplies for an increasing population. Aquaculture has the significant advantage that proteins of high dietary quality can be produced with low economic inputs by the culturing of shellfish and of those finfish which feed low on the biological food

chain on phytoplankton, zooplankton and vegetation. They are readily accepted as traditional foods, but their production as yet lacks the scientific and organizational support which has been provided for agriculture.

5. The opportunity exists of rationalizing and applying experiences on a standardised scale. This can best be realized by mission-oriented multi-disciplinary research.

6. Within the philosophy which the CGIAR has consistently applied to agriculture, there remains a very important aquacultural field for scientific and technical reinforcement, in the improvement of the production of those species which require low inputs and which do not compete for human food-stuffs. The milkfish is the most important for coastal brackishwater culture, with mullets and tilapia species as other potentially important crops. In the freshwater ponds, lakes, reservoirs and rivers there are already well-established species: the indigenous carps, the Chinese, Indian and Mekong basin carps, and omnivores like Leptobarbus (Jelowat) of the Indonesian archipelago. Where only salt water is available, mussels, oysters and other bivalves can be cultured by simple methods and there are very large and unexploited areas which could be brought into production to provide shellfish as an improvement for low-income diets.

7. In most of these fish species the production of fingerlings and their husbandry is crudely empirical with heavy mortality and unreliable provenance, although sufficient progress has been made to show that some of the methods developed elsewhere can be used for development of similar techniques for reproduction of tropical fishes. In some species, such as both Indian and Chinese carps, induced breeding techniques are well established on an empirical basis.

Need for Reinforcement of Research

8. After visiting both government laboratories and university departments in the region, we consider that the development of aquaculture is not yet adequately backed by applied research. There is great interest

and much empirical work in progress on the induced spawning and hatchery production of fingerlings of some ten or more species of finfish. Both external aid and government investment are, however, at present strongly diverted to the politically attractive production targets of high-priced carnivorous species for export, and for internal consumption as luxury foods. Prawns, shrimps, sea-bass, grouper and various catfish are at present given priority for scientific and technical support and for both government and private investment. These species require expensive inputs; the main feed supplied is "trash-fish", but this term is deceptive, since most of the small fishes used are of the size and species widely consumed by the poorer sections of the population. The intensive culture of carnivores does not add to the total food supply for the lower income groups and is in some cases in direct competition with them. In most cases the energy costs of trash fish feeding, either raw or especially as fish-meal, are adversely high. Improvement of monoculture techniques for high value crustaceans, especially those of the giant prawn, Macrobrachium rosenbergii, in freshwater ponds and the similar technology for the monoculture of the marine penaeid prawns are already attracting strong support from national funds and increasing commercial investment, so that the work is already well into the development phase. FAO/UNDP have already contributed to this development and we understand that some 20 centres in North America and Europe are experimenting with these species. We do not consider that CGIAR support could be justified for work on prawns. They have a minor role in food utilization in polycultures of non-carnivores.

9. We have found that the practical progress of development of technology for the reproduction of the milkfish, the Chinese carps (silver, bighead and grass carps), the mullets and other useful plankton feeders is delayed by lack of knowledge of the reproductive and nutritional physiology, and particularly of the applied endrocrinology, of these fish species. The nutrition of the cultured species at all stages of development, and their ability to make use of industrial products such as rice bran and vegetable processing wastes, requires systematic and accurate study. We do not

consider that the highly intensive pellet feeding of high protein foods, which is a commercial development of aquaculture in the USA and elsewhere, is either appropriate to the food production problems of the tropics, or requires CGIAR support. Since many of the fisheries scientists in South and East Asia have received training in North America and Japan, there is a tendency to give preference to such production methods. In so far as they are commercially attractive these intensive high-input methods do not need CGIAR support.

10. We met evidence of success in the combination of both freshwater and brackishwater fish cultures with pig production at levels of management ranging from the small farmer with twenty pigs and half a hectare of ponds to the large producer with 100 ha of ponds and a sophisticated 2000-pig production unit. We also saw experiment station work with combinations of ducks and pond-fish production. The full integration of fish culture into the livestock production of small farms is a field in which we believe that further scientific study would pay dividends in production and that CGIAR support would be appropriate.

11. The improvement of low-input field technologies, however, implies greater concentrations of food fish or shellfish and this inevitably increases the risks of diseases. The purposeful study of the maintenance of fish-health in low-input production systems needs to be greatly increased now, so that more practical help in diagnosis and advice may become available in five years' time, when, if production development is successful, farmers will urgently need the results of such research.

12. The greatest opportunity for development of very large unused resources for food production in South and East Asia is to be found in the development of culture techniques in enclosures in reservoirs, lakes and sheltered marine waters. The use of fish-pens, fixed or floating cages, or enclosures of small bays or lagoons all involve both problems of practical engineering and of biological management. The engineering aspects involve

technical aid for the application of well-known engineering technology to the use of local materials and skills, but the biological management of food-chain exploitation has many unknowns which require applied research in the sense in which we have already defined it. Such exploitation of local water resources avoids both the capital costs of pond construction and the competition with agriculture for land and water. In the sea it reduces the problems of over-fishing and avoids the high costs in both investment capital and energy consumption of coastal capture fisheries.

13. Cage or pen cultures depend upon the successful control of all kinds of pollution. Research into industrial technologies for purification of waste water and for recovery and recycling of waste products is worldwide and has made great progress in some countries of advanced industrialisation. We do not consider that this is properly part of an aquacultural research program, but there is an urgent need for governments of this region to organise the monitoring of water quality and to develop the legislative basis for pollution control. In experimental aquaculture, monitoring of water quality is, of course, essential.

14. Economic analysis is needed when major problems are under consideration for research, in order that research priorities should, in general, reflect potentials for development. We found economic studies of research objectives to be a subject in need of reinforcement.

## Priorities for Research

Within the culture systems described, we consider that priority should be given as follows:

1. Herbivorous and omnivorous fish species capable of rapid growth through feeding on phytoplankton, zooplankton and green vegetation, preferably in combinations of species to exploit the ecological resources.

2. Filter-feeding bivalve molluscs - oysters, mussels, cockles, clams, etc.

3. Combined production of such fish with pigs or poultry, or with agricultural crops.

4. Air-breathing fish, suited to waters of low productivity.

5. From the foregoing considerations, we consider that priority should be given to the study of the following groups of species. We find on studying the Report of the TAC Working Party on Aquaculture (1973) and the recommendations of the conferences, seminars, and working parties which we have consulted (Appendix 3) that there is general agreement on this list:

## SPECIES LIST

FISHES:

Indian major carps:

Catla *Catla catla* (Hamilton & Buchanan)
Rohu *Labeo rohita* (Hamilton & Buchanan)
Mrigal *Cirrhina mrigala* (Hamilton & Buchanan)

Chinese carps:

Bighead carp *Aristichthys nobilis* (Richardson)
Silver carp *Hypophthalmichthys molitrix* (Valenciennes)
Grass carp *Ctenopharyngodon idella* (Cuvier & Valenciennes)

Other carps:

Common carp *Cyprinus carpio* (Linnaeus)
Goldfish *Carassius auratus* (Linnaeus)

Other cyprinids:

Tawes *Puntius javanicus* (Bleeker)
*Puntius gonionotus* (Bleeker)

Mekong Basin species:

Pla eesok *Probarbus jullieni* (Sauvage)
Pla prom *Catlocarpio siamensis* (Boulenger)
Jelowat or Sultan fish *Leptobarbus hoeveni* (Bleeker)

Tilapia:

*Tilapia mossambica* (Peters)
*Tilapia nilotica* (Linnaeus)

Brackishwater species:

Milkfish *Chanos chanos* (Forsskal)

Mullet *Mugil cephalus* (Linnaeus)
*Mugil tade* (Forsskal)
*Mugil dussumieri* (Cuvier & Valenciennes)

Air breathing species:

Climbing perch *Anabas testudineus* (Bloch)
Giant goramy *Osphronemus goramy* (Lacépéde)
Kissing goramy *Helostoma temmincki* (Cuvier & Valenciennes)

MOLLUSCS:

Mussels:

*Mytilus* spp.

Oysters:

*Crassostrea* spp.

Cockle:

*Anadara* spp.

## Chapter 10. THE RESEARCH FIELDS IN WHICH INTERNATIONAL AID COULD MOST USEFULLY SUPPORT REGIONAL STUDIES

Domestication of fish and hence successful culture depends greatly on control over "seed, feed, breed", in other words reproductive physiology, nutrition and selection for genetic improvement. In fact the last is not possible without mastery over the first. Research in these areas as well as sanitation and prevention of disease are necessary for development of aquaculture in the region.

Supply of viable fry either caught from the wild or bred in hatcheries is the most direct constraint on the expansion of food fish culture in all countries visited by the mission. The production of milkfish and mullet depends on wild-caught fry; small numbers of milkfish have been spawned in captivity for the first time in 1976 while mullet spawning, though achieved experimentally, has not reached the stage where it can be applied commercially. Tilapia and to some extent Puntius and common carp are probably the only food fish for which, given adequate management, reproduction is not the main constraint to profitable culture. Hence induced spawning and the rearing of larvae of the most common food fish of the region are perhaps the two most important subjects for regional research.

### Hypophysation

A generally used technique to bring about controlled spawning is the injection of pituitary hormones or of the crude extract of this gland (hypophysation). Spawning in captivity of the Indian and Chinese carps and of many Mekong River species depends on injections of this kind. Some success has been obtained with the use of purified salmon and carp gonadotropins; human chorionic gonadotropin has also been tested but these methods are expensive and insufficiently studied. Practical application of these techniques are now being undertaken on species which have been subjected to little or no detailed physiological or endocrinological studies. Their success is variable, as can be expected; it would be improved by systematic research on a species by species basis.

Recourse to the sacrifice of large broodfish to obtain pituitary gland material for injection into others, as seen at a research station, underscores the need for endocrinological research.

Such research on temperate zone fish has not yet established clearly whether there is more than one effective pituitary hormone involved, or whether there is advantage in the use of purified gonadotropins over that from extracts of the whole pituitary gland. This comparison is currently being pursued by radioactive tracer assays. There is also some evidence of a synergistic effect of sex and growth hormones.

Releasing hormones

Shedding of eggs, the final event in the spawning sequence is promoted by releasing hormones. One of these, an analogue of a mammalian anti-estrogenic hormone has been synthesized; it appears to be the same in all fish. So far the method has been tested only on salmonids but the 1976 FAO Aquaculture Conference at Kyoto recommended that the method be applied to carps. In fact a releasing hormone had been successfully synthesized in Chinese laboratories in 1976; it has proved effective on Chinese carp species.

Yet another fruitful subject for applied endocrine research lies in the hormonally produced arrest of gonad development; this has been achieved experimentally with tilapias and is of importance in producing fish of a harvestable size by channeling food-energy and food-materials entirely into body growth rather than diverting these partly into the gonads.

Local Environmental Influences

Reproductive physiology and the spawning act itself are also subject to local environmental influences such as variation in day length and temperature and more importantly, rainfall and surface runoff. In the monsoon areas the latter is reported to contain chemicals that promote spawning. Another area of fruitful research in this category deals with the relation of sex pheromones to the

governance of behavior, in conjunction with hormones. Management techniques which employ some of these mechanisms or processes, though on an empirical basis, are consistently successful in Indonesia with species of Puntius and with common carp. Such studies will not only have to be done in specific locales they will have to rely to a great extent on help by local universities while affording valuable training to future professional personnel.

## Nutrition

We have a very meager base on which to rely for information concerning the successful feeding under culture of most tropical food fishes. The rearing of carnivores and omnivores in the temperate zone (the trouts, salmon and the common carp as well as channel catfish) provide data that are inapplicable to controlled, successful rearing of plankton feeders, especially of the herbivorous kind. It is true that empirical milkfish pond management and the growing of some freshwater phytoplankton feeders based on providing adequate plant nutrients have led to some successful cultures but extrapolation is unreliable without a broad limnological information base that would permit assessment of variation of the underlying factors in other, even slightly different circumstances.

## Larval Rearing

Lack of knowledge in tropical fish nutrition is most crucial in the realm of larval rearing; tropical fish larvae are minute, they have small mouths and on energetic grounds they must have numerous food particles within easy lunging reach. In addition they require high protein diets. Thus the provision of food for them through culture in separate tanks or in their rearing ponds represents a very important research subject. It should start with hydrobiological studies of the food organisms in ponds and their use by the successive larval stages of cultivated fish. The next step is the development of culturing techniques for the main organisms in the aquatic food chain, including both phytoplankton and zooplankton since most larval fish are believed to be carnivores at some stages of development. In parallel with the culture of feeds, the study of pond management by fertilization, etc. to produce a controlled

sequential development of algae blooms and other feeds is an important alternative to the expense of maintaining cultures in hatcheries.

The manufacture of artificial feeds by techniques such as micro-encapsulation to give appropriate size and buoyancy could only be advocated for large central hatcheries. Such manufacture relies on the development of processing techniques to achieve particle sizes of 10 microns which are not attainable by grinding, e.g. the flash-drying of liquid nutrient films or the use of centrifuges. While such highly sophisticated feeds may be successful, their costs tend to be high, and we were informed that even Israeli fish growers are moving back, on economic grounds, from prepared pelleted feeds to manuring of ponds for phytoplankton growth.

Nutrition of Brood Stocks. There is a need to study the influence of nutrition on maturity and to develop methods for manipulating feeding to advance or delay maturity.

Study of supplementary feeds. There is a need widely recognized among the directorates of the countries visited, to explore the use of vegetable wastes, by-products of canning and other industrial food preparations. We saw encouraging demonstrations at the Central Institute of Fisheries Technology at Cochin that application of known methods could produce valuable feeds from shrimp-head wastes and similar products. We learned of a move to link international computer-operated data banks for feedstuff nutrients, but we do not consider that the aquacultural industry is as yet sufficiently developed for such sophisticated and expensive support.

Basic nutritional requirements and digestive capabilities of tropical fish.

This field has already been entered on a wide front for cold-water fish. Similar work has produced convincing economic benefits in narrowing the conversion ratios between food input and saleable products in poultry and pigs, and to a lesser extent in ruminants. When applied to the stages from larval forms to brood fish, in some twenty or more tropical species, this is a very long-term

program. It should be undertaken in cooperation with advanced laboratories.

Selective Breedings and Genetic Improvement

The selection and breeding of animals is generally considered to be a very long term research endeavour and instances of true breeding strains of fish in temperate climates, such as salmon in Washington (Donaldson, 1970) have only been achieved over a period of some 20 years. However, culturing fish under tropical conditions has been shown to offer greater promise for shorter term results. The great fecundity of many of the species of interest allow for the production of several million eggs from a single spawning resulting in a wide range in variability in growth rates and other evident characteristics. This affords the opportunity for rapid crude selection. The normal spawning season which may be twice per year, can be increased by environmentally or hormonally induced breeding, e.g., this has resulted in monthly breeding of bighead and silver carps at Malacca, the frequent breeding of Ctenopharyngodon in Indonesia and Singapore, and the possibility of the breeding of Cyprinus carpio or Puntius gonionotus virtually at any time of the year.

The consequence of these practices is to be seen in the successful fish breeders' selection of the Israeli strain of Cyprinus carpio; the "Sinonia", "Punten", and "Majalaya" strains in Indonesia; and the 'Taiwan' and 'Yamatogoi " strains. Similarly aquarium fish dealers have produced many varieties of the Amazon species "Oscar" Astronotus ocellatus and "angel fish" and currently breed attractive varieties at will.

While in the case of aquarium fish their size and easy domestication in small tanks makes their handling practical and convenient, it is clear that to retain large numbers of healthy selected progeny and broodstock of various generations for back-crosses require considerable numbers of well-maintained ponds. Information on many of the species concerned indicate that some of the Chinese, Indian and common carps can live for several decades. Additionally, the technique of cryogenic sperm preservation provides promise of long-term storage of sperm from selected donor males.

This technology is well established for salmon, where 88% survival of deep-frozen sperm has been achieved, but initial tests with tropical foodfish have shown limited survival. Some recent tests with milkfish have been more successful. This is a research task best undertaken in the tropics, with backing from laboratories where there is good experience of the methods.

The physical pond faciltiies for containment of fish for breeding for genetic improvement now exist at Malacca, Malaysia and are planned for imminent construction at Dhauli in India. Owing to the influence at any locality of environmental factors which trigger spawning, such as day-length and climatic conditions, seasonal rainfall or water conditions, it will also be necessary to experiment with stocks of fish from other areas. Some criteria that may be considered in particularly useful indigenous fish, include fast growth, robustness, and disease resistance, shape, docility or adaptability to pond confinement as well as early or late spawning in their natural environment.

It should be stressed that the selection that has been done so far in Southeast Asia, though based on visibly evident differences, and not on chromosome investigations or gene linkages, have already been able to produce strains with heritable characters. This therefore gives promising indications that closer scientific study may lead to medium-term results for the domestication of particular strains of tropical species now cultured. After pure strains have been established one can proceed to selective improvement as well as to hybridization; species crossing results with tilapia have resulted in crosses with hybrid vigor as well as in the production of populations with monosex or sterile progeny. This is of advantage in controlling the numbers of fish in ponds. In fact based on the experience with avian and mammalian stock and with temperate zone fish it is indeed likely that investment in genetic research will eventually pay handsome dividends, provided that it is associated with advances in reproductive physiology and nutrition.

Health of stocked fish

Only in Indonesia has fish disease as yet reached the level of economic significance. An ectoparasite (Lernea cyprinacea) probably introduced with imported

fry, is causing severe losses in pondfish production. There is a general acceptance, in all countries visited, that as fish-cultural practices are intensified, disease problems may be expected to increase. Experience in the temperate zone illustrates how serious the losses can then be. Studies to produce a "veterinary service" style of support for aquaculture are long-term but are necessary if cultured fish are to play a more substantial part in the feeding of millions of people in the region. As an experienced fisheries pathologist at the Nanaimo Biological Laboratory put it, "In pathology research a lead-time of only 5 years is a scientific emergency." Thus, studies to improve the security of production by protecting stock from disease should begin now.

The highest priority should go to the diagnosis and assessment of the incidence of parasites, and of fungal, bacterial and viral diseases. There is, as yet, too little known to be able to plan a sound institution of research resources among the very numerous candidate organisms. There is a general observation that well-fed fish in well-managed enclosures remain healthy, while diseases become evident when stresses are imposed. In fact, experimental stressing can be a valuable technique in determining which diseases are particularly prone to turn into epidemics. Only simple laboratory equipment is required at the survey stage, but isolation facilities are clearly needed for detailed studies. Overseas laboratories can help, mainly by training pathologists from the region, and by consulting visits.

The biology and ecology of species under study for aquacultural production

In spite of centuries of traditional production at low levels of productivity, the full life history and ecological requirements of the milkfish (Chanos chanos) and the mullets (Mugil spp.) are still unknown. We were in fact shown the half-grown progeny of the first successful spawning of milkfish in captivity, after centuries of culture techniques that rely on collection of larvae from the wild. Similarly, important freshwater species such as the Probarbus jullieni of the Mekong Delta, or the Leptobarbus hoeveni of Indonesia are as yet little studied. The former species crosses political frontiers; both are of regional importance. Their study needs regional support and experienced scientific collaboration to lay the basis for their management under culture. Comparable statements apply to yet other species of the large carp family such as

Catlocarpio siamensis of the Mekong Basin which reaches over a meter in length. This type of investigation relies heavily on field work; central planning for any country or region as is envisaged here would rely, with profit, on close collaboration with colleges and Universities.

Aquacultural Engineering technology

Basic to all fishculture is the control of water quality. Surprising gaps in this regard were found to prevail in the countries visited. New stations, constructed with adequate and sometimes ample capital investment, were equipped with very crude sand filters which were serviced by manually digging out and discarding the sand at intervals. For the control of water quality for hatcheries this is inadequate and unnecessary when well-tried, inexpensive designs of reversible sand filters have been available for several decades, and swimming pool filtration plant is on sale, with spares and service, in all countries concerned.

There are several other established techniques for revetment of ponds, adjusting of pH of water flows, ultra-violet sterilization in cases where this is necessary, as well as improvements in harvesting technology, based on species specific behavior traits, where a central advisory and experimental development service might serve the region well.

Cage construction, and adapting the types to peculiar hydrologic conditions while using local materials, involves long-established techniques of marine and field engineering, but there is a need to share successful details of technology. Here again connections with local engineering schools and colleges would be of advantage.

## Chapter 11. DEVELOPMENT FROM EXISTING STRUCTURES OF A REGIONAL ORGANIZATION FOR AQUACULTURAL RESEARCH

### A New Pattern of Regional Reinforcement of Research

1. Opinions expressed by both administrators and scientists of each of the countries visited were unanimous in recognising the value of regional cooperation in research, and the advantages of reinforcement by experienced research workers drawn from the world-wide community. Each country, however, wanted to see such action within its own laboratories, rather than elsewhere in the region and agreed that a new pattern of organization is therefore needed.

2. In contrast to agricultural livestock production, aquaculture involves a great diversity of species with a very wide range of ecological environments in fresh, brackish and marine waters. We therefore agree with the earlier conclusions of the TAC that there is no feasible prospect for the reinforcement of aquaculture on a world scale from a single international institute. Even within the region studied the diversity is such that we do not recommend the reinforcement of aquacultural research from a single geographical location. A network of research groups working with national organizations in solving production problems of significance to major environmental areas would, we believe, provide the most effective pattern of support. Such a network, however, will have common support requirements for logistic services, biometrics, library and information services and the pooling of some highly specialized skills and equipment, so that association with a regional headquarter support and training centre would greatly increase the effectiveness and coordination of the network.

3. In the countries in the region we visited many laboratories whose construction and equipment had been provided from national resources and

substantially supported by technical aid. We also met staffs of many laboratories who are predominantly young qualified graduates with very slight practical experience. Many had been overseas for higher degree training, which had increased their specialisation, but had not provided experience adequate for leadership of research projects.

4. The possibility of reinforcement of such laboratories by cadres of experienced research scientists from developed countries with large establishments for applied research has long been apparent, and there have been many attempts to provide such help in research by the short-term technical aid mechanisms which are often effective in development programs. In research however, the lack of continuity has proved to be self-defeating. The need for sustained maintenance of high calibre research effort under experienced leadership has led in agricultural research, to the CGIAR system of International Agriculture Research Centres as a reinforcement for national research organisations.

5. The ecological diversity of aquacultural problems in this region is such that we consider that the advantages of on-the-spot sharing of research experience would best be realized by posting a small cadre of experienced scientists to the main aquaculture research laboratory in each country. Since budgetary considerations must sharply limit the size of such reinforcement units, they will be more effective if they are organised as a mutually supporting regional network and backed up by a headquarters laboratory from which logistic, biometric, library and specialist research technology services could be provided.

6. Essential principles of such a network are that the research cadres would be controlled by, and effectively be outposted divisions of, the regional centre; they would be working on regional priorities and would not be specifically concerned only with the problems of their host country, although ecologically they would be working on local species in local conditions.

The Advantages of Building on the Existing Regional Initiatives

7. In agriculture the history of regional research organisation in tropical countries has shown that the most critical requirement is the will and determination of the national governments to cooperate. The Consultant Mission therefore studied in detail the existing regional cooperation in aquacultural research represented by the Aquacultural Department of the Southeast Asian Fisheries Development Centre. (SEAFDEC)

8. There are, however, several important constraints which would presently impede the use of SEAFDEC as a means for international reinforcement of applied aquacultural research and training.

(a) The SEAFDEC organization comprises Japan, Malaysia, the Philippines, Singapore, Thailand and Vietnam. It does not include Indonesia or India, Pakistan, Sri Lanka, Bangladesh, Burma, Laos or Cambodia. Indonesia and India both have substantial production in aquaculture and have declared government policies for aquacultural development as part of their rural development strategy; their participation in an internationally reinforced network would be necessary, while the possibility of helping the people of the remaining countries to augment their food supplies by aquaculture should be available as opportunity occurs.

(b) Although the Aquaculture Department of SEAFDEC has much of the infrastructure to undertake work on foodfish and bivalve shellfish, these are at present minor priorities; included only in the last two years. The Centre relies heavily on support from Japan, both for specialist staff and equipment, all of which are very specifically devoted to prawn culture at the request of the SEAFDEC Council.

(c) The structures of organization, staffing and chain of command are reflections of the governmental and bilateral nature of the

initiatives which created SEAFDEC. They would not be acceptable in an internationally supported centre without very substantial changes.

(d) Among the present group of more than 60 researchers and associates there is great enthusiasm and initiative but very little maturity of experience. A substantial reinforcement of more experienced international research staff would be essential.

(e) The Council of SEAFDEC, comprising the Directors of the Fisheries Departments of the component governments, is concerned with the overall development of the fishing industry, 90% of which is based on marine capture fisheries. The scientific policy and direction of aquacultural research requires a more specialized governing body, which would call on international scientific experience and would include the expertise available in the universities of the region, which are not yet sufficently involved.

(f) Finally, on the operational side, the main centre at Tigbauan has severely outgrown its life-support systems. Freshwater, seawater and aeration supplies are at present quite inadequate even for the present scale of operations. A fully engineered redevelopment of the freshwater supply system, involving new boreholes, 4 km of mains and an additional 50,000 gallons of storage is under construction and will, shortly, provide a good supply. Substantial capital development of intake, treatment, storage and distribution works for seawater are also urgently required and much of the present compressed air system needs replacement. Organization to give stronger logistic support to the outstations would also be essential.

9. None of these constraints need be permanent; the first and most serious of them, the incomplete membership of SEAFDEC, would be partially overcome by a new initiative, designed to make the research and training facilities of the SEAFDEC aquacultural laboratories more accessible to all of the countries of South and Southeast Asia. This is the proposal for an "Asian Institute of Aquaculture" as a collaborative network of both government and university laboratories to organize joint training and research programs. Both India and Indonesia have already indicated interest. The Mission found that enthusiasm for this idea was more evident among universities and that their concept of the AIA appeared to be mainly as a source of funds and of additional post graduate students for their own Departments.

10. In its present tentative form, the AIA would have an international council which would direct a cooperative research and training program, making use of the staff and facilities of the SEAFDEC Aquaculture Department, while the latter would continue its program of aquacultural research under the SEAFDEC Council. The Consultant Mission does not consider that this complex arrangement, devised as an outgrowth from within the present bilateral prawn-dominated program, could be recommended to the CGIAR for support. The concept of an AIA, however, is bold and imaginative, and if supported to the logical conclusion that the entire Aquaculture Department of SEAFDEC should develop into an Asian Regional Organization for Aquacultural Research, the outcome could be a powerful instrument of scientific support for cultured fish production throughout South and Southeast Asia.

11. This development would be reinforced by action on a second SEAFDEC initiative, taken in the last two meetings of the Council, in which the Aquaculture Department was authorized to prepare proposals for outposting divisions to work in the various countries of the region, on a basis of ecological or disciplinary specialization.

12. A third and subsequent development which would reinforce these proposals, is the plan by the Government to set up a further campus of the University of the Philippines to specialize in the training of fisheries personnel. The Mission was informed that the site selected is immediately adjacent to the present SEAFDEC laboratories at Tigbauan and that the new campus would be known as UP (Visayas), for which a World Bank loan of $20 million is now under negotiation.

## Chapter 12. PROPOSALS FOR A REGIONAL RESEARCH NETWORK WITH A SUPPORT & TRAINING CENTRE

a) Proposals for a SEAFDEC/CGIAR Agreement

1. The constitution of SEAFDEC permits the Council to enter into agreements with other organizations for any purposes approved by the member countries. We therefore propose that an agreement be entered into by which the SEAFDEC Council makes available to the CGIAR the main facilities for research and training at Tigbauan and its substations of Binangonan, Igang and Pandan, in which work would be undertaken on the regional research priorities which we have recommended.

2. The work on prawns, which would not qualify for CGIAR support, would continue to be funded as at present by the governments of the Philippines and Japan, and would be concentrated as far as possible on the Leganes station, but would continue as an integral part of the program of the new Organization.

3. The CGIAR would set up a new Regional Organization for Aquacultural Research in Asia to consist of an administrative headquarters, and a support and training centre at Tigbauan, with outposted divisions to the five countries as described, and with contracts to Hong Kong and to individual universities throughout the area.

4. A director and heads of departments would be recruited by international competition, and the present staff would be absorbed in capacities appropriate to their qualifications and experiences.

b) The Effects of these Proposals on SEAFDEC as a Regional Organisation

5. The partnership of CGIAR in one of the three principal projects of SEAFDEC would be a major form of recognition by an international group

of donors of the initiative and enterprise of this regional organisation. It would, at the same time, carry forward two policies already recommended by the Council of SEAFDEC, i.e. the establishing of regional aquacultural research activities in member countries, and the broadening of the research and training in aquaculture to include other countries of the region.

6. The value of SEAFDEC cooperation in the fields of marine capture fisheries and of fish processing is in no way diminished by the development of cooperation in aquaculture, and the Mission hopes that the new agreement may help to overcome the present political obstacles to a wider participation of countries in SEAFDEC membership.

c) Proposals for regional divisions outposted to national centres

7. Outposted divisions would comprise research leaders, one of whom would be Head of Division, who would have some years of successful and relevant postdoctoral research experience at an international level. Counterpart research associates would be at Master's degree level and capable of taking advanced research.

8. We propose that each country should make available and maintain the physical structure of the laboratory space required, but that equipment, staff, running costs and training provisions would be supplied by CGIAR funding the Regional Organization.

9. These ideas have been discussed in general terms with the research authorities of each country visited, and have been informally welcomed, but no detailed discussions of the allocation of specialisations within such a network have been held. However, in order to illustrate more clearly the reinforcement pattern proposed, we set out below the subject groupings which we believe would make best use of the facilities and environments which we were able to assess in this comprehensive, but inevitably incomplete, tour of research stations.

d) Suggestions for allocation of research responsibilities

10. Mekong River Basin Division: Thailand

National Inland Fisheries Institute (NIFI) (new laboratories with ample capacity to house such a unit).

Staff: 3 research leaders - Physiologist
Limnologist
Ecologist
3 counterpart graduate students
6 technicians
1 clerical assistant

Program Objectives:
Biology of fishculture management of important Mekong River fish species such as the *Probarbus jullieni* and *Catlocarpio siamensis;* study of the stocking of reservoirs by productive species which do not grow well in ponds.

11. Composite culture division: India

Central Inland Fisheries Research Institute (CIFRI) at Dhauli, Orissa (new laboratories and large pond complex under construction, with ample capacity to house a regional unit).

Staff: 3 research leaders
3 counterpart graduate students
6 technicians
1 clerical assistant

Program Objectives:

Biology of selected species suitable for aquaculture from the river systems of the Indian sub-continent. Management of composite cultures in still-water ponds. Adaptation of present technology to areas beyond Northeast India.

12. Genetic Improvement Division: Malaysia

Fisheries Research Station at Melaka. A large well-developed complex of fish ponds suitable for replicated experimentation for the production of selected strains; with supporting laboratories, with capacity for additional staff.

Staff: 3 research leaders
3 counterpart graduate students
6 technicians
1 clerical assistant

Program Objectives:
Selection and hybridisation in pond fish. Biology of indigenous omnivores and coarse vegetation feeders such as the "Jelawat" *(Leptobarbus hoeveni)* and their adaptation to pondculture.

13. Fish Health Division: Indonesia

Inland Fisheries Research Institute (LPPD), Bogor, Java. New research facilities are planned by the Government to support the extensive Indonesian aquaculture industry, which is one of the largest in the region.

Staff: 3 research leaders
3 counterpart graduate students
6 technicians
1 clerical assistant

Program Objectives:
Fish health in culture systems: Parasitology and Microbiology:
Indonesia is the only country which has indicated that fish diseases are a major constraint on aquacultural production. This is therefore the preferred location for a fisheries pathology team for the region. It is expected that solutions found here will be adaptable in other countries of the region.

14. Cageculture Division: Singapore

Primary Production Dept. Fisheries Research Laboratories. The existing fisheries research facilities are being expanded to accommodate increased research programmes.

Staff: 3 research leaders
3 counterpart graduate students
6 technicians
1 clerical assistant

Program objectives:
Pen and cagecultures of phytoplankton feeders by intensified culture systems in fresh, brackish and marine waters.

15. Special Contracts

Hong Kong

Contracts for study of Chinese aquacultural systems.

e) Proposals for the Administrative Headquarters, Research Divisions and Services at Iloilo

The complex of laboratories and of facilities for accommodation and training which is nearing completion at Tigbauan, near Iloilo in the Philippines, is by far the largest and best equipped in the region. The total investment in structures and equipment now exceeds U.S. $ 11 million. There are also two substantial substations, one for pond-culture at Leganes, some 20 Km from Iloilo, and one for freshwater culture at Laguna de Bay. There are also smaller substations concerned with reproduction of milkfish and with seafarming in enclosed bays. Details of the main facilities are summarised in Appendix 7.

These structures and facilities offer unique advantages to reinforce the network with service facilities such as library and information, biometrics and economic analysis. The laboratories newly constructed and equipped for reproductive physiology and for nutrition would provide excellent facilities for these two research divisions, which would also be able to make use of the freshwater and seafarming substations. The brackish water substation at Leganes would be able to accommodate much of the prawn program which lies outside the policy boundaries for CGIAR support, but which the Governments of both the Philippines and Japan would probably be prepared to sustain.

We therefore propose that the following units of the network be located at Iloilo:

Nutrition Division
Reproductive Physiology Division
Biometrics Unit
Economics Unit
Library and Information Unit
Training Unit
Life Support Systems Unit
Administrative Services
Directorate

Nutrition Division

4 Nutritionists, specialising in requirements and sources of

Energy
Proteins
Minerals
Vitamins

It would share with the Reproductive Physiology Division a Biologist and a Technologist specialising in hatchery operations. The Nutrition Division will concentrate on studies on the digestive capabilities and nutrient requirements of the important food-fishes which are being cultivated as well as studies on diet formulation and test feeding of all stages of juvenile to adult fish. The laboratories will be fully equipped for analytical studies of all the essential components for efficient nutrition of fish. It will accommodate student researchers for instruction in procedures which will be applied in field trials in the different conditions of the region. Particular emphasis will be on diets for larval nutrition and for efficient broodstock diets. Locally available feed ingredients which may be used for formulating supplementary fish feeds as well as the role of natural food organisms, will be studied.

Reproductive Physiology Division

1 Physiologist
1 Endocrinologist
1 Hatchery Biologist ) Shared with Nutrition Division
1 Hatchery Technologist )

The Reproductive Physiology Division will elucidate the gonadal maturation of target fish species, study the environmental factors such as water conditions, photoperiodicity and behavioural responses which govern reproduction and devise standard procedures for induced spawning whether by hormones, environmental changes or dietary control. Standard spawning methods will be the basis for adequate supplies of seed for fishculture and subsequently for breeding and selection procedures.

Biometrics Unit

The physical limitations on pond or pen replication have restricted the value of many results in experimental aquaculture, in that the estimates of data variance which have long been regarded as essential features of scientific evidence in agriculture have rarely been applied. For many years the field station at Malacca appears to have been the only centre for tropical aquaculture which was equipped to provide effective field replication of experiments. There are, incidentally, many problems for which subdivision of ponds by netting enclosures, served by floating walkways, offers an inexpensive means for the replication which is essential in biological measurements. The sites suggested for research reinforcement are those in which replication facilities are available or are being constructed so that this restriction should no longer apply.

There is thus a very clear need for a greater input of biometrical thinking into the design and analysis of aquacultural experiments in the region. The provision of a small team of specialists in biometrics is therefore proposed as a priority measure.

Economics Unit

Economists at ROARA should work with the divisions at headquarters and in the field; they should assess the value to production economics of procedures under research scrutiny as early in the process of research commitment as possible, thus enabling economic considerations to be used in iterative planning for research development. They should also be charged with relating market economics to the research program wherever applicable.

Library and Information Unit

A fisheries and aquaculture library has been established at the SEAFDEC Tigbauan station. This will require upgrading in terms of holdings and information retrieval and distribution systems. Better linkage with the researchers

within ROARA will be required as well as additional linkages with other regional and international information services. We consider that improvement of technical information gathering and exchange on a common language basis will be particularly important in the proposed organization, since it includes a number of geographically separated units. Many researchers in the region have noted that it is very difficult to obtain background publications and expressed the desire to see the establishment of a central clearinghouse for this material. It is essential that this unit include an individual thoroughly conversant with information retrieval and distribution systems.

Training Unit

In all of the countries which we visited the importance of training of national research staff was emphasised as a welcome major role for a regional organization. While training must draw directly on the experience of the active research workers, frequent interruptions are clearly inimical to research progress; the preparation of course materials, the input of teaching skills in the planning and conduct of research-related courses and help with the workload of travel and consultations has been found essential in the major International Institutes of the CGIAR system. We believe that they will be at least equally necessary in a regional network and suggest provision accordingly.

A major element of training of research workers is the provision of 44 posts for scientists from the region, at the Masters' Degree level, to do advanced work as members of the Research Divisions and Units. This training should in many cases provide the basis for a doctoral thesis. There will be opportunities for ad-hoc short courses for research workers to learn new research techniques at Tigbauan and there will be opportunities for the Training Unit to help outposted divisions to conduct such training courses in their host countries. For higher-degree training, other than that noted above, bilateral aid schemes are already in operation and tentative suggestions for such development at Iloilo are outlined in Chapter 16.

Life Support Systems Unit

The problems of engineering for biological management which confront research authorities in aquaculture do not involve new principles. However, the need for innovative technology is specific enough in this field to justify investment in a regional team which will both develop and adapt the technology and ensure prompt sharing of advances wherever they are made. This team should have competence in devising of procedures as well as in the design of structures and equipment. Supplies of seawater and of brackish water of controlled salinity, filtered and where necessary, sterilized are essential requirements for many research aspects of production problems, although they may not be necessary to commercial operations.

Construction of ponds, intake services, drainage works, filters and pumping stations in tidal, estuarine or river situations are site-specific for research institutions as for commercial units. A team of engineers and technicians, with strong biological backing from the other Divisions and Units, would have much to contribute to the progress of the proposed research network. The unit should be led by a civil engineer and should include a chemist with experience in soil and water problems.

Administrative Services Unit

The rapid construction and furnishing of the complex of buildings and services at Tigbauan and substations, much of it by direct employment of craftsmen, has required a very substantial administrative organization. However, construction is now nearing completion and the full strength would not be required to maintain the laboratories. The national traditions of organization have also resulted in more senior administrative positions than would be acceptable in an internationally funded structure. However, the energetic and determined attitude with which difficulties have been overcome has led to the establishment of a valuable technical maintenance cadre for buildings, plant and equipment and this will continue to be necessary. It is not possible at this stage to be precise as to the posts and duties required for administering and servicing this complex but we recommend that a strong group be provided, as shown in the next Chapter.

Directorate

Both the Director and his Deputy would need to undertake a great deal of travelling to coordinate and develop the regional network, so that provision of two senior and experienced scientists is recommended.

(f) Contracts for Research Tasks

Hong Kong

The Mission is sharply aware that aquacultural research of significance to the region is taking place both in China and in Taiwan. A study of the applicability of such scientific advances to the needs of developing countries of South and East Asia would be a very appropriate undertaking for the Hong Kong institutions actively working in these matters.

University Contracts

Contracts with universities in donor countries are a matter of bilateral aid arrangements and their potential involvement in training is discussed in Chapter 16.

Within the developing countries of South and East Asia there are many opportunities for universities to undertake specific problem-solving research in areas in which they have both professional strength and research facilities. Such contracts should, we believe, be arranged by the Director, working with Heads of Divisions to ensure that such university research contracts form an integral part of a planned program. The advantage to the universities would be the funding of additional post-graduate students and continuous contact with the work of the regional organization. This aspect of the program should start in a modest way and should increase as the regional organisation develops.

## Chapter 13. AN OUTLINE OF THE STRUCTURE AND BUDGET OF THE PROPOSED ORGANIZATION

REGIONAL ORGANIZATION FOR AQUACULTURAL RESEARCH IN ASIA

(R O A R A)

HQ., Research Divisions & Network Support Units

| | Senior International Scientists | Post Doctoral Fellows | Graduate Associates | Technical Assistants (T.A.) | Administrative Assistants (A.A) |
|---|---|---|---|---|---|
| Director | 1 | | | | 2 |
| Deputy Director | 1 | | 1 | 2 | 2 |
| Nutrition Div. | 1 | 3 | 6 | 12 | 1 |
| Reproductive Physiology Division | 1 | 3 | 6 | 6 | 1 |
| Biometrics Unit | | 1 | 2 | 4 | 1 |
| Economics Unit | | 1 | 2 | 2 | 1 |
| Library, Information Unit | | 1 | 1 | 2 | 3 |
| Training Unit | | 1 | 2 | 4 | 1 |
| Life Support Systems Unit | | 1 | 4 | 8 | 1 |
| Administrative Services Unit | | 1 | 6 | 6 | 10 |
| Totals | 4 | 12 | 30 | 46 | 23 |

Outposted Divisions

| | | | | | |
|---|---|---|---|---|---|
| Mekong River Division | 1 | 2 | 3 | 6 | 1 |
| Composite Culture Division | 1 | 2 | 3 | 6 | 1 |
| Genetic Improvement Division | 1 | 2 | 3 | 6 | 1 |
| Fish Health Division | 1 | 2 | 3 | 6 | 1 |
| Pen Culture Systems Division | 1 | 2 | 3 | 6 | 1 |
| | 5 | 10 | 15 | 30 | 5 |
| Total full establishment | 9 | 22 | 45 | 76 | 28 |

I. Proposed annual recurrent budget. The network will take three to four years to reach full development; but the eventual full costs have been estimated on the basis that no new capital construction from CGIAR funding will be needed, since the deficiency throughout the region is of trained manpower to make full use of the facilities already available. After discussions with CGIAR secretariat staff it has been assumed that all direct costs and overheads in the personnel account could be met on the following scale.

| Staff Position | Salary | U.S. $ Support | Total |
|---|---|---|---|
| Senior International Scientist | 35,000 | 15,000 | 50,000 |
| Post-Doctoral Fellows | 25,000 | 13,000 | 38,000 |
| Graduate Associates | 16,000 | 10,000 | 26,000 |
| Technical Assistants | 8,000 | 3,000 | 11,000 |
| Administrative Assistants | 6,000 | 3,000 | 9,000 |

On these scales the annual costs of one outposted division would be: -

| | |
|---|---|
| Div. Head | 50,000 |
| 2 Post-Doc. | 76,000 |
| 3 Grad. Assoc. | 78,000 |
| 6 T.A.'s | 66,000 |
| 1 A.A. | 9,000 |
| 2 Drivers & Casual labour | 12,000 |
| | $291,000 |

Assuming personnel expenses to be 60% of running costs, the provision for all other expenses would be $194,000, giving a total of $485,000. which for 5 Divisions will total 2,425,000.

Costs of H.Q.

| | |
|---|---|
| 4 Senior Scientists | 200,000 |
| 12 Post-Docs | 456,000 |
| 30 Grad. Associates | 780,000 |
| 44 Technical Assistants | 560,000 |
| 23 Admin. Assistants | 207,000 |
| | $2,149,000 |

Assuming personnel expenses to be 60% of the running costs, provision for all other expenses would be $1,433,000, giving a total of $3,582,000. $3,582,000

As a check on this estimate, the present operations of the SEAFDEC Aquaculture Department, which has approximately 70 researchers and associates, a large sector and a very large support group of administrative, service and security personnel, field staff and labour, cost U.S. $5,000,000. At present some 60% of this force is devoted to the study of prawn production and some 40% to subjects which the CGIAR could be recommended to support. It is therefore proposed that the CGIAR should build up additional senior staff; the initial expenditure would rise slowly as the foodfish program was developed, to reach a level of about $3,600,000.

Simultaneously, recruiting would begin for the five outposted divisions; their equipment and supply would build up to an eventual total of $2,425,000. $2,425,000

The total recurrent expenditure of the full network organization would thus reach $6,007,000 in three to four years. $6,007,000

II. Capital costs of equipment for outposted divisions.
Capital investment would be limited to the equipment of the five teams as they took up appointment in the laboratories made available by each country. We estimate that the provision for this initial equipment should be as follows: (Equipment for the Nutrition and Reproductive Physiology Division has already been provided.)

| | U.S. $ |
|---|---|
| Mekong Basin Division NIFI Laboratory) (includes transportation and other needs for field work) | 120,000 |
| Genetic Improvement Division (Malacca) | 80,000 |

| | | |
|---|---|---|
| Composite Culture Division (CIFRI Lab) (includes nursery and live fish transport equipment) | 150,000 | |
| Support Units and Divisions at Iloilo (other than Reproductive Physiology & Nutrition) | 150,000 | |
| Total capital provision for equipment | | $660,000 |

Research Contracts

| | | |
|---|---|---|
| Hong Kong | | $20,000 per annum |
| Universities | 1980 | $50,000 |
| | 1981 | $50,000 |
| | 1982 | $75,000 |
| | 1983 | $100,000 |

BUDGET SUMMARY ($U.S. x 1,000)

| | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|
| 1) RECURRENT | | | | | |
| a) OUTPOSTED DIVISIONS | 200 | 750 | 2,000 | 2,425 | 2,425 |
| b) HEADQUARTERS | 300 | 2,250 | 3,000 | 3,582 | 3,582 |
| c) CONTRACTS. HONG KONG | - | 20 | 20 | 20 | 20 |
| OTHER UNIVERSITIES | - | 50 | 50 | 75 | 100 |
| | 500 | 3,070 | 5,070 | 6,102 | 6,127 |
| 2) CAPITAL | | | | | |
| a) OUTPOSTED DIVISIONS | - | 510 | - | - | - |
| b) HEADQUARTERS | - | 150 | - | - | - |
| | | 660 | | | |

## Chapter 14. A SUGGESTED TIMETABLE FOR NEGOTIATIONS

| | | |
|---|---|---|
| April 1978 | - | Report distributed to TAC, SEAFDEC and IDRC. |
| June | - | TAC considers report. |
| August | - | SEAFDEC Program Advisory Committee |
| September/October | - | (i) A special meeting of SEAFDEC Council<br>(ii) A meeting of Government representatives called by TAC to discuss the Mission's proposals with all of the countries concerned. |
| November | - | (i) A TAC Progress Report and Outline Proposals to the CGIAR.<br>(ii) Appointment of an Executive Agency. |

## Chapter 15. A SUGGESTED TIMETABLE FOR FUNDING

| | | |
|---|---|---|
| 1979 | - | Appointment of a Governing Board<br>Appointment of a Director and some senior scientists to head Divisions & Units.<br>Provision $0.5 m. |
| 1980 | - | Regional Organization begins operations. CGIAR undertakes financial support of foodfish aquacultural research at $2 m. New posts and initial operations $1 m.<br>Total provision $3 m. |
| 1981 | - | All Divisions & Units in operation but not at full strength. Recruiting continues.<br>Provision $5 m. |
| 1982 | - | Full network organization in operation.<br>Provision $6.25 m. |

This very rapid suggested rate of development of a new organisation is only possible because the buildings and other infrastructure are already in place over most of the network.

## Chapter 16. SUGGESTIONS FOR THE TRAINING OF RESEARCH STAFF

The need for postgraduate training in aquacultural technology and research methods was expressed in each of the countries visited. Somewhat unfortunately, the Aquacultural Department of SEAFDEC responded to pressure from member countries to begin postgraduate training courses before their preparations were adequate to achieve course-organization at international standards. As a result of this initial experience, an ambitious scheme to improve postgraduate training arrangements has been proposed under the title of an "Asian Institute of Aquaculture". The project was to create a separate organization for training, with its own Board of Governors and financial provisions, with a membership embracing all countries in the region, which would make use of the staff and facilities at Iloilo for research and training, while the ongoing SEAFDEC research program also continued sharing these same facilities. SEAFDEC Council approved in principle that the project be explored but came to no decisions about implementation. The Consultant Mission does not consider that such complex arrangements with a dual authority would be viable.

A previous exploratory proposition by the SEAFDEC Aquacultural Department for postgraduate training does, however, appear to have much merit and to have made very encouraging initial progress. This is a plan for regional postgraduate training in Reproductive Physiology and Nutrition. These two subjects have been given highest priority by SEAFDEC, by those who have advised the TAC, and by various FAO international conferences and regional seminars. Proposals to invite overseas universities in donor countries to cooperate in such training have been prepared in detail by the Aquaculture Department of SEAFDEC with the assistance of consultants Dr. A. Gorbman (Reproductive Endocrinologist of the University of Washington, Seattle), and Dr. J. Halver, Senior Scientist in Nutrition of the U.S. Fish & Wildlife Service. Drs. Gorbman & Halver undertook a tour of the main universities and institutes concerned with aquaculture in India, Thailand, Malaysia, Singapore and the Philippines. The proposals, include the training of 20 postgraduate students; initially in two-year joint courses for Masters' degrees, in conjunction with a consortium of

overseas universities. The first year would be spent in course-work at the cooperating universities, who would jointly appoint a senior resident supervisor of studies to assist with and to certify, the standards of the subsequent year of practical work in the laboratories at Iloilo. Each of the universities would in turn supply a supervisor for a one-year tour. Dr. Halver has supervised the design of a new laboratory for studies in reproductive physiology and nutrition and a new building has been provided by the Government of the Philippines. The Consultant Mission saw the new three-storey building at an advanced stage in construction. The Japanese Government has provided the initial equipment, as listed by Dr. Halver, and most of this already arrived, to a total value of U.S. $1.5 m. These new provisions will shortly make a substantial addition to the research facilities of this centre, which is already the largest in the region. Five universities (Michigan, Cornell, Auburn, Washington (Seattle) and Tokyo Fisheries University) have each indicated willingness to accept two postgraduate students per year, and to take turns in providing the supervision of studies at Iloilo. This project now seeks funding, and the governments of the region are looking hopefully to the "Title XII" programme of USAID, and to the "University-on-the-spot" program of the Ministry of Education of Japan for assistance.

Even with such assistance however, the training scheme would not be viable without a strong reinforcement of the research staff at Iloilo, which does not yet have the experience to undertake such responsibilities.

The Mission, however, recommends that if TAC should agree to support the main research proposals to CGIAR, then both USAID and JICA, and indeed other donor countries with substantial university capacity in research into fisheries reproduction and nutrition, should give consideration to these training proposals.

In making this recommendation, we wish to make it clear that the training scheme would be an integral part of a new CGIAR/SEAFDEC Asian Regional Organization for Aquacultural Research, and that we are not recommending support for the original draft proposals for an "Asian Institute of Aquaculture" to share the SEAFDEC laboratories, as prepared initially by the SEAFDEC Aquacultural Department.

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# APPENDIX 1

## DATA ON PRODUCTION BY COUNTRIES, BY MARINE AND INLAND CAPTURE FISHERIES AND BY AQUACULTURE

TABLES 1 TO 4.

Table 1. DEVELOPING ECONOMIES OF SOUTH AND SOUTHEAST ASIA LANDING STATISTICS OF FISH (MARINE & INLAND) OF COUNTRIES IN SOUTH AND SOUTHEAST ASIA[1]

| COUNTRY | (in 1976) MARINE | INLAND | (in metric tons) TOTAL |
|---|---|---|---|
| Bangladesh | 90,000 | 550,000 | 640,000 |
| Burma | 367,190 | 134,370 | 501,560 |
| Hong Kong | 152,699 | 5,238 | 157,937 |
| India | 1,525,000 | 875,000 | 2,400,000 |
| Indonesia | 1,043,000 | 405,000 | 1,448,000 |
| Democratic Kampuchea | 10,800 | 73,900 | 84,700 |
| Laos People's Democratic Republic | --- | 20,000 | 20,000 |
| Malaysia | 514,559 | 2,344 | 516,903 |
| Nepal | --- | 2,200 | 2,200 |
| Pakistan | 177,168 | 28,491 | 205,659 |
| Philippines | 1,319,811 | 110,000 | 1,429,811 |
| Singapore | 15,775 | 654 | 16,429 |
| Sri Lanka | 123,314 | 12,539 | 135,853 |
| Thailand | 1,479,704 | 160,692 | 1,640,396 |
| Vietnam, Socialist Republic of | 837,200 | 176,300 | 1,013,500 |
| Total | 7,656,220 | 2,556,728 | 10,212,948 |
| World Production | 65,117,849 | 10,349,186 | 75,467,000 |
| % of World Production | 12.13% | 24.70% | 13.90% |

[1]From Yearbook of Fishery Statistics, 1976.
Food and Agriculture Organization of the United Nations, 323 pp.

Table 2. DEVELOPED ECONOMIES OF SOUTHEAST ASIA
LANDING STATISTICS OF FISH (MARINE & INLAND) OF CHINA, KOREA AND JAPAN

in 1976[1]

| COUNTRY | MARINE | INLAND | (in metric tons) TOTAL |
|---|---|---|---|
| China | 2,312,000 | 4,568,000 | 6,880,000 |
| Korea, Democratic People's Republic | 500,000 | --- | 800,000 |
| Korea, Republic of | 2,390,025 | 16,660 | 2,406,685 |
| Japan | 10,419,230 | 200,687 | 10,619,917 |
| Total | 15,921,255 | 4,785,347 | 20,706,602 |

[1]From Yearbook of Fishery Statistics, 1976, Food and Agriculture Organization of the United Nations, 323 pp.

Table 3. TOTALS FOR ALL COUNTRIES OF SOUTH AND SOUTHEAST ASIA AND THE FAR EAST AS A PROPORTION OF WORLD CATCH
LANDING STATISTICS OF FISH (MARINE & INLAND) OF COUNTRIES IN SOUTH, SOUTHEAST ASIA AND THE FAR EAST

| | 1976 MARINE | INLAND | (in metric tons) TOTAL |
|---|---|---|---|
| COUNTRIES IN Southeast Asia & The Far East | 23,577,475 | 7,342,075 | 30,919,550 |
| World Catch | 63,117,849 | 10,349,186 | 73,467,000 |
| % of World Production | 37% | 71% | 42% |

Table 4. ESTIMATED PRODUCTION AND POTENTIAL OF AQUACULTURE OF COUNTRIES IN ASIA AND THE FAR EAST

| COUNTRY | AREA (ha) | PRODUCTION (t) | POTENTIAL SITES FOR DEVELOPMENT (ha)[3] |
|---|---|---|---|
| Bangladesh[1] | 76,485 | 23,000 | 476,000 |
| Burma[1] | 2,920 | 1,494 | 6,477,000 |
| China[1] | 700,000 | 2,240,000 | No data available |
| Hong Kong[1] | 1,500 | 2,776 | 2,100 |
| India[1] | 611,915 | 483,800 | 2,730,000 |
| Indonesia[2] | 266,957 | 160,000 | 10,787,000 |
| Japan[1] | 508 | 649,200 | No data available |
| Kampuchea, Demo.[1] | 350 | 5,500 | 15,000 |
| Korea, Rep.[1] | 75,260 | 147,571 | 452,000 |
| Lao, Peo. Demo. Rep.[1] | 180 | 360 | 20,000 |
| Malaysia[2] | 9,087 | 34,559 | 150,000 |
| Nepal[1] | 77 | 90 | 2,500 |
| Pakistan[1] | 30,780 | 37,540 | 682,000 |
| Philippines[2] | 187,640 | 122,346 | 526,000 |
| Singapore[2] | 700 | 640 | 2,400 |
| Sri Lanka[1] | 10,000 | 15,000 | 278,000 |
| Taiwan[1] | 39,234 | 68,945 | 53,800 |
| Thailand[2] | 37,800 | 70,000 | 4,522,000 |
| Vietnam[1] | 95,000 | 101,500 | 500,000 |
| TOTAL | 2,146,393 | 4,164,321 | 27,675,800 |

[1]Data obtained from Rabanal, H.R., 1974. The Potential of Aquaculture Development. Indo-Pacific Region. FAO/UNDP/CIDA South China Sea Fisheries Development and Coordinating Program, Manila, November, 1974, page 33.

[2]Data obtained from Technical Report, First ASEAN Meeting of Experts on Aquaculture, Semarang, Indonesia, January, 1977, page. 2.

[3]The areas include all existing fresh and brackish water swamps, many of which are important in their present state as nurseries for commercial species. Their total area cannot therefore be counted as potential aquacultural development.

Table 4 (cont'd)

COMMENTS:

(1) The total world aquaculture production in 1975 was estimated by Pillay (1975) as approximately 6 million metric tons. The production in Asia and the Far East was therefore about 70 percent of the world production through aquaculture.

(2) As only 2 million hectares out of an estimated total area of 27.7 million hectares have been utilized for aquaculture; when scientific input is made effective and the culture becomes more intensive the potential for increased production is very high in Asia and the Far East.

# APPENDIX 2

## VITAL STATISTICS

Appendix 2

VITAL STATISTICS OF DEVELOPING COUNTRIES IN REGION

| COUNTRY | Area (000 $km^2$) | 1977 Population (000,000) | Density (1977) Persons/$km^2$ | Growth Rate of Average Annual Population (%) 1973/1977 | Per Capita GNP 1976 $ | Growth Rate of Per Capita GNP (% 1965-74)* |
|---|---|---|---|---|---|---|
| Bangladesh | 144.0 | 82.79* | 574.9 | 2.8 | 110 | -1.9 |
| Burma | 678.0 | 31.51* | 46.5 | 2.2 | 120 | 0.8 |
| Hong Kong | 1.0 | 4.51 | 4311.7 | 1.7 | 2110 | 5.4 |
| India | 3287.6 | 621.67* | 189.1 | 2.0 | 150 | 1.3 |
| Indonesia | 1904.3 | 136.91* | 71.9 | 2.4 | 240 | 4.1 |
| Democratic Kampuchea | 181.0 | 8.57* | 47.3 | 2.8 | --- | 6.2 |
| Korea, Republic of | 98.7 | 36.44 | 369.0 | 1.7 | 670 | 8.7 |
| Laos, People's Democratic Republic | 236.8 | 3.46* | 14.6 | 2.1 | --- | 2.0 |
| Malaysia | 329.7 | 12.61* | 38.2 | 2.8 | 860 | 3.8 |
| Nepal | 140.8 | 13.14* | 93.3 | 2.2 | 120 | 0.0 |
| Pakistan | 803.9 | 74.54* | 92.7 | 3.0 | 170 | 2.5 |
| Philippines | 300.0 | 44.47* | 148.2 | 2.7 | 410 | 2.7 |
| Singapore | 0.6 | 2.31* | 3928.6 | 1.3 | 2700 | 10.0 |
| Sri Lanka | 65.6 | 13.94* | 212.5 | 1.6 | 250 | 2.0 |
| Thailand | 514.0 | 44.88 | 87.3 | 3.0 | 380 | 4.3 |
| Vietnam, Socialist Republic of | 332.8 | 47.87 | 143.8 | 2.9 | --- | -0.8 |

Taken from: ADB, Key Indicators of Developing Member Countries of ADB: Volume VIII No 2, October, 1977.

*Provisional

## APPENDIX 3: ITINERARY OF THE MISSION

(Visits, Discussions, Institutions)

VANCOUVER, CANADA

January 9 - 10 - Fisheries office of IDRC.
Meeting with Director General, Pacific and Yukon Region of Fisheries and Marine Service, Environment Canada, and staff with service in Southeast Asia.

HAWAII

January 11 - 15 - Meetings.
Dr. Bardach; State Aquaculturists, Director East-West Centre.
Anuenue Fisheries Research Centre
Oceanic Institute, Aquatic Farms Ltd.

HONG KONG

January 16 - 18 - Director of Agriculture and Fisheries, Marine Research Station Aberdeen cageculture operations;
Ocean Park Ltd.

INDIA

January 19 - 27

- Barrackpore (Calcutta)
  Central Inland Fisheries Research Institute (CIFRI)
- Dhauli, Cuttack (Orissa)
  Aquaculture Station and new laboratories under construction.
- Kulia Fish Farm
  Sewage fishculture project at Rahara, CIFRI, Barrackpore.
- Hanspukur rural aquaculture project
  Child-in-need Institute.
- Madras
  Central Marine Fisheries Research Institute (CMFRI)
  Central Institute of Fishery Technology (CIFT), Cochin,
  Narakkal, Travincore.

Madras, Kovalam sub-station.

- New Delhi
  Indian Council on Agricultural Research (ICAR) Director-General and staff, UNDP regional representative.
- Calcutta
  Summary discussions with CIFRI Director and staff.

THAILAND

January 28 - February 8

- Bangkok
  Ministry of Agriculture and Cooperative, Director General of Fisheries and senior staff. FAO Asst. Director General, Regional Fisheries staff.
- National Inland Fisheries Institute, Bangkhen, Kasetsart University.
- SEAFDEC headquarters and training Department Samutprakorn Chainat Station; cageculture operations Utai Thani province.
- Nongkai Fisheries Station on the Mekong River.
- Udorn Fisheries Station; Ubolratana Reservoir; Khon Kaen Station.
- Chulalongkorn University, Private Fish farm fish/Macrobrachium
- Bangkok/Haalyai - Songkla Marine Fisheries Research Stations.
- Phuket
  Fisheries Research Station, Marine Biological Centre.
- Bangkok
  Meeting with Deputy Minister. Review meeting with Director General of Fisheries.

MALAYSIA

February 8 - 14

- Penang
  University Sains Malaysia, Vice Chancellor and Biological Sciences faculty, Muka Head Field Station.
  Fisheries Research Institute; Public Aquarium; Discussion with University and Fishery staff.
- University Sains Malaysia Department of Biological Sciences Cageculture operations, Glugor.
- Kuala Lumpur
  Director-General Federal Dept. of Fisheries.
  U. N. Development Programme - Deputy Representative and FAO Officer. Malaysian Agriculture Research and Development Institute - Acting Director-General (Animal Production) and staff; University Pertanian Malaysia (Animal Science Dept); University of Malaysia (Zoology Dept.)
- Malacca
  Freshwater Fisheries Research Station; private fish farm.

SINGAPORE

February 13 - 20

- Malaysian Agriculture Research and Development Institute (MARDI) Freshwater Fishculture Research Station, Malacca/Singapore.
- IDRC Regional Office for Asia.
- University of Singapore, Vice Chancellor and Biological Science Faculty.
- Selatar Reservoir cageculture of Bighead carps, Public Utilities Board.
- Primary Production Dept. - Freshwater Research Station Sembawang Piggery wastewater fertilisation project.

- Marine Research Station, Changi Point - mussels, marine cages, kelongs.
- Meeting SEAFDEC Marine Dept. Director of Primary Production Dept. and staff.
- To Johore Bahru, Gelang Patah, Malaysia and return to Singapore Brackishwater fishculture station under construction.
- IDRC Regional office
  Report collating, literature review. Singapore/Jakarta.

INDONESIA

February 21 - 27

- Jakarta
  Directorate General of Fisheries.
- Bogor
  Meetings at Agriculture Research Institute, LPPD. Fisheries Research Institute of Agriculture University, IPB, Dean and faculty. Tropical Biological Institute (BIOTROP of SEAMEO), Fishculture station Cibalung, Bogor/Jakarta.
- Jakarta/Semarang (plane) Semarang/Jepara return by road
  Shrimpculture research station and UNDP extension project.
- Semarang/Jakarta
  Meetings with Director General of Fisheries and staff.
- Jakarta/Bogor return
  Meeting with Director General, Agricultural Research & Development Agency. Departure for Singapore.

PHILIPPINES

February 28 - March 14

- Southeast Asia Fisheries Development Centre, Aquaculture Dept.
- Manila
  Administrative office.

- Iloilo
  Tigbauan main laboratories of Aquaculture Dept. Discussions with all staff and project leaders.
- Igang
  Guimares Island sea-cage culture station for milkfish (observation visit).
- Leganes
  SEAFDEC pondculture station for milkfish and prawns (visit and staff discussions). University of the Philippines Brackishwater Aquaculture Centre (staff discussions).
  Iloilo: Discussions West Visayas Federation of Fishfarm Producers.
- Pandan
  Milkfish breeding and marine studies substation (visit, staff discussions).
- Hamtik
  Sabalo collecting and egg/juvenile collection post.
- Manila
  PCARR Director-General, conference.
- Nueva Ecija, Munoz.
  Central Luzon State University, Freshwater Aquaculture Centre. University President and fisheries faculty (visit and discussions).
- Manila
  International Centre for Living Aquatic Resources Management Director-General and staff discussions of program and current projects.

  South China Seas Development Program - Project Manager and staff (discussions)
  SEAFDEC Aquaculture Freshwater Station, Binangonan, Lake Laguna, University of the Philippines at Diliman - President and Dean of Fisheries College.

- Lake Bunot
  San Pablo Freshwater cageculture of tilapias.

- Manila
  Bureau of Fisheries and Aquatic Resources (BFAR), Director and staff. Meeting of Indo-Pacific Fisheries Council - attendance at selected BFAR aquaculture stations - Bacoor Cavite, Batangas.

- Manila
  Asian Development Bank - Discussions on regional financing of fishculture developments.

- Tigbuan
  Detailed discussions and further site visits.

- Manila
  USAID - discussions on aquaculture programs; UNDP - current programs; Japanese Embassy - SEAFDEC program and perspectives.

SINGAPORE

March 15 - 16

- Regional literature collating

JAPAN

March 20 - 28

- Bentenjima, Shizuoka Pref. Hamana Branch Station, Shizuoka Prefecture Fisheries Experiment Station. Commerical Farms on eelculture, soft-shell turtle and oysterculture.

- Tokyo
  Japan International Cooperation Agency, Vice-President and staff.
  Tokyo University of Fisheries - Aquaculture specialists.
  Fisheries Agency, Ministry of Agriculture & Forestry - Deputy Secretary-General and staff.
  Multilateral Cooperation Division, Ministry of Foreign Affairs.
  United Nations University - Program Coordinator, Biological Sciences.

UNITED STATES

March 28

- Los Altos, California
  Resources Development Associates, USAID, Title XII program.

CANADA

March 29 - April 21

- IDRC (Fisheries) Vancouver office for final report compilation and consultant interviews re Nutrition and Reproduction Physiology.
  Pacific Biological Station, Nanaimo - Fish pathology discussions.
  University of Victoria - Fish nutrition research on grass carp.

UNITED STATES

March 10 - 12

- USAID
  Fisheries Directors of NOAA, NMFS, FSWS.*
- World Bank
  Fisheries programs in South and Southeast Asia. Washington/Ottawa.

CANADA

March 13

- IDRC (Ottawa) Headquarters of IDRC.

March 14 - 19

- IDRC (Fisheries) office.

* National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Fisheries and Wildlife Service (F&WS)

## Appendix 4. SUMMARY OF OBSERVATIONS ON STUDY TOUR

The itinerary, the names of people with whom discussions were held, and a list of reports consulted, are in Appendices 3, 5, and 6 respectively.

### CANADA

The Mission met initially for 3 days at the IDRC AFNS Office in Vancouver. Dr. Pritchard of the Canadian Fisheries Research Board, and Dr. W.E. Ripley of UNDP took part in these discussions. Aquaculture programs of Southeast Asia were discussed in some detail with Dr. W. Johnson, (Director General for Pacific & Yukon of the Fisheries and Marine Service) and some of his colleagues of the Biological Research Stations, who were associated with the Institute in Thailand.

### HAWAII

En route to Asia the Mission spent 3 days in Hawaii for discussions with Professor Bardach and visits to both government and private aquacultural centres. Discussions were held with the Director and Staff of the Oceanic Institute, the Hawaii State Aquaculture Development Program and the Anuenue Fisheries Research Centre. The impressive enterprise of Aquaculture Farms Ltd. was also visited.

### HONG KONG

In a two-day stop we had discussions with the Director of the Agriculture and Fisheries Department of the Government of Hong Kong and were taken by the principal fishery research officer to see small scale marine fish farming in floating cages. We also visited Ocean Park with Mr. W. Williamson, General Manager of the Park, to see the successful water quality control methods and fish health maintenance systems used in the large scale aquarium and complex of pools.

Hong Kong was revisited by two members of our Mission during our journey back to Vancouver, B.C. Discussions were held with the faculty staff of the University of Hong Kong and Chinese University of Hong Kong. The authorities of both universities indicated their willingness to collaborate with a regional aquaculture network both in research and training, particularly in the field of environmental physiology, fish pathology and general aquaculture. A visit to the research stations of the Department of Agriculture and Fisheries and of Ocean Park gave the impression to the Mission that Hong Kong could extend co-operation to countries in the region in the development of cage culture and aspects of fish health maintenance in closed systems.

INDIA

The Mission concentrated its observations on the project activities of the Central Inland Fisheries Research Institute (CIFRI) in Barrackpore, the Central Marine Fisheries Institute (CMFRI) and their stations. The Mission also visited south-west India and the Central Institute for Fisheries Technology (CIFT) in Cochin. These institutes are under the direction of the Indian Council for Agricultural Research (ICAR).

Dhauli: The Mission, accompanied by Dr. V.R.P. Sinha, visited the Cuttack station and new freshwater aquacultural research and training center under construction at Dhaulli, near Bhubaneswar, Orissa. CIFRI has acquired about 360 ha. of land for this aquacultural complex, which will have approximately 80 scientists and 800 experimental ponds of different sizes to facilitate experiments on fish production, genetic selection and fish nutrition with composite culture of Indian and Chinese carps. At present the construction of ponds and of a two-storey laboratory and administrative building is in progress.

The Mission also visited the offices of Krishi Vigyan Kendra (KVK) or Fish Farmers' Training Center and Trainers' Training Center for Fish Culture (TTC) at the adjacent State Government Fish Farm at Kausalyaganga. These centers are operated by CIFRI and the State Government of Orissa.

Cuttack: The Mission visited the Freshwater Fish Culture Division, Cuttack, to observe fish ponds and a fish hatchery for experiments on carp breeding and hybridization. The Indian major carps viz. Catla catla, Rohu (Labeo rohita) and Mrigal (Cirrhinus mrigala) and Chinese carps are now seasonally induced to spawn through hypophysation. Fingerlings of these fish are supplied to the State Fisheries Departments and fish farmers for culture. Carp hybridization and frog culture experiments show promising results.

Kalyani: At the Kulia Fish Farm, Kalyani, near Calcutta, the average yield obtained by multiple cropping of a composite of six species of carp was reported to be 3-5 tons/ha/yr. without supplementary feeding. When supplementary feeding is given, the total yield per crop may be equivalent to a rate of 9 tons/ha/yr. It was stated that diseases are often a constraint to carp production, particularly to the common carp fry towards the end of the monsoon season.

The Air Breathing Fish Culture station demonstrated the experimental cultures of Anabas spp., Clarias batrachus, murrel, and Indian catfish (Heteropneustes fossilis). The constraint for this type of culture is the feed costs as trash fish is given to the species as additional feed.

Rahara: The Mission also visited the sewage fish culture project in Rahara and was informed that a production rate of 7 tons/ha/yr. could be obtained in a sewage effluent pond. The Mission visited Headquarters of CIFRI at Barrackpore and had discussions with the Director, Dr. Jhingran. The CIFRI/IDRC Project on Rural Aquaculture was conducting demonstrations of the polyculture of carp species in several village ponds in the states of W. Bengal and Orissa and the Mission observed some very successful results. This was clearly increasing the experience of the research scientists and establishing the viability of their experimental station methods under rural conditions. Yields of 4 tons/ha in 10 months were reported. We visited an interesting successful pond enterprise by a small private charitable foundation, the Child in Need Institute organized by Dr. Chaudhuri.

South India: Marine and brackish water field stations in Madras and on the South Western coast at Cochin, gave an impression of the immense new resource of which exploration and technological development was just beginning. We were able to visit both the Central Marine Fisheries Research Institute (CMFRI) and Central Institute of Fisheries Technology (CIFT). The progress made in the processing and packaging of marine fish products was impressive. The opportunities for cage and pond culture, both of fish and of molluscs, to meet these markets was very evident.

A private brackishwater pond estate in Kannamaly, Cochin was visited. It was reported that the productivity of the ponds was very high and no supplementary feeding was needed. Shrimps, mainly Metapenaeus dobsoni and Penaeus indicus, were harvested twice within 7 months. Finfishes found in the ponds include sea catfish (Tachysurus spp.), pearl spot (Cichlidae) and mullet (Mugil macrolepis). It was noted that M. dobsoni spawned naturally in the ponds and thus complicated hatchery rearing of juveniles was avoided.

The Mission visited the Headquarters of CMFRI in Cochin and was briefed by Dr. E.G. Silas, Director of the Institute, on the administrative structure and programs. CMFRI is composed of 12 research centers and 30 field stations along the east and west coast of India. The mariculture program includes pearl oyster, seaweed, prawn, fish, and mussel and oyster culture. Under the Sixth National Economic Development Plan the Government will give equal priority to both marine and aquaculture research. Dr. Silas pointed out that major constraints encountered in the development of mariculture included production of quality seed, varying survival rates of cultivated organisms as juveniles grown to market-size, and transfer of technology to rural fish farmers.

The Mission visited the prawn culture laboratory at Narakkal where it observed composite cultures of milkfish and prawns, experiments on the breeding of P. indicus and of live food organisms including indigenous Artemia spp. for post larval prawns. It also attended a closing ceremony of a training course given by CMFRI to local fish farmers.

At the Headquarters of CIFT in Cochin Dr. Kuriyan, the Director, described work on fishing boats, fishing gear, fish processing and utilization, quality

control, engineering, extension and statistics. In the area of aquaculture CIFT can assist in product development, in the design of suitable harvesting gear and in weed eradication machinery for initial clearing.

Kovalam, Madras: Accompanied by Dr. Silas, the Mission flew to Madras and visited the mariculture station of CMFRI at Kovalam to see lobster culture and mussel culture projects. The station staff have worked closely with local fishermen in the development of mussel culture in the area. The average production per raft of 50 ropes in the open sea is approximately 5 tons per year, resulting in a net profit of 500 rupees.

New Delhi: Our visit involved discussions with the Director-General of the Indian Council of Agricultural Research, Dr. Swaminathan, and his Deputy, Dr. Soni. A discussion with the UNDP Regional Representative, Mr. Henry Kaufman, was followed by a further discussion with Dr. Pillay of FAO, who was then visiting India. An overnight stop at Calcutta provided a final opportunity for discussion with the director of CIFRI and his senior staff members. There was also opportunity for an evening discussion with three members of the World Bank team, which was then assessing an Indian Government request for a major investment in aquacultural hatcheries to supply fingerling fish to stock farmers' ponds.

## THAILAND

In Bangkok the Mission held detailed discussions with the Deputy Minister of Agriculture and Cooperatives, Dr. Arporna Sribhibhadh, a brief discussion with the Director-General of the Department of Fisheries, Mr. Cherdchai Amatyakul and a very detailed discussion with the Director of the National Inland Fisheries Institute (NIFI) of the Department of Fisheries, together with the Directors of the Inland and Brackishwater Divisions, the CIDA Project Officer and other members of NIFI staff.

The Mission was accompanied by the Director of the Inland Fisheries Division, Mr. Aryee Sidhimunka, to visit a fishery unit at Chainat in the Central Plain, inland fisheries field stations at Nong Kai (on the bank of the Mekong River)

Udorn Thani, and Khon Kaen and a fisheries management unit at Ubolratana Reservoir, all in the northeastern part of Thailand. To the far south, we were accompanied by the Director of the Brackishwater Fisheries, Mr. Umphol Pongsuwan, to visit the main brackishwater fisheries research station and the Marine Biological Center in Phuket on the west coast of peninsular Thailand.

The Mission thus had an excellent opportunity to assess the potential for aquaculture, the problems encountered and the extent and quality of the resources available. The Mission was left in no doubt by the Deputy Minister and the staff of the Department of Fisheries that aquaculture has been fully recognised as a national priority for rural development in the program "fish as food for the people".

Before leaving Thailand the Mission also visited the Marine Training Department of SEAFDEC and observed the aquacultural investigations of the Faculty of Fisheries, Kasetsart University. Discussions were also held with Dr. J. Umali, Asst. Director-General of FAO, and the Secretary of the Indo-Pacific Fisheries Commission (IPFC), Mr. D.D. Tapiador, and the FAO Regional Aquaculturist, Mrs. M. Delmendo.

The Government of Thailand is faced with a declining marine fish catch due both to overfishing of the Gulf of Thailand and its territorial waters along the west coast of the Thai peninsula, as well as to increasing pollution in the inner Gulf of Thailand. The effect of the imposition of 200 mile limits by neighboring countries will also reduce heavily the catch of the main fleet of long distance trawlers. The very successful hinterland development of large scale irrigation schemes has eliminated large areas of freshwater marshes which previously yielded substantial production. There is therefore a high national priority for the aquacultural promotion in rural areas, in ponds, cages and reservoirs, or irrigation ditches; and for coastal brackishwaters and sheltered sea areas.

The Mission observed a very strong drive for species of high market value, with the main emphasis on freshwater prawns (Macrobrachium spp.), sea prawn (Penaeus monodon), and carnivorous fishes both marine and inland. It was explained

that Thailand is presently an exporting country for both rice and fish and was currently more concerned to raise the low income level of its rural agricultural producers than to grow cheaper food. The Mission is, however, of the opinion that other indigenous species such as the Thai major carps (Catlocarpio siamensis, Probarbus jullieni) which are highly esteemed by people of the riparian countries of the Mekong River System, and which are considered as important cultivable species for future aquaculture development of these countries, should be given more attention.

MALAYSIA

At Penang we visited the University of Science (Universiti Sains Malaysia) lunched with the Vice Chancellor Tan Sri Hadji H.S. Tahir, and were accompanied by the Dean of Biological Sciences, Dr. Wong Tat Meng, to the laboratories and the coastal field station. Large new university buildings and ample accommodation at the Muka Head field station were newly constructed under a World Bank scheme but were not yet fully in operation. The new provisions include good equipment for information services, including both computer and microfiche production facilities, but the national policy of phasing out the use of the English language will reduce its wider potential value as an information centre.

The Mission visited the Fisheries Research Station at Glugor, where Mr. Ong Kah Sin showed us very effective prawn hatcheries. Disease in wild-caught prawns has led to the installation of good water quality control equipment, employing standard commercially available swimming-pool filtration units and a 20 tons/hour U-V. sterilizer. We were impressed by the large and well-organized public aquarium, which has a representative collection of important indigenous species.

In Kuala Lumpur the Mission reviewed national and regional aquaculture research activities of Fisheries with the Director, Tengku Ubaidillah. The University of Agriculture (U. Pertanian Malaysia) and the Malaysian Agricultural Research and Development Institute (MARDI) occupy adjacent sites and we were able to have a useful discussion with the relevant staff of both organizations under the chairmanship of Tuan Syed Ali. It was evident to the Mission that there is room for more effec-

tive coordination between the three universities, MARDI and the Fisheries Department in the field of aquaculture research.

At the long established research station at Malacca, which is now administered by MARDI, we found the excellent pond facilities to be under-utilized by the small staff. They have spawned bighead (Aristichthys nobilis) and silver carp (Hypophthalmichthys molitrix) by induction techniques in every month of the year, while spawning of grass carp (Ctenopharyngodon idella) which matures only in March remains a seasonal operation.

In the Malacca area Mr. Khoo Peck Wan, a vigorous and successful fish farmer, showed us a most efficient combination of pig and pond-fish culture. (We subsequently saw a very large and successful commercial development of a pig-pondfish complex in the Philippines).

SINGAPORE

The Mission was much impressed with a large scale floating cage operation by the Public Utilities Board which is successfully raising bighead carp (Aristichthys nobilis) as a control for phytoplankton growth. We had full and useful discussions with the Director of the Department of Primary Production, Dr. Siew Teck Woh, the Principal Primary Production Officer, Mr. Chen Foo Yan, the Head of the Freshwater Laboratory, Mr. George Tay and several other members of the Fisheries staff. We were taken to visit impressive experimentation on floating marine cages, pond culture, aquarium stock production and brackish water cage culture. At the University of Singapore we held a discussion with the Biology Department for which fisheries are not at present a dominant interest (there is no fisheries course in the faculty). Extensive opportunities for inland food fish production are mainly restricted to cage cultures of phytoplankton-feeders in reservoirs, but these are all for water supply and are not open to the public. The opportunities for marine and brackish water cage culture are considerable and are being carefully investigated. Useful work is being done in maximising carp breeding/incubator/nursery procedures; in selections of hybrids of ornamental fishes and in studies of pig wastes for fishpond fertilisation.

INDONESIA

The Mission, visited Bogor and was briefed on the programs of activity of the Agency for Agricultural Research and Development of the Ministry of Agriculture, the Faculty of Fisheries of the University of Agriculture at Bogor (IPB) and of the Tropical Biology Institute of the Southeast Asian Ministry of Education Organization (BIOTROP/SEAMEO). The Ministry of Agriculture of Indonesia had recently re-organized the research institutes of various directorates under the new Agency for Agriculture Research and Development. This includes the marine inland and fish processing research institutes. The Directorate of Fisheries deals with development and extension aspects of fisheries though working closely with the new Agency.

The Mission visited research facilities of the Inland Fisheries Research Institute and its field station at Cibalagung where selected strains of common carps namely "Sinonya," "Punten" and "Majalaya" have been bred and reared.

The Mission also visited the shrimp culture research center at Jepara, where the FAO/UNDP shrimp culture project is being implemented. At this center well-established facilities for milkfish and prawn research were observed. It was learnt that the Center will be transformed into a development and extension unit under the Directorate General of Fisheries after 1979.

The Mission conferred finally with First Admiral Iman Sardjono, Director General of Fisheries in Jakarta, and with Dr. A. Sadikin, Director-General of the Agency for Agricultural Research and Development of the Ministry of Agriculture in Bogor. From these discussions it became evident that the Government of Indonesia had given a high priority to aquaculture research and development in its national economic and social development plan. It will place more emphasis on the increased production through aquaculture of milkfish, common carp, gouramy and Macrobrachium sp. with a view to increasing the productivity and income of the mass of poor rural farmers.

The Mission was also informed of the active Indonesian collaboration at the technical level with the aquaculture department of SEAFDEC and of Indonesian

participation in training programs and in the meetings exploring the possibilities of establishment of an Asian Institute of Aquaculture.

Indonesia has one of the largest populations depending on aquaculture and among the largest producers of food fish. It has received considerable technical assistance from both bilateral and multilateral agencies in the past and will soon receive a substantial loan from the World Bank to strengthen its research capability in aquaculture. It was pointed out that the loan would cover only 60 percent of the total requirement input for the development of the Indonesian program until 1985. The hope was expressed that regional aquaculture research funding will also reinforce the aquaculture research programs in Indonesia.

PHILIPPINES

SEAFDEC (Aquaculture Department): Visits were made to the SEAFDEC office in Makati, main station at Tigbauan, and substations at Leganes, Igang, Binangonan and Pandan. The mission was able to obtain a fairly complete overview of the structure and operations of the Department. It was felt that these SEAFDEC Stations provided an excellent base of physical facilities for much of the aquacultural research needed in the Philippines and parts of the Southeast Asian region. A major emphasis on prawn research were noted. Research funding was largely from Philippine and Japanese sources. Present problems of freshwater supply are hopefully now being corrected. Research is centered on 4 major areas: 1. prawn, 2. milkfish, 3. seafarming, 4. freshwater aquaculture. Some critical subject areas such as larval rearing and survival needed technical support. The facilities and work of the SEAFDEC Aquaculture Department are discussed later in this report.

Bureau of Fisheries and Aquatic Resources (BFAR); Visits to the research stations at Cavite and Batangas of the BFAR (one a mussel/oyster station and the other a brackishwater station) illustrated some of the ongoing BFAR experimental and extension activities. Later visits to the BFAR headquarters and discussions with its Director indicated the broad development plans for the Bureau under a 1978 budget of 162 million pesos. (U.S. $22.5 m.).

Philippine Council for Agricultural & Resources Research (PCARR): Brief discussions with the Director provided information on the priority research projects contracted by PCARR to the various aquacultural research institutions in The Philippines. Broad policy papers on fisheries including aquaculture had been prepared by subject specialists for research in the country. PCARR does not carry out any research programs on its own.

South China Seas Development Program (SCSP): has completed its fifth year of operation and has plans for a further operational period. Aquaculture (e.g., cage culture) is being tested as an alternative form of employment and income generation in a number of coastal fishing development sites starting with Malaysia. Additionally workshops on various subjects are being held and advisory services provided to countries.

International Center for Living Aquatic Resource Management (ICLARM): With initial funding from the Rockefeller Foundation, they are developing a program to cover all areas of management. Plans include projects for fish breeding of estuarine species, data on combined livestock and aquaculture practices, workshops, and publication of hatchery manuals, and providing for information exchange systems. Some projects are being started but the program is, as yet, too small to be a significant factor in the research activities of the region.

University of the Philippines at Diliman: In meetings with the President and the Dean of the College of Fisheries, the mission was able to discuss the AIA concept. The new "U.P. of the Visayas" will be the new College of Fisheries and is planned for beginning of construction in 1979, hoping for World Bank Support. It is proposed that this campus be located adjacent to SEAFDEC in Tigbauan. This university already has a joint M.Sc. graduate training program with SEAFDEC through their brackish water station in Leganes as well as an independent research program at the same site. At the University of the Philippines at Los Banos the mission was informed of the activities of UPLB related to aquaculture. UPLB has maintained a research station on the nearby Laguna de Bay carrying out a variety of ecological studies. The joint program with SEAFDEC will continue to expand this work and provide a more detailed biological base for the production work at Binangonan.

Central Luzon State University: A smallholding which integrates farming and aquaculture (the "Farm of the Future") was seen illustrating the benefits of an integrated approach. The College of Inland Fisheries has recently begun an extended research and teaching program to the M.Sc. levels, initially, with USAID support. Cageculture of tilapia, earthworm culture and rice and fish culture were major research thrusts of the Freshwater Aquaculture Center, aimed for implementation by small farmers.

Discussions with members and visits to the extensive farms and shrimp hatcheries of the West Visayas Federation of Fishfarm Producers indicated the strong interest of this private sector group in immediate field application of new research findings. A close working relationship existed with the SEAFDEC research programs. An advanced standard of farm management with substantial capital input were characteristic of this group.

JAPAN

The visit was intended to acquaint the Mission with some of the advanced technical facilities available in the public and private sector, some relevant studies in progress at institutions concerned with aquaculture, as well as to provide an opportunity for technical and policy discussions at various Government agencies with regard to the Aquaculture Department in SEAFDEC.

The relative importance of aquaculture in Japan was illustrated by the country's 1973 statistics of fish production, of which aquaculture provided 8%, with freshwater species comprising only 0.5%.

In the Shizuoka prefecture, much effort was concentrated on eels, oysters and seaweed. The trends in the industry here could be taken as an indicative example of the developments of the services rendered to, and the problems involved in the industry generally. The efficiency of food conversion in relation to costs for eel culture and the control of diseases have increasingly become of major concern as the culture practices were intensified in heated raceway culture systems. Cooperative groupings for handling and processing controls permitted economies of scale whether pertaining to culture of eels or oysters. There was a tendency to develop cultures for higher value products such as

soft-shelled turtles and to reduce costs of food by lowering animal protein content. Private enterprise sought to promote the production of the indigenous herbivore "ayu", Plecoglossus altivelis as a speciality fish in contrast to carnivores like trout and eel, recognizing the constraints of high feed costs due to dependence on trash fish. The increasing occurrence of diseases, which already reduce eel production by 10%, have pointed to a critical need for pre-emptive studies of diseases likely to occur when more intensive fishculture is applied. Some of these seemed possibly to be nutrition-related or associated with the introduction of elvers from Europe.

The visit to the Fisheries University of Tokyo permitted the Mission to observe the high level of research investigations and researcher training facilities which were available. Discussions with faculty members of the departments dealing with fish nutrition and pathology as well as aquaculture engineering, were most informative and of relevance to specific problems of SEAFDEC.

Discussions with a representative of the Natural Resources Division of the U.N. University provided information of their planned programmes for support studies in aquaculture in collaboration with both SEAFDEC and Indonesian institutions: these were on too small a scale to affect the main issues which the Mission was studying.

In regard to SEAFDEC, the Deputy Secretary General of the Japanese Fishery Agency and his staff expressed the Agency's viewpoint that practical applied research as well as longer-term research was needed for the rapid development of fishculture since the chief limitation seemed to be the capture or production of juvenile fish. While agreeing that fundamental studies of a longer-term nature were needed, the general emphasis expressed by fishery departments of the region seemed to be for shorter-term applied, and more production-oriented studies, because of the increased demand for food fish supplies.

The Vice-President of JICA confirmed that their policy was one of responsiveness to the expressed wishes of the member countries of SEAFDEC. While recognizing the limitations of its current programmes ten years after the launching of SEAFDEC, they considered that the Mission's observations, with respect both to

the geographic range and technical activities of the aquaculture department, had in general, confirmed their own information. It seemed timely and appropriate to consider a system that could strengthen the regional collaboration, raise technical standards to international levels and widen the range of countries involved. Such proposals should receive careful consideration for sympathetic support by all countries concerned. At the same time, it was the stated policy of JICA to increase its support in fisheries to all countries in South and Southeast Asia, both in training and development.

The Chief, Multilateral Cooperation Division, and other staff of the Ministry of Foreign Affairs reiterated the Government's policy of further support for the development of fisheries in Southeast Asia which was not limited to SEAFDEC or its member countries. Referring both to origins and functioning of SEAFDEC as well as to Japanese support for the CGIAR programmes, the discussions reflected their apprehension as to the future structure of SEAFDEC if the proposals of the Mission resulted in the largest of the three departments being separated. After reviewing the origin of the Mission, various suggestions were discussed which may ensure the future stability of SEAFDEC.

Appropriate arrangements for implementing the proposals were also considered in the event of their acceptance by TAC/CGIAR. It was agreed that it would be desirable to review the situation at the next SEAFDEC Council Meeting, if a favourable reception of the proposals was indicated by TAC. At such a Council Meeting measures may be effectively considered to strengthen other departments, perhaps including establishments catering to the ideas for fish processing technology and effective marine multispecies management in adjacent seas. There was shortly to be a review of the structure of the other departments of SEAFDEC, and this may result in proposals which could contribute to the additional strengthening of this successful initiative of regional cooperation.

APPENDIX 5

People Consulted during the Study

1. Canada (Vancouver, Nanaimo, Victoria)
2. U. S. A. (Hawaii)
3. Hong Kong
4. India
5. Thailand
6. Malaysia
7. Singapore
8. Indonesia
9. Philippines
10. Japan
11. U. S. A. (Los Altos, Washington)

Other Persons Consulted

U. K.
FAO (Rome)

1. CANADA

Vancouver, B. C.

- Prof. Peter A. Larkin, Dean of Graduate Studies U. B. C. Member of Advisory Committee of ICLARM.
- Prof. William S. Hoar, Professor of Zoology U. B. C.
- Prof. Norman J. Wilimovsky, Professor Institute of Animal Resource Ecology.
- Dr. W. E. Johnson, Director-General of Fisheries, Pacific & Yukon Fisheries and Marine Service, 1090 Pender St., Vancouver, B. C.
- Dr. Leo Margolis, Scientist Fish Diseases, Pacific Biological Station, Nanaimo, B. C.
- Dr. Howard Smith, Former Co-ordinator, National Inland Fisheries Institute Bangkhem, Thailand. Scientist Fisheries & Marine Service.
- Dr. Fred Withler, Acting Director, Pacific Biological Station.
- Dr. Z. Kabata, Scientist Fish Diseases, Pacific Biological Station.
- Dr. G. Bell, Scientist Fish Diseases, Pacific Biological Station.
- Dr. E. Donaldson, Scientist Endocrinology and Nutrition, West Vancouver Laboratory.
- Dr. J. Halver, Senior Scientist Fish Nutrition, U. S. Fish & Wildlife Service.
- Dr. D. B. Quayle, retired oysterculturist, Pacific Biological Station.

University of Victoria, Victoria, B. C.

- Dr. T. Buckley, Professor, Dept. of Microbiology and Biochemistry and staff.

2. HAWAII

- Prof. J. E. Bardach, East-West Resource Systems Institute, The East-West Centre.
- Prof. Harrison Brown, Director East-West Resource Systems Institute.
- Dean William Furtick, Dean College of Tropical Agriculture, University of Hawaii, Manoa.
- Mr. Michael T. Santerre, Aquaculture Development Program, State of Hawaii, Dept. of Planning & Economic Development, Honolulu.
- Mr. Justin Rutka, Aquaculture Development Program, State of Hawaii, Dept. of Planning & Economic Development, Honolulu.
- Mr. Richard Fassler, Aquaculture Development Program, State of Hawaii, Dept. of Planning & Economic Development, Honolulu.
- Dr. Colin E. Nash, Director of Research & Vice-President Oceanic Institute, Waimanalo, Hawaii 96795.
- Mr. Richard W. Power, President, Oceanic Institute.
- Dr. Ching-Ming Kuo, Fish Physiologist, Oceanic Institute.
- Senators T. C. Yim, Jean King & Aides, U. S. Senate Representatives, Hawaii.

- Mr. Takuji Fujimura, Director & Chief Biologist, Anuenue Fisheries Research Centre, State of Hawaii Dept. of Natural Resources, Division of Fish & Game.
- Dr. Edward D. Scura, President, Aquatic Farms Ltd., Box 1026, Kaneohe, Hawaii 96744.
- Dr. Linden A. Burzell, Vice-President, Aquatic Farms Ltd.
- Mr. Charles F. Greenwald, Vice-President, Aquatic Farms Ltd.

Others

- Dr. Moav, visiting Professor, University of Hawaii for Fishculture Dept. Israel.

- Dr. Z. Kabata, Scientist Fish Diseases, Pacific Biological Station, Nanaimo, B.C.

3. HONG KONG

- Mr. E. H. Nichols, Director of Fisheries & Agriculture.
- Dr. William Chan, Chief Research Officer, Agriculture & Fisheries Dept.
- Mr. J. M. Riddell-Swan, Director of Agriculture & Fisheries, Agriculture & Fisheries Dept.
- Mr. Alexander Murray, Assistant Director, Agriculture & Fisheries Dept.
- Mr. T. K. Mok, Chief, Kat-O Fisheries Research Station, Agriculture & Fisheries Dept.
- Mr. W. Lim, Biologist.
- Dr. Yok Chan Tai, Pollution Biologist, Tolo Harbour project, Agriculture & Fisheries Dept.
- Prof. B. Lofts, Prof. of Zoology and Head of the Dept. of Zoology, University of Hong Kong (U. H. K.).
- Dr. D. K. O. Chan, Endocrinology Environmental Physiology, U. H. K.
- Dr. R. C. Ko, Pathology, U. H. K.
- Sir Maurice Yonge, visiting Professor, U. H. K.
- Prof. D. Thrower, Head, Department of Zoology, The Chinese University of Hong Kong (C. U. H. K.).
- Dr. James C. N. Ma, Prof. Chemistry Dept. (Organic Chemistry) C. U. H. K.
- Dr. Wen-Young Tseng, Associate Director Marine Science Laboratory, C. U. H. K.
- Dr. Norman Woo, Fish Physiologist, C. U. H. K.
- Sir Kenneth Ping-Fan Fung, Chairman of the Board, Ocean Park Ltd.
- Mr. W. Williamson, General Manager, Ocean Park, Ltd.
- Mr. R. Kwok Chung, Operations Manager, Ocean Park, Ltd.
- Mr. Johnny P. F. Chin, Senior Aquarist, Ocean Park, Ltd.

4. INDIA

a) Indian Council of Agricultural Research (ICAR), New Delhi

- Dr. M. S. Swaminathan, Director-General, ICAR
- Dr. B. K. Soni, Deputy Director-General, ICAR

- Dr. S. P. Tuli, Coordinator for External Assistance.
- Dr. Raghu Prasad, Assistant Director-General (Fisheries)

b) Central Inland Fisheries Research Institute (CIFRI), Barrackpore, West Bengal

- Dr. V. G. Jhingran, Director, CIFRI
- Dr. V. R. P. Sinha, Head, Freshwater & Fishculture Division, Cuttack.
- Dr. P. V. Dehadrai, Scientist, CIFRI, Barrackpore.
- Dr. A. V. Natarajan, Head, Division of Lacustrine Fisheries, Allahabad (Uttar Pradesh), CIFRI.
- Mr. N. K. Tripathi, Scientist, CIFRI, Barrackpore.
- Mr. M. A. V. Lakshmanan, Scientist, Cuttack, CIFRI.
- Mr. M. R. Sinha, Director, Kulia Fish Farms, Kalyani, Orissa.
- Mr. R. N. Pal, Fishery Scientist (Fish diseases).

c) Central Marine Fisheries Research Institute, (CMFRI), Cochin, Kerala

- Dr. E. G. Silas, Director, CMFRI, Cochin.
- Dr. P. V. Rao, Scientist, Crustacean, Fisheries Division, Cochin.
- Dr. V. Balakrishnan, Officer-in-charge, Krishi Vigyan Kendra, Narakkal.
- Mr. T. Tholasilingam, Scientist, Officer-in-charge, Madras (MRFI) project.
- Mr. S. S. Rajan, Scientist, Kovalam Mariculture Project.
- Mr. K. Rangurajan, Scientist, Kovalam Mariculture Project.
- Mr. R. J. Johar, Scientist, Kovalam Mariculture Project.

d) Central Institute of Fisheries Technology (CIFT), Cochin

- Mr. G. K. Kuriyan, Director CIFT and his staff.
- Mr. P. V. Rao, Crustacean Biologist.

e) State Department

- Mr. S. M. Banerjee, Deputy Director of Fisheries, Government of West Bengal.

f) Private Foundations & Others

- Child in Need Institute (CINI), Hanspukur
  Dr. S. N. Chaudhuri, Director, CINI
- Bengal Bratachari Society, Hanspukur
  Mr. S. K. Mitra, Secretary of the Society.
- Khari Beria (Village Pond)
  Mr. Saroj Koyal

g) IBRD Mission to India

- Dr. William Royce, University of Washington
- Dr. James Grover, University of Auburn
- Dr. John Snow, University of Auburn

h) UNDP Office, New Delhi

- Mr. Henry Kaufman, Deputy UNDP, resident representative.

i) FAO

Dr. T. V. R. Pillay, Coordinator UNDP Global Aquaculture Project

5. THAILAND

Bangkok

- Dr. Arporna Sribhibhadh, Deputy Minister of Agriculture & Cooperatives.
- Dr. Tavee Homchong, Secretary to the Deputy Minister.
- Mr. Chertchai Amatyakul, Director-General of Fisheries
- Comdr. Sawang Charoenphol, R. T. N., Deputy Director-General
- Mr. Aryee Sidhimunka, Director of Inland Fisheries.
- Mr. Umphol Pongsuwan, Director of Brackishwater and Marine Fisheries.
- Dr. Anand Saraya, Fisheries Biologist.
- Mr. Kasemsan Chlayondecha, Biologist Brackishwater.
- Mr. Kachornsak Vechakanan, Fishery Economist.

Bangkhen - National Inland Fisheries Institute & Kasetsart University

- Mr. Vanich Vareekul, Director NIFI
- Dr. Alex N. Fedoruk, CIDA Co-ordinator NIFI
- Dr. Plodprasop Surasswadi, Fishery Biologist
- Dr. Thirapan Bhukaswan, Reservoir Fisheries Biologist.
- Dean Mek Boonbrahm, Dean, College of Fisheries, Kasetsart University.
- Dr. Wiang Chuapoehuk, Fish Nutrition & Feeds, Dept. of Aquaculture, Kasetsart University.

Chia Phya Dam and Chianat Fishery Station

- Mr. Manob, Officer-in-charge of Station
- Mrs. Gomut.

Interior Fisheries Stations

- Mr. Chanintorn Sritongsuk, Officer-in-charge Nongkhai - *Probarbus*, *Pangasius*.
- Mr. Boonhai Tamsamui, Chief, Udorn Fishculture Station.
- Mr. Tawan Chookajorn, Chief, Ubolrathana Fisheries Station.
- Mr. Prathom Taweesak, Chief Khon Kaen Fisheries Station.
- Mr. Sanay Pholprasith

Chulalongkorn University, Bangkok

- Dr. Piamsak Menasveta, Macrobrachium & environmental studies.

Marine Stations

- Mr. Pairoj Bromanondah, Chief Songkhla Station
- Mr. Niwes Reongpanich, Shrimp culture Biologist
- Mr. Pinij Kangwankich, Chief of Satul Station
- Mr. Panit Sangkasem, Extension Shrimpculture Officer, Songkhla Station
- Mr. Uruphan Boonprakorb, Chief Phuket Marine Biological Centre (PMBC)
- Mr. Charoen Chirasatit, Chief Phuket Fisheries Station.
- Mr. Anuwat Ratanachote, Brackishwater Fisheries Biologist.
- Mr. Suchart Vichiensawan, Songkhal Lake Survey, Songkhla Station
- Mr. Sawat Wongsamnuk, *Lates* breeding, Songkhal Station
- Mr. Poonsin Panichsuk, *Lutianus* breeding

Other

FAO

- Dr. D. L. Umali, Assistant Director General for Asia and Far East.
- Mr. D. D. Tapiador, IPFC Secretary and Regional Fishery Officer.
- Mrs. M. N. Delmendo, Regional Aquaculture Officer.

SEAFDEC Training Department

- Dr. Deb Menasveta, Secretary-General of SEAFDEC & Chief of Training Dept.
- Dr. S. Shindo, Deputy Secretary-General and Deputy Chief of Training Dept.
- Mr. T. Yamamoto, Fishing Gear Technologist, Chief, Training Division.

6. MALAYSIA

Penang (Universiti Sains Malaysia)

- Tan Sri Haji Hamdan S. Tahir, Vice-Chancellor, USM
- Dr. Wong Tat Meng, Dean of Biological Sciences School.
- Dr. Tan E. S. P., Zoology Lecturer, Fish Endocrinology Specialisation.
- Dr. Khoo Kay Huat, Zoology Lecturer, Fish Endocrinology Specialisation.
- Dr. Lai Hoi Chan, Zoology Lecturer, Freshwater Plankton
- Dr. Ong Jin Eong, Zoology Lecturer, Mangrove & Cockel Ecology.
- Mr. Teng Seng Keh, Zoology Lecturer, Grouper Biology.

Fisheries Dept.

- Mr. Shaari B. S. Abdul Latiff, Director of Research, Fisheries Research Institute, Glugor.
- Mr. Ong Kah Sin, Senior Research Officer and other staff.

Kuala Lumpur (Malaysia Fisheries Dept.)

- Tengku Ubaidillah bin Abdul Kadir, Director-General of Fisheries.
- Mr. D. Pathansali, Assistant Director-General of Fisheries.

MARDI & University Pertanian Malaysia (UPM)

- Mr. Syed Ali bin Abu Bakar, MARDI Asst. Director of Animal Production.
- Mr. Ahmad Tajuddin bin Zainuddin, Head, Freshwater Fisheries Research Station.
- Dr. Bahrain Kassim, Head, Veterinary Medicine & Fisheries UPM.
- Dr. Ang Kok Gee, Lecturer in Zoology & Fisheries.

University of Malaysia

- Prof. J. I. Furtado, Dean of Biological Science.
- Dr. P. Canagaratna, Lecturer
- Dr. J. Green, Lecturer.
- Dr. R. P. Lum, Lecturer.
- Other staff members of the faculty

Malacca (MARDI Freshwater Fisheries Station)

- Mr. A. Tajuddin, Head
- Dr. E. G. Watts and other staff.
- Mr. Khoo Peck Wan, Practical Fish Farmer & Former Member of Fishculture Station Advisory Committee.

Johore Bharu & Gelang Patah Fishculture Station

- Mr. Ti Teow Loon, Fisheries Officer-in-charge, Johore.
- Mr. Lam Wah Chang
- Other staff and construction engineer for Gelang Patah Brackishwater Fishculture station.

Kuala Lumpur (UNDP/FAO)

- Mr. Roger Garda, UNDP Deputy Regional Representative.
- Miss Prida Panis, FAO Country Representative.

7. SINGAPORE

Primary Production Department

- Dr. Siew Teck Woh, Director.
- Mr. Chen Foo Yan, Chief, Marine Fisheries Research Dept. Changi Point.
- Mr. George Tay Seng Hock, Senior Fishery Biologist.
- Mr. Matthew Chow Tian Pow, Fishery Biologist.
- Mrs. Renee Chou Tuan Neo, Fisheries Biologist.
- Mr. Ng Chee Kien, Research Officer
- Mr. Chou Kai Chih, Project Leader Pig Waste Aquaculture project.
- Mr. Hooi Kok Kuang, Chief SEAFDEC Marine Research Dept.

University of Singapore

- Prof. Kwan Sai Kheong, Vice-Chancellor
- Prof. Ang Kok Peng, Dean of Science
- Dr. C. F. Lim, Chairman Zoology Dept. (Freshwater fish, marine molluscs)
- Dr. T. J. Lam, Lecturer Zoology Dept. (Reproduction physiology)
- Dr. W. H. Tan, Lecturer Zoology Dept. (Invertebrates, fish larvae)
- Mr. D. H. Murphy, Lecturer Zoology Dept. (Systems ecology).
- Mr. R. E. Sharma, Lecturer Zoology Dept. (Coral reef biology).

Public Utilities Board

- Mr. Yang Swee Ling, Fisheries Biologist in-charge water quality and fish production cageculture, Seletar Reservoirs

8. INDONESIA

a) Directorate of Fisheries, Ministry of Agriculture, Jakarta

- Admiral Iman Sardjono, Director-General
- Mr. V. Soesanto, Director, Conservation
- Mr. Salamat Prajitno, Director, Production
- Mrs. Boedinings ih Soenyoto, Subdirectorate of Foreign Relations, Planning Directorate
- Mr. Soehardi, Subdirectorate of Environment and Management, Conservation Directorate.

b) Agency for Agricultural Research & Development
Ministry of Agriculture, Bogor

- Dr. A. Sadikin, Director General of the Agency
- Prof. Dr. Sumardi Sastrakusumah, Director of Fisheries and Animal Husbandry.
- Mr. Sofian Ilyas, Director, Fish Processing Research Institute, Jakarta
- Mr. Wardona Ismail, Coordinator of Mariculture Research, Marine Fisheries Research Institute, Jalan Kerapu 12, Jakarta. (Representing Dr. M. Unar, Director of the Institute)
- Mr. R. Rustami Djajadiredja, Director of the Inland Fisheries Research Institute, Lembaga Penelitian Perikanan Darat, LPPD, Jalan Sempur, No. 1 Bogor.
- Mr. Santosa Koesoemadinata, Head of Division of Parasitoloty, Pesticides & Environmental Problems, LPPD, Cibalagung Station.

c) Faculty of Fisheries, University of Agriculture at Bogor (IPB)

- Mr. Hasid H. Jasin, Dean of the Faculty of Fisheries, IPB. (Fisheries Economics)

- Dr. Kusman Sumawijaya, Limnology
- Mr. Gelar Atmaja, Aquaculture.
- Mr. Chairal Muluk, Fishery Biology
- Mr. Pong Suwignyo, Limnology
- Mrs. Lestari Angka, Fish Diseases
- Mr. Joko Setianto, Water Chemistry
- Mr. Sutrismo Sukimim, Water quality, oysters.
- Mr. Sutomo Akhmad, Mariculture.
- Mr. Mohamed Raswis, Fishery Biology
- Mr. Darnas Dana, Fish Parasitoloty

d) Cibalung Fishculture Research Station

- Mr. Isnadi Isnandar, Biologist-in-charge.
- Mr. Bambang Salamoen

e) Regional Centre for Research in Tropical Biology
Southeast Asian Minister of Education Organization (BIOTROP/SEAMEO)
Bogor

- Mr. Pong Suwignyo, Program Manager of Aquatic Biology.
- Mrs. Bakhoven, Program Manager of BIOTROP, Clearing House/Librarian.

f) Shrimpculture Research Centre, Directorate of Fisheries
Ministry of Agriculture, Jepara

- Mr. Sukotjo Adisukresno, Director of the Centre.
- Mr. Ali Poernomo, Research Scientist.
- Mr. Bambang S. Ranoemihardjo, Chief, Fishculture Station
- Dr. Won-Tack Yang, FAO/UNDP Expert on Shrimpculture.

9. PHILIPPINES

SEAFDEC Aquaculture Dept.

a) Makati Office

- Dr. Q. F. Miravite, Executive Director
- Dean R. S. Ignacio, Deputy Director for External Affairs.
- Ms. Z. Balangue, Executive Officer.

b) Tigbauan

- Dean D. K. Villaluz, Chief
- Mr. N. Hoshino, Deputy Chief.
- Dr. J. A. Eusebio, Director of Research
- Mr. J. M. Garay, Director for Development & Administration Services.
- Mr. P. R. Manacop, Deputy Director for Planning & Evaluation.
- Mr. J. A. Agbayani, Head, Training & Extension Division
- Mr. Y. C. Kim, O. I. C. Business Affairs Division
- Mr. E. B. Gapit, Librarian

- Dr. J. V. Juario, Researcher
- Dr. H. Chaudhuri, Regional Aquaculture Coordinator.
- Mr. S. Kumagai, Researcher (Japan)
- Mr. R. R. Platon, Researcher
- Dr. C. Lim, Researcher
- Mr. Y. Nukiyama, Researcher (Japan)
- Mr. H. Motoh, Researcher (Japan)
- Mrs. J. H. Primavera, Researcher
- Mr. W. G. Yap, Researcher
- Dr. C. T. Villegas, Researcher
- Dr. F. P. Pascual, Researcher
- Dr. C. Mock, visiting scientist from Galveston, Texas, U. S. A.
- Mr. R. O. Gacutan, Research Associate
- Dr. L. Benitez, Researcher
- Dr. L. Engle, Researcher
- Dr. P. Sorgeloos, visiting scientist, State University of Ghent, Belgium

c) Leganes

- Mr. M. L. Lijauco, Researcher
- and other research staff.

d) Igang

- Mr. L. M. Rodriguez, Research Associate
- and other research staff.

e) Binagonan

- Dr. Benjamin Cer Gabriel, Researcher
- Dr. J. B. Pantastico, Researcher
- Commissioner A. Mane, Consultant-Researcher
- Dr. A. M. Bautista, Researcher
- Mr. J. Lesaga, Administration.

f) Pandan

- Dr. W. E. Vanstone, Senior researcher - Milkfish Breeding Program
- Dr. N. C. Carandang, Researcher

Bureau of Fisheries & Aquatic Resources (BFAR)

- Mr. Felix Gonzales, Director
- Mr. E. Velasquez, Head Batangas Station

Philippine Council for Agricultural & Resources Research (PCARR)

- Dr. J. Madamba, Director-General
- Dr. E. Tan

International Centre for Living Aquatic Resources Management (ICLARM)

- Dr. J. C. Marr, Director-General
- Dr. Z. H. Shehadeh, Associate Director-General
- Dr. F. Christy, Jr.
- Ms. J. M. Reinhart, Literature.

South China Sea Fisheries Development & Coordinating Programme

- Mr. A. G. Woodland, Programme Leader
- Dr. H. R. Rabanal, Fishery Officer (Aquaculture Development)

University of the Philippines

a) Diliman

- President O. D. Corpus
- Dean R. O. Juliano, College of Fisheries

b) Brackishwater Aquaculture Station

- Dr. A. Camacho, O. I. C. (absent)
- Mr. V. Dureza, Assistant Project Leader
- Dr. D. Leary, USAID, Aquaculture Advisor.
- Mr. R. Fortes, Research Coordinator

University of the Philippines at Los Banos

- Chancellor A. G. Samonte
- Vice-Chancellor for Academic Affairs A. A. Gomez
- Dr. Ed Reyes, Dept. of Soil Science
- Dr. W. P. David, Dept. of Land & Water Resources Engineering & Technology
- Dr. C. Madamba, Dept. of Zoology
- Prof. Sta. Iglesia, Inst. of Agricultural Development & Administration.
- Dr. B. Cariaso, Dept. of Entomology
- Dr. C. Barril, Dept. of Chemistry.

Central Luzon State University

- President A. Campos
- Dr. R. D. Guerrero
- Dr. C. R. Dela Cruz
- Dr. E. M. Cruz
- Mr. R. G. Arce
- Mr. F. Carbonel, model fish farmer

West Visayas Federation of Fishfarm Producers

- Atty. C. De Los Santos, Jr., President
- Mr. E. Jamandre
- Mr. T. Jamandre

Asian Development Bank

- Mr. M. Z. Azam
- Mr. V. M. Nair, Senior Fisheries Specialist
- Dr. R. C. May, Aquaculture Specialist.
- Mr. G. Escritor.

UNDP (Manila)

- Mr. B. Devarajan, New representative
- Mr. J. B. Melford, Representative (leaving)

Embassy of Japan (Manila)

- Ambassador Kiyohisa Mikanagi
- Mr. Sota Iwamoto, First Secretary

United States Agency for International Development (Manila)

- Mr. W. H. Mc Cluskey, Agriculture Advisor

- Mr. J. Krantz, Fishery Advisor

Private Fish Farming Enterprise

- Lake Bunot Cageculture/Resort
  Mr. N. Guia, Manager
- Leganes Fish Ponds
  Mr. E. Jamandre
- Tigbuan Commercial Shrimp Hatchery
  Mr. N. Jamandre

10. JAPAN

1. Ministry of Foreign Affairs

- Mr. T. Kimura, Chief, Multilateral Cooperation Division
- Mr. M. Horiguchi, Deputy Chief Multilateral Cooperation Division (SEAFDEC Alternate Director for Japan)
- Mr. N. Ichida, Official Multilateral Cooperation Division
- Mr. O. Yoshihara, Official Multilateral Cooperation Division
- Mr. A. Matsusaki, Official, International Cooperation Division, Ministry of Agriculture & Forestry

2. Japanese International Cooperation Agency (JICA)

- Mr. Y. Hisamune, Vice President
- Mr. T. Kasai, Chief Office for SEAFDEC affairs.
- Mr. Misei, International Affairs Division.

3. Fisheries Agency, Ministry of Agriculture & Forestry

- Mr. T. Onda, Deputy Chief
- Mr. Y. Mori, International Affairs Division

4. Professors, Tokyo University of Fisheries

- Dr. Chinkichi Ogino, Fish Nutrition
- Dr. Seiichi Watanabe, Fish Nutrition
- Dr. Juichi Kato, Marine Engineering
- Dr. T. Kano, Marine Engineering
- Dr. Minoru Nomura, Fish Reproduction

5. Shizuoka Prefecture Fisheries Experimental Station

- Mr. Makoto Nonaka, Chief, Hamana Branch Station
- Mr. Hideo Oka, Biologist, Hanana Branch Station
- Mr. Hiroshi Noguchi, Former Chief of the same station

11. U. S. A.

- Mr. K. W. Cox, Senior Fishery Scientist, Resource Development Associates
- Mr. J. Myers, Fishery Scientist, Los Altos, California

Washington D. C.

- Mr. P. Roedel, Fisheries Advisor, Development Support Bureau, USAID.
- Mr. Doug Jones, Economist, Dept. of Commerce, USAID.
- Dr. James E. Storer, Director, Dept. of Fisheries, NOAA, State Dept.
- Dr. Clare Idyll, Aquaculture Specialist, NOAA
- Dr. David Wallace, Special Assistant on International Marine Affairs, NOAA and Chairman of the Inter-Agency sub-committee on Aquaculture.
- Mr. Ed Williams, Asia Bureau Dept. of Agriculture. USAID
- Dr. W. E. Ripley, Fishery Advisor, UNDP, New York City.

International Bank

- Dr. L. Sprague, Team Leader Fishery Programs.

## Appendix 6. FACILITIES FOR RESEARCH AND TRAINING AT THE SEAFDEC AQUACULTURE DEPARTMENT

(As of March 1978)

Tigbauan, Iloilo, Panaye Island

| | | | |
|---|---|---|---|
| Laboratories: | Single storey laboratory buildings | No. 1 | 525 $m^2$ |
| | | No. 2 | 525 $m^2$ |
| | Double storey building for physiology & Nutrition | No. 3 | 4,750 $m^2$ |
| | Wet laboratories | | 525 $m^2$ |
| | Roofed hatchery with | 6 x 50 ton tanks | |
| | | 6 x 120 ton tanks | |
| | Open air hatchery with | 4 x 200 ton tanks | |
| | Food preparation & store | | 80 $m^2$ |
| | Open air pond & tanks | | 3,000 $m^2$ |

Survey Vessels

20 ton & 5 ton diesel powered boats

Administration

| | |
|---|---|
| 3 storey admin. building | 1,928 $m^2$ |
| Workshops & physical plant | 300 $m^2$ |

Library & Training complex 2,300 $m^2$

(offices, classrooms, with audio-visual equipment, conference rooms, library, bookbinding workshop.)

Staff Accommodation

26 two-bedroomed staff houses

4 three-bedroomed senior staff houses

Guest Accommodation

40 apartments each with bedroom, bathroom, kitchen & dining room.

Students Accommodation

Dormitory with 20 rooms, cafeteria

## SUBSTATIONS

Panaye Island

There are 2 substations & 8 field stations.

Leganes Substation (25 km from Tigbauan)

Research laboratories & 96 ha of ponds.

Pandan Field Station

Small field laboratory, guest house & staff houses.

Igang Field Station

Sea farming in lagoons. Temporary Office.

Luzon Island

Binagonang Substation: Laguna de Bay

Research laboratories on 45 ha site with good hatchery facilities and experimental fishpens.

Of six smaller substations 3 are sited on Panaye Island. (Batan in Aklan, Capian in Capiz and Hamtik in Antique provinces.)

One is on Negros Island (Himamaylan, Negros Occidental),
One on Mindanao Island (Cruz, Zamboanga), and
One on Mindoro Island (Naujan).

Liaison Offices are maintained in Manila (Makati) and at Iloilo City.

Communication

A radio-communication network connects all units.

## Appendix 7: TECHNICAL LITERATURE CONSULTED

The main texts used for this study are listed below. In addition many others were scanned, and many research papers by individual workers were read. A number of translations from Japanese, Chinese and the local languages of the region were referred to, but this list represents only the material available in English. It is not necessary to attempt an exhaustive cataloguing of the literature, but reference is made to:

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