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AQUACULTURE RESEARCH PROGRAMME

Report of TAC-Subcommittee on Aquaculture

(Agenda Item 4)

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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AQUACULTURE RESEARCH PROGRAMME

Report of TAC-Subcommittee on Aquaculture

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SUMMARY

The systems of aquaculture, for international research support in the three developing regions of the world and the species groups involved are described. Three systems of culture are recommended for Asia and Oceania, six systems for Africa and four systems for Latin America. The Sub-committee recommends the establishment of networks consisting of regional centres and a small number of outreach stations, in each of the three regions (Asia and Oceania, Africa and Latin America). It is suggested that the linkages should be expanded after the first phase of operations. The Sub-committee does not consider it desirable or feasible to concentrate efforts on specific problems relating to culture systems as the simultaneous solution of the problems is considered essential to make rapid progress in aquaculture research. Staggering of the establishment of networks and hence of the allocation of funds in the three regions is possible, but to decide on the priorities different criteria can be used.

Training and information services are most essential for the success of the programme. The regional centres should provide for the in-service training of scientists and the outreach stations of field personnel. FAO should expand its information activities to fulfill the needs of the programme.

It is recommended that an international board be appointed to assist in the implementation of the programme and its coordination. Based on the assumption that only modest external support would be necessary for upgrading the activities of the selected centres and stations, an indicative budget has been prepared. It involves a total investment of US \$14.594.000, for the initial period of 5 years.

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## I. INTRODUCTION

1. The report of the TAC Working Group on Aquaculture (Spoleto, July 1973) reviewed the culture systems and research priorities and indicated the wide range of critical problems concerning species groupings in the various regions of the world which could contribute considerably to enhanced production in aquaculture. Their report also provided the rationale for their recommendations and indicates the constraints hindering effective fulfillment of aquaculture potential. This report was considered by TAC at its Seventh Meeting 4 - 8 February 1974.

2. TAC agreed that the report indicated considerable research gaps in aquaculture which warranted concerted international effort, whether in regard to species groups or regional problems. They further recognised that despite a certain similarity of problems, various aspects of site-specificity with regard to ecology and diseases as well as other problems pertaining to exchange of species, preclude the centralisation of global aquaculture research studies in a single "traditional" international centre. TAC appreciated that one feasible approach involved the regional strengthening of research work at particular centres to concentrate on key problems concerning species groups of wide regional availability and applicability. Such research could provide larger dividends once effectively coordinated within a global programme designed for selected areas, species and key problems and linked in a network of outreach stations.

3. TAC appointed a small Sub-committee comprising Drs. W.H.L. Allsopp, IDRC, J.E. Bardach, Hawaii Institute of Marine Biology, and T.V.R. Pillay, FAO, who, after consultation with concerned authorities or institutions were required to formulate an appropriate programme.

4. The terms of reference of the TAC Sub-committee on Aquaculture were:-

- (1) specify systems of culture and species groups on which priority research efforts should be concentrated and the areas where the application of the results of such research can have an appreciable impact on aquaculture production;
- (2) identify national or regional institutions where the above-mentioned priority research could possibly be carried out;
- (3) describe in some detail the nature and duration of each research project including requirements for equipment and personnel;
- (4) prepare cost estimates for each individual project.

5. Some informal consultations were held with Dr. Marcel Huet of Belgium, Dr. John Halver at US Western Fish Nutrition Laboratory, Dr. Wayne Shell of Auburn University, Alabama, Dr. Lucien Sprague of IBRD, Washington, Dr. Ian Pritchard of Environment, Canada and other scientists in North America and Europe.

6. The Sub-committee met at FAO headquarters in Rome, 17 - 25 June. It reviewed in some detail the expanding regular programme and field programme activities of FAO in the field of aquaculture, with particular reference to research, training and information. The relevant bilateral assistance programmes of IDRC, and USAID were also reviewed. The programme prepared by the Sub-committee thus takes into account all the ongoing research and related activities known to its members.

## II. CULTURE SYSTEMS AND SPECIES GROUPS FOR RESEARCH SUPPORT

7. The TAC Working Group on Aquaculture (Spoleto, 1973) identified the culture systems in the three developing regions that could be upgraded by the simultaneous removal of the major constraints. Based on this a small number of systems and species groups can be recommended for initial research support.

8. Each of these culture systems involve the use of a number of indigenous species, although they include a few which are rather widely or even globally distributed. Many of the problems for research may at first sight look similar for the different species or even some of the culture systems selected in the three regions, but it has to be remembered that the reproduction physiology, nutrition or response to high density culture of one species are usually very different from others and need to be studied in the set of environmental conditions in which the particular species occurs in nature and those in which it has to be reared.

9. The Sub-committee considered the advantages that are inherent in farming and husbandry practices based on a small number of species, as in world agriculture or animal production. A relatively new science like aquaculture, with even the limited research input obtaining now, could result in more rapid technological development if such a restriction were possible. However, the environmental damage that may result from a world-wide exchange of exotic species; the practical difficulties of implementing international control of introductions, particularly with reference to the spread of communicable diseases; and the strong consumer preferences that exist in different regions, countries and even localities, make such a restriction of species impracticable, at least for the present.

10. Having recognized that it would be counter-productive to confine world-wide research in aquaculture to one central international station or to a few key species, one must further appreciate that an integrated systems-approach to such research is essential if a major impact on aquaculture production is to be made in a reasonable period of time.

11. Aquaculture, like other agricultural production systems has strong feed-back components. For instance improvement in seed supply requires new food or feed production techniques as well as changes in engineering and management. The same is, of course, true when new strains or varieties emerge from the research effort. Thus the research in any one culture system must be considered as indivisible and selection of certain research problems for solution, at the expense of others would be technically and economically imprudent. In fact the problems listed in the table of Programme Summary (see Appendix I) and described in some detail in Appendix II together constitute the overall research programme for each system. This explains the reason for the Sub-committee not indicating the nature and duration of specific research projects, or the equipment and personnel required for individual projects, as suggested in the terms of reference.

12. Similar considerations apply to the advantages that accrue to research performance from the interaction between systems within a region.

13. Technically it should be possible to reduce in any one region the number of systems recommended for research and to single out only some of them. If this were attempted the savings would not be commensurate to the loss in interaction potential among the systems.

14. The potential of shared services in regional centres in equipment for physiology

of reproduction or nutrition, for instance, would not be utilized to best advantage nor would there be feed-back between more extensive or intensive systems, and interaction possibilities between short and longer-term research would be curtailed.

15. In view of the above, the Sub-committee unanimously and strongly recommends that the three regional networks with supporting activities proposed, be considered as the minimum programme required for the advancement of aquacultural science in the short-term in order to derive the maximum benefits from the investments of funds and efforts involved.

#### Culture systems and species groups for regions

##### 16. Asia and Oceania

1. Culture of carps in ponds and other impoundments
2. Pond culture of milkfish and grey mullets
3. Pond culture of shrimps and prawns

The carp culture system in Asia and Oceania bears mainly on the following species:

Grass carp, Ctenopharyngodon idella, Silver carp, Hypophthalmichthys molitrix, Bighead, Aristichthys nobilis, Catla, Catla catla, Rohu, Labeo rohita, Mrigal, Cirrhina mrigala, Common carp, Cyprinus carpio, Tawes, Puntius gonionotus

The pond culture of milkfish and grey mullets is mainly practised in the brackishwater environment, though sometimes acclimatized to freshwater also. The species concerned are:

Milkfish, Chanos chanos, Grey mullets, Mugil cephalus, M. dussumieri, M. belanak, M. tade

Shrimp and prawn culture, which is still in an early stage of development, involves a number of species, but the more important are:

Giant freshwater prawn, Macrobrachium rosenbergi, Shrimps, Penaeus monodon, P. merguensis, Metapenaeus brevicoornis, P. japonicus and P. orientalis are also of importance in certain areas.

##### 17. Africa

The Spoleto Meeting considered the whole continent of Africa and the Middle East as constituting one region for purposes of aquaculture research support. While this is perfectly valid in so far as most of the systems of culture in the area are concerned, the Sub-committee feels that brackishwater fish culture in lagoons in North Africa and the Middle East countries deserve to be considered as a separate system. In as much as the Cooperative Research Programme on Aquaculture (COPRAQ) of the General Fisheries Council for the Mediterranean (GFCM) is promoting research on item 5 below, it is suggested that this Programme be entrusted the responsibility for the work on that system. The relevant systems for the whole African region will be:

1. Culture of tilapias in freshwater ponds

2. Culture of catfish in fresh and brackishwater ponds
3. Brackishwater pond culture of grey mullets
4. Cage culture of tilapia and catfish
5. Brackishwater fish and shellfish culture in North Africa and Middle East

For pond culture of tilapia, several species and some hybrids are now employed. The more important of them are:

Tilapia aurea, T. macrochir, T. melanopleura, T. nilotica and hybrids resulting from crosses of T. hornorum X T. mossambica, T. hornorum X T. nilotica, T. aurea X T. nilotica

The most important catfishes used for freshwater pond culture in Africa are Clarias lazera and C. senegalensis. The species for brackishwater pond culture are:

Chrysichthys nigrodigitatus and C. walkeri

The grey mullets of importance in brackishwater aquaculture are:

Mugil cephalus, M. capito, M. falcipinnis, M. grandisquamis

Cage culture in lakes and reservoirs, which is under development in some areas, is based on the species of tilapia and catfishes mentioned earlier.

In shrimp culture Penaeus kerathurus is the most important in North Africa, whereas in West Africa it is P. duorarum.

The species concerned in the brackishwater lagoon culture of fish and shellfish in North Africa and the Middle East are:

Grey mullets, Mugil cephalus, M. capito, M. ramada, Eel, Anguilla anguilla, Seabass, Dicentrarchus labrax, Gilthead bream, Sparus auratus, Oysters, Crassostrea angulata, Ostrea edulis, Mussel, Mytilus gallo-provincialis, Shrimp, Penaeus kerathurus

#### 18. Latin America

1. Aqua-range farming in lakes and reservoirs
2. Shrimp culture in ponds
3. Culture of new Amazonian species
4. Culture of tilapia hybrids

The aqua-range farming in lakes and reservoirs in Latin America, which consists of improving natural resources by stocking autochthonous species, or the introduction and transplantation of other species, at present involves mainly the following:

Tucunare, Cichla ocellaris, Bocachico, Ichthyoelephas humeralis, Pescada, Plagioscion squamosissimus, Boquichico, Prochilodus amazonensis, Boquichico, Prochilodus reticulatus

There are a number of Amazon fish species that deserve to be tried for pond culture, but the species that have shown the maximum promise are: the tambaqui, Myletes bidens and pirapitinga, Mylossoma sp.

Similarly the pond culture of the hybrid of Tilapia hornorum and Tilapia nilotica has also shown considerable promise for expansion and improvement in the region.



### III. REGIONAL RESEARCH NETWORKS

19. None of the existing research centres in the developing world and few elsewhere have a truly multidisciplinary, highly trained staff and the facilities required for the necessary mission and systems-oriented research capable of producing the results essential for the rapid progress of aquaculture. There is also no centre or organization anywhere in the world designed to carry out long-range inter-disciplinary research needed to underpin scientific aquaculture along the lines indicated in the programme. The formidable constraints to centralisation of research have already been recognized.

20. Similarly, there is a serious insufficiency (nationally, regionally and internationally), of trained research personnel capable of implementing a comprehensive programme which is a prerequisite to the development of aquaculture.

21. In view of these shortcomings and recognizing the inter-disciplinary nature of research effort required; the need for institutional, financial and other support; the differences in ecological conditions, species available for culture, as well as socio-economic conditions; the Sub-committee supports the conclusion of the Spoleto meeting that investigations on the major problems of aquaculture have to be organized regionally. The Sub-committee therefore recommends the strengthening of selected national institutions as regional centres for research, closely linked to a network of national outreach stations. In selecting such institutions the Sub-committee has been guided by the consideration of present and past research activities, existing physical facilities and additional facilities that can be developed with modest investments, the availability of a nucleus of scientific and supporting staff, nearness to academic institutions, and the suitability of living conditions for internationally recruited scientists. Only a limited number of outreach stations are proposed to be developed during the first phase (5 years) of the programme. Wider linkages are expected to be developed later.

22. To achieve the full potential for aquaculture in the developing world, it will be necessary to initiate the recommended activities in the three regions as soon as feasible.

23. The programme of the regional centres should be developed, based on the selected systems of culture and the major constraints to their improvement and wider application for increased food production. The centres should also undertake training of scientists as proposed on page 8. The outreach stations, besides carrying out research of local importance, will concentrate on testing the technologies developed in the regional centres, including pilot-scale operations and the training of field personnel. Some of the site-specific research in the regional centres may also have, at least partly, to be carried out at the selected outreach stations. The programme of work in each region has to be sufficiently flexible and dynamic to accommodate changing regional needs.

24. With these considerations in mind the Sub-committee recommends, for the first phase of the programme, the following regional centres and networks of outreach stations. The possible expansion of the networks in the three regions is indicated by suggesting the countries that are developing requisite basic facilities for effective participation, in a second phase programme.

## I. Asia and Oceania

25. This region is acknowledged to be that with the greatest effort in aquaculture and where there is a long-standing tradition of freshwater and brackishwater aquaculture. The Sub-committee finds it difficult to identify one country for the development of a regional centre to concentrate research on both these two systems of aquaculture. Accordingly, two centres for regional research are recommended. It is recognized that there are already some bilateral assistance projects to support current activities in these centres. The mobilization of these efforts, supplemented by the international assistance envisaged under this proposed programme, should lead to a highly beneficial concentration of research, yielding significant dividends in a reasonably short period of time.

### Regional Centres:

- 1) India:  
Central Inland Fisheries Research  
Institute  
Barrackpore and Cuttack  
(for freshwater aquaculture)
- 2) Philippines:  
Brackishwater Aquaculture Centre  
Ilo Ilo

### Outreach Stations:

- 1) Indonesia:  
Brackishwater Aquaculture Centre  
Jepara, Semarang, Java  
and  
Research Institute for Inland Fisheries  
Bogor, Java
- 2) Malaysia:  
Freshwater Fisheries Research Station  
MARDI, Malacca
- 3) Thailand:  
Bangkhen Inland Fisheries Station  
Bangkok

Future expanded linkages in: Bangladesh, Fiji, Hong-Kong, Korea,  
Nepal, Singapore and Vietnam

## II.(a) Africa (South of the Sahara)

26.

### Regional Centre : comprising: Nigeria:

Freshwater Fish Culture Station  
Ministry of Agriculture  
Ibadan  
and  
The Brackishwater Fish Culture Station  
Buguma

### Outreach Stations:

- 1) Central African Republic  
Fish Culture Research Station  
Landjia, Bangui

- 2) Ivory Coast:  
Inland Fisheries Research Station  
Bouaké
- 3) Madagascar:  
Fish Culture Station  
Perinet
- 4) Uganda:  
Kajansi Experimental Station  
Fisheries Department

Future expanded linkages in: Cameroon, Ghana, Kenya, Mauritius,  
Zaire and Zambia

## II.(b) Africa (North Africa and Middle East)

27. The following research institutions from developing countries participating in the General Fisheries Council for the Mediterranean (GFCM) Cooperative Programme of Research on Aquaculture (COPRAQ) are proposed:

- 1) Egypt:  
Institute of Inland Fisheries and Fish  
Culture  
El Kanatir, Elkhaira
- 2) Israel:  
Fish Culture Research Station  
Dor, D.N., Hof Hacarmel
- 3) Tunisia:  
Institut National Scientifique et  
Technique d'Océanographie et de  
Pêche (INSTOP) Salambo

Future expanded linkages in: Iran, Lebanon and Syria

## III. Latin America

28. Regional Centre: comprising: Brazil:  
Fish Culture Research Station  
Pentecoste, Fortaleza  
and  
Brackishwater Aquaculture Station  
Natal

### Outreach Stations:

- 1) Colombia:  
Fish Culture Station  
University of Caldas  
Manizales
- 2) El-Salvador:  
Fish Culture Station  
Santa Cruz Purillo
- 3) Mexico:  
Fish Culture Station  
El-Zarco, D.F.

Future expanded linkages in: Guyana, Venezuela and Trinidad

#### IV. RESEARCH TRAINING AND OUTREACH ACTIVITIES

29. The complexity and fundamental nature of the research that has to be undertaken with the selected species of fish require that new techniques be developed or existing techniques modified for application in their regional environment. It is well to note that, on a world-wide basis, intensive physiological investigations of fish are only now being developed in depth, and experience is being accumulated with two, at most three, species. The application of these techniques to other fishes (and particularly to the juvenile stages of normally fast-growing tropical species whose life processes are virtually unknown) is a matter requiring considerable research endeavour in situ. This emphasizes the need for training of national researchers at various levels to carry out the programme, in addition to the international inputs, if there is to be an effective critical mass of scientific expertise mobilised at the various regional centres initially, and at the outreach network stations subsequently.

30. When considering the role that the network stations must play in the testing of species, selection of varieties and in observations in field trials, the critical importance of training of an increasing number of research scientists in developing countries becomes obvious. It bears repeating that in the regions concerned current aquaculture training facilities at the few existing centres are designed for extension personnel and are, in any event, inadequate for even this. However that part of the outreach activities may encourage the development of national extension programmes which involve the application of research results. Further the medium and long-term conduct of the programme will probably devolve more directly on the nationals of the region, so emphasis on research training programmes initially is considered justified.

31. The Sub-committee suggests that the regional centres should have adequate provision for in-service training of young scientists, e.g. one or two from each country, specializing in disciplines of immediate importance to them. Priority will necessarily have to be given to the countries which have outreach stations. The minimum training period for such research specialisation will be about two years, after which the scientists may be recruited as research workers in the regional or outreach stations. It is necessary to make adequate provision for further short-term training of a selected number of them in specialized institutions abroad.

32. Another type of training activity that the regional centres should undertake is the organization of short-term courses in the newly developed techniques for the scientific staff of outreach stations. Organization of about three courses or workshops in each of the three regional centres is envisaged during the five-year-period of the proposed research programme.

33. The Sub-committee feels that a system of recognition of individual and institutional achievements in aquaculture research through a special award may serve as an incentive for aquaculture research. It is recommended that such an award (both citation and financial) be provided for the researcher or laboratory that has made an outstanding scientific contribution, the money being intended to assist or promote the pilot-scale application of the technique. The award may be granted annually, biennially or when specially merited, at the discretion of the International Board on Aquaculture Research (see page 10).

V. INFORMATION COLLECTION AND DISSEMINATION

34. It is recognized that information sources on aquaculture, especially of tropical species, are inadequate in contrast to agriculture. While the FAO Aquaculture Bulletin serves a very useful purpose in disseminating information on current aquaculture research and development activities, a wider coverage of technical data and research findings is clearly needed.

35. For the efficient functioning of the regional networks proposed and the effective utilization of the results of research undertaken, it is essential that the existing information services be strengthened. The collection of information from the network and other centres and their storage and dissemination can best be done in close association with the International Board on Aquaculture Research. Appropriate cooperation with other research and development organizations has also to be established. This service is among the normal responsibilities of FAO as a depository of world aquaculture data and there is no other Agency better equipped than FAO to do this at present. The Sub-committee therefore recommends that FAO's current activities be further strengthened to fulfill this need adequately.

## VI. ADMINISTRATION AND PROGRAMME COORDINATION

36. The Sub-committee discussed in some detail the organizational requirements pertaining to the establishment of a coordinated programme. It came to the conclusion that an International Board of Aquaculture Research (IBAR) should be created and specifically proposed the following terms of reference, mode of operation and membership for such a Board.

### Terms of Reference

37. The International Board of Aquaculture Research, shall under the authority of the Consultative Group on International Agricultural Research, have responsibility for recommending policies and developing programmes in close collaboration with, and with the help and advice of FAO, to meet the objectives discussed in this report. They are:

- i ) To advise on the establishment and operation of a network of aquaculture research centres and outreach stations, and to coordinate their activities.
- ii ) To assist in strengthening the programmes of regional centres and outreach stations and to encourage the establishment of institutions and programmes to the above end.
- iii) To promote international research liaison between developed and developing centres.
- iv ) To promote training activities at all levels.
- v ) To promote the dissemination of information, among the centres participating in this network, as well as other institutions and Agencies.
- vi ) To review the annual financial requirements of the Programme and to assist in the formulation of a follow-up of the presently proposed 5-year programme.
- vii) To mobilise other means to support the rapid development of aquaculture, including the TAC Aquaculture Research Award.

### Mode of Operation

38. i) IBAR will be expected to draw as fully as possible for technical advice on the knowledge and experience of scientists in relevant disciplines throughout the world in developing as well as developed countries. In particular the full cooperation of FAO's expertise and services in its Regular and Field Programmes is anticipated.

ii) IBAR shall recommend financing for appropriate institutions and organizations, national, regional and international, including FAO, for the furtherance of generalized aquaculture research thrusts as outlined in this report. It shall have at its disposal a central fund, contributed by the members of the Consultative Group on International Agricultural Research, both to meet its own budgetary expenses and to help carry out the programmes which it will recommend. Appropriate arrangements shall be made with an international organization, e.g. FAO, for the administration of such a fund.

iii) The Sub-committee agrees that a central and integral role in the programme will be played by information collection, storage, retrieval and dissemination. It further agrees that FAO has the best existing potential capabilities for this set of tasks, but that it lacks the funds to execute them on the level postulated by the research programmes outlined in this report. It is therefore suggested that special funding be provided to FAO for this purpose through CGIAR. Provisions for such funding as included in the tentative budget are intended to complement but not to replace the services normally budgeted in the regular programme of FAO.

Membership

39. i ) The Group will consist of nine members.  
ii ) Three members of the Board will be the directors of the regional centres mentioned in this report.  
iii) Five members of the Board will be selected by CGIAR. Members will serve for a three year term, to be arranged on a staggered basis.  
iv ) FAO will appoint one member to the Board.  
v ) The members will serve in their personal capacities, regardless of their professional or official affiliations.  
vi ) The Chairman of the Group will be elected by the members of the Group. His term of office will be for three years.

40. The creation of a central fund to finance centralized operations is recommended by the Sub-committee. This fund is to be at the disposal of the Scientific Advisory Group and would be utilized for financing the activities of coordination, administration and information services. Effective functioning of the Scientific Advisory Group will necessitate the establishment of a modest secretariat the expenses of which are also to be defrayed from the proposed central fund.

41. The above mentioned secretariat would in its function be akin to an executing agency for enabling adequate functioning of the Scientific Advisory Group. It is suggested that the appointment of the secretariat personnel follow the normal UN personnel selection and appointment procedures.

## VII. INDICATIVE BUDGET

42. The Sub-committee attempted to prepare indicative cost estimates for an initial five-year programme and these are given in Table I on page 13. The constraints and limitations of this exercise are obvious, as they are not based on any negotiations with the host governments or a detailed assessment of the staffing and equipment at the selected centres and outreach stations. However, the Sub-committee prepared the estimates based on the experience of its members in the organization of aquaculture projects and the available information on the existing facilities in the stations. It firmly believes that the proposed budget is the minimum required for the implementation of an effective programme. Moreover the budget is based on the assumption that the national governments concerned will continue to maintain, if not increase their present level of financial and personnel support. The budget is also predicated on the assumption that the bilateral or multilateral assistance any or all of these Centres/Stations are receiving now will be continued. With the modest international assistance envisaged under this programme, it is hoped that a substantial upgrading of research activities would result to the benefit of the developing regions and eventually of all the regions.

43. In the absence of any targets of financial resources that may be available for aquaculture research, the Sub-committee considered the possibilities of phasing the programme. The Spoleto meeting had also given thought to this and stated that "to achieve the full potential for aquacultural production in the developing world, it is necessary to initiate the recommended activities in all the three regions as soon as feasible, but these could be started in one region and on the basis of experience gained during the first phase, the subsequent phases can be planned". Even if there were no financial constraints operational reasons suggest that a staggering of the establishment of regional networks is advisable. There are different criteria that could be used in deciding on the sequence. If it were to be based on the present state of development, existing scientific capabilities, and food production needs, the choice for the first regional network may be Asia and Oceania where two regional centres are recommended for purely operational reasons. This is clearly reflected in the budget prepared. However, if the low state of development, lack of local expertise and requirements for balanced diet of the population were to be the criteria, the first choice may be Africa, particularly the region South of the Sahara. The indicative budget shows the needs of each region separately and the TAC or the CGIAR could make the choice on the basis of the criteria it considered most appropriate.



TABLE I.

INDICATIVE BUDGET (in thousands of US Dollars)

	Year-1			Year-2			Year-3			Year-4			Year-5			Component total			Component Total
	AS	AF	LA	AS	AF	LA	AS	AF	LA	AS	AF	LA	AS	AF	LA	AS	AF	LA	
Regional operations	150	100	100	100	80	80	70	70	70	50	50	50	-	-	-	370	300	300	970
Equipment	40	30	30	70	90	50	50	90	50	60	90	50	60	50	40	280	350	220	850
Training	180	100	100	180	100	100	150	80	80	150	80	70	100	80	70	760	440	420	1620
International resident staff	90	80	80	70	80	80	60	80	80	50	60	60	40	40	40	310	340	340	990
Consultants	200	150	120	210	160	130	230	170	130	230	180	140	240	180	150	1110	840	670	2620
Operation expenses for regional centres	-	-	-	300	300	300	400	600	300	400	700	300	400	700	300	1500	2300	1200	5000
Outreach stations	65	45	43	93	83	74	96	110	70	94	115	67	85	105	60	433	458	314	1205
Contingencies	725	505	473	1023	893	814	1056	1200	780	1034	1275	737	925	1155	660	4763	5028	3464	
Sub-total																			
Component total	1703			2730			3036			3046			2740			13.255			13.255
Central services																			
International Board	40			40			50			50			60			240			
Administrative expenses	50			55			60			65			70			300			
Information activities	180			150			150			130			130			740			
Contingencies	14			10			10			12			13			59			
Component total	284			255			270			257			273			1339			1339
GRAND TOTAL	1987			2985			3306			3303			3013			14.594			14.594

## PROGRAMME SUMMARY OF CULTURE SYSTEMS AND PROBLEMS BY REGIONS

REGION	PROBLEMS		BREEDING, SEED PRODUCTION	NUTRITION, FEEDS	GENETICS, SELECTIVE BREEDING	CULTURE SYSTEMS INTENSIFICATION	AQUACULTURE ENGINEERING	AQUAPANS MANAGEMENT	NEW SPECIES SELECTION
	SYSTEM								
ASIA AND OCEANIA	Carp culture in ponds	Reproduction physiology (S) larval rearing methods (S)	Nutrition requirements (S) food and feeds (S)	Select for suitable traits (L) Hybridisation (L)	Densities (S) stocking rates (S) polyculture (S)	Installations equipment, pond design (S)	Physico-chemical factors (S) Metabolites (S) Economics (S)		
	Milkfish and mullet in brackishwater ponds	Reproduction physiology (S) larval rearing (S)	Production of food in ponds (S) Nutrition requirements (S) feed development (S)	Genetic variation (L)	Polyculture (S) densities (S) stocking/cropping(S)	Pond design, installations construction techniques (S)	Physico-chemical factors (S) Diseases, predators, economics (S)		
	Shrimp culture	Reproduction physiology (S) larval rearing (S)	Nutrition requirements (S) foods and feeds (S)	Genetic variation and trait selection (L)	Densities (S) stocking/cropping(S)	Hatchery design (S) pond installation (S) raceways (L)	Predators (S) physico-chemical factors (S) economics (S)		
AFRICA	Mullet: Brackishwater ponds	Reproduction physiology (S) larval rearing (S)	Nutrition requirements (S) of all stages (S) food and feed production(S)		Densities (S) stocking/cropping(S) metabolites (S)	Design and construction of ponds (S)	Physico-chemical factors (S) diseases (L) economics (L)		
	Tilapia: freshwater		Nutrition requirements (S) feed production (S)	Hybridisation (S) growth and sterility (S)	Polyculture (S) stocking/cropping(S)	Pond design (S)	Economics (S) culture unit -size (S)		
	Catfish: fresh and brackishwater ponds	Reproduction physiology (S) Extend breeding season (S)	Nutrition requirements (S) development of feeds (S)	Select for growth and disease resistance (L)	Densities (S) polyculture (S) stocking/cropping(S)	Site selection (S) pond design (S)	Physico-chemical factors (S) economics (S)	Screen new species (L)	
	Catfish: cage culture					Design suitable cages (S)	Diseases (L) economics (S)	Screen new species (L)	
	Shrimp in ponds	Reproduction physiology (S)	Nutrition requirements (S) feeds (S)	Select for desirable traits (L)	Densities (S) stocking/cropping(S)	Pond design (S)	Economics (S) predators (S) physico-chemical factors (S)		
Fish and Shellfish Culture in Lagoons in North Africa and Middle East Research priorities already determined to be implemented under COPRAQ or OPEC (see text .....)									
LATIN AMERICA	Aqua-range farming: Cichlids, Sciaenids, Characids.	Reproduction physiology (S) larval rearing (S) breeding (S)				Feeding and harvesting techniques (S)		Screen new species (L)	
	Mullet: brackishwater	Reproduction physiology (S) larval rearing (S)	Nutrition requirements (S) of all stages (S) food and feed (S)		Metabolites (S) cropping/stocking(S)	Pond design and construction (S)	Physico-chemical factors (S) diseases (L) economics (S)		
	Shrimps in ponds	Reproduction physiology (S) larval rearing (S)	Nutrition requirements (S) feeds (S)		Metabolites (S) cropping/stocking(S) polyculture (S)	Pond design (S)	Physico-chemical factors (S) diseases (L) economics (S)		
	New Amazon species	Reproduction physiology (L) seed production (L)	Nutrition requirements (L)				Define parameters (L)	Screen and select species (L)	

(S) Problems likely to yield applicable results in the short term; further research may lead to refinements.

(L) Results expected in the longer term.

APPENDIX II

HIGH-PRIORITY RESEARCH PROBLEMS RELATING TO THE SELECTED CULTURE SYSTEMS

44. The culturesystems selected for research support and the major species groups concerned have been described on pages 3 and 4. The specific objectives of the investigations and the recommended approaches for the main problems involved (some of them applicable to a number of systems; other system-specific) are enumerated below. They are not considered exhaustive, and are intended only to indicate the initial thrusts of the programme. The tabular statement in Appendix I summarizes the information and also indicates the time-frame in which results applicable in the field are expected to become available.

Problem I.

BREEDING AND SEED PRODUCTION

45. 1. Objectives:

- a. To ensure adequate and reliable seed supplies independent of natural sources and to extend the period of seed availability.
- b. To enable domestication of species presently used in aquaculture.
- c. To enable domestication of additional species of promise for aquaculture.
- d. To make genetic selection and hybridisation possible.

2. Recommended approaches:

a) Basic investigations

Study of factors governing reproduction of target species including:

1. reproduction physiology
2. nutrition of brood fish, larvae and juveniles
3. environmental factors (water conditions, photoperiodicity, space, etc.)
4. behavioural responses (stress, crowding, shock, sex segregation etc.)

b) Experimentation

1. Induction of spawning by (i ) biochemical means  
and/or (ii ) manipulating environmental factors  
and/or (iii) dietary control
2. Efficient larval rearing and seed distribution through:
  - (i ) hatchery and nursery design and operation
  - (ii ) production and delivery systems for natural food and artificial feeds suited to nutritional requirements
  - (iii) control of environmental conditions in hatcheries and nurseries
  - (iv ) disease and mortality control
  - (v ) improved transport systems

Problem II.

NUTRITION, FOOD AND FEEDS

46. 1. Objective:

- (a) To develop economical and nutritionally efficient feeds based on locally available materials.
- (b) To optimize food production.

2. Recommended approaches:

a) Basic investigations

- 1. Determine the nutritional requirements of different species in the various life history stages
- 2. Survey availability of adequate inexpensive feed ingredients, including substitutes for conventional animal proteins used in fish feeds
- 3. Conduct analyses of potential feed ingredients
- 4. Factors affecting the production of natural food organisms

b) Experimentation:

- 1. Formulation of feeds according to nutritional requirement of species and their life stages
- 2. Processing of feeds adapted to feeding systems
- 3. Development of suitable feed dispensing methods
- 4. Testing feed according to performance criteria
- 5. Development of fertilization and pasture management techniques

Problem III.

GENETIC SELECTION AND HYBRIDISATION

47. 1. Objective: To develop domesticated strains for culture characteristics and consumer preferences.

2. Recommended approaches:

a) Basic investigations

- (i ) Determination of genetic variabilities within species
- (ii ) Identification of characters for selection experiments
- (iii) Study of the genetic nature of desirable characteristics  
(growth, disease-resistance, dressed weight, etc.)

b) Experimentation

- (i ) Intra specific and inter-specific crossing experiments
- (ii ) Progeny testing
- (iii) Field trials of selected strains

Problem IV.      INTENSIFICATION OF CULTURE SYSTEMS, INCLUDING POLYCULTURE

48. 1. Objective: To obtain optimum economic yields from aquaculture systems.

2. Recommended approaches:

a) Basic studies

- (i ) Determination of physico-chemical parameter constraints
- (ii ) Effects of accumulating metabolites
- (iii ) Stress effects - physiology and behaviour
- (iv ) Utilization of ecological niches
- (v ) Assessment of species suited for unutilized niches

b) Experimentation

- (i ) Testing of sizes, densities and species/strains combinations
- (ii ) Study of culture systems under experimentally controlled conditions
- (iii ) Development of stocking/cropping procedures
- (iv ) Development of high density culture systems providing for metabolite elimination, water quality maintenance, etc.

Problem V.

AQUACULTURE ENGINEERING

49. 1. Objectives:

- (a) To improve or design aquaculture installations for efficient operation.
- (b) To devise and test aquafarm equipment and installations, especially labour-saving devices.
- (c) To develop appropriate techniques for construction and operation of aquafarms under different soil, water and topographic conditions.

2. Recommended approaches:

a) Basic studies

- (i ) Study of physico-chemical, soil and site characteristics
- (ii) Assessment of constraints in present systems of construction and operations

b) Experimentation

- (i ) Designing and testing of new systems, including cages and raceways
- (ii ) Fabricating and testing new types of equipment under field conditions
- (iii) Adapting systems and equipment to local conditions



Problem VI.

AQUAFARM MANAGEMENT

50. 1. Objective: Development of efficient and economic methods of operating aquaculture installations.

2. Recommended approaches:

a) Basic studies

- (i ) Identification of diseases, parasites, predators, pests and weeds
- (ii ) Identification of physico-chemical and other causes adversely affecting aquaculture operations
- (iii) Assessment of proper balance of fixed and variable cost factors especially energy demands, to optimize economic returns
- (iv ) Determination of minimum economic size of culture units

b) Experimentation

- (i ) Improve or develop control practices for pests and predators, diseases and parasites and weed infestation
- (ii ) Develop methods of sanitation in culture installations
- (iii) Test new management procedures

Problem VII.

SELECTION OF NEW SPECIES FOR CULTURE

51. 1. Objective: To screen new species in order to meet identified aquaculture or consumer needs.
2. Recommended approaches:
- a) Basic investigations
    - (i) Select species for studies based on available pertinent information
    - (ii) Study the relevant biological features (e.g. food habits, fecundity, spawning, growth)
  - b) Experimentation
    - 1. Test - rear juveniles gathered from nature
    - 2. Breeding
    - 3. Rearing of larvae to juvenile stages
    - 4. Test suitability for selected aquaculture systems