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India: Farmers net out Indian Catla carp from their village pond

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The FAO Aquaculture Newsletter (FAN) is issued three times a year by the Inland Water Resources and Aquaculture Service, Fishery Resources Division, of FAO's Fisheries Department, Rome, Italy. It presents articles and views from the FAO aquaculture programme and discusses various aspects of aquaculture as seen from the perspective of both Headquarters and the field programme. Articles are contributed by FAO staff from within and outside the Fisheries Department, from FAO regional offices and field projects, by FAO consultants and, occasionally, by invitation from other sources. The FAN is distributed free of charge to various institutions, scientists, planners and managers in Member Countries and has a current circulation of about 3,000 copies. It is also available on the FAO internet Home Page: http://www.fao.org./waicent/fishery/newslet/newslet.htm

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Editorial

Fishery Enhancement and the Code of Conduct for Responsible Fisheries

An article in this issue presents the conclusions of the FAO/DFID Consultation on Inland Fishery Enhancements. The topic of enhancements has been treated on previous occasions in FAN (issue 12, April 1996; issue 14, December 1996) and the outcome of the forthcoming International Symposium on Stock Enhancement and Sea Ranching (Bergen, Norway, 8 - 11 September 1997) will, in due course, be reported in these pages. This concentration on techniques on the borderline of aquaculture which are aimed at improving yields per unit area and for increasing control over the production process in lakes, reservoirs, rivers and even marine coastal areas, is symptomatic of the changing view of management in many parts of the world. Clearly, the increasing demand for fish for food and for social and recreational amenity that is being placed on the fishery and on waters, which are themselves subject to a number of other uses, is leading to an intensification of management through stocking, fertilization and other practices. Such approaches have been used for many years to bias natural productivity and species composition towards goals set by society, but only rarely has there been any scientific study of the processes involved. Such is the present scale of fish production from aquaculture installations and abstraction of young from natural stocks for the purpose of stocking into other bodies of water, that it is now necessary to evaluate most carefully the economics and ecology of the various practices. One motive for this is clearly financial in that the cost of seed is a major input in the cost-benefit relationship and, as governments are now less enthusiastic about subsidising production of this type, the private sector is increasingly called upon to pay the full cost of management. A further reason is that many countries have adhered to the Code of Conduct for Responsible Fisheries or are subject to conservationist pressures for the management of their natural resources. The provisions of the Code frequently require careful interpretation in the case of intensified fisheries. It is central to the philosophy of enhancements that the various methods are deliberately aimed at changing the productivity of the water, the nature of the fish stock, and even the form and function of the environment. As such they conflict with the conservation oriented requirements of the Code in that they involve a shift of the management of natural resources from some criterion of sustainable yield towards input-output based systems. These, in common with aquaculture, are aimed at increasing the overall supply of fish available for human consumption. As most enhanced fisheries require high levels of inputs of fish seed, feed, fertilizers etc., they can only be regarded as sustainable in the sense that any agricultural or aquacultural activity is sustainable. That is, that the practice may continue from year-to-year at the same levels of input and offtake without noticeable degradation to the natural support system. This means that the financial and social need for the enhancement should be clearly established and that any impacts on the natural system should be monitored as closely as possible. It also implies that different levels of control should be applied depending on the intensity of the activity. For instance systems which are simply stocked in support of capture fisheries should have little effect on surrounding waters and would require little special provision. Those requiring large inputs of fry and fertilizers, on the other extreme, should be carried out in waterbodies isolated as far as possible from other parts of the system so that nutrient rich effluents or escapes of stocked fish are kept to a minimum. Thus to better comply with the spirit of the Code of Conduct, and the need to establish viable and sustainable rural enterprises, enhancement of fisheries in inland and coastal water should not be allowed to proliferate anarchically but should be subject to assessments of social, economic and environmental impacts.

Robin L. Welcomme, Chief
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Introducing AAPQIS: the FAO's Aquatic Animal Pathogen and Quarantine Information System

by
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BACKGROUND

In an era where the growth of aquaculture is above 10% per year and the losses due to diseases amount to billions of dollars world-wide, measures to combat diseases of fish and shellfish are assuming high priority in most regions of the world. In Asia-Pacific, for example, a series of major disease epizootics have swept through much of the region during the past decade (e.g., Epizootic Ulcerative Syndrome in freshwater fish, and several viral diseases of penaeid shrimps). Taura Syndrome devastated penaeid shrimp farming in Latin America, whilst a number of bacterial pathogens have resulted in considerable damage to the salmon industry globally. These disease outbreaks have resulted in huge economic losses to aquaculture and the total collapse of some industries, and have affected both production and marketing of artisanal fisheries. These problems have led to a heightened interest in methods to prevent the introduction and spread of exotic aquatic pathogens through the development and implementation of programmes of quarantine and certification. Such a programme is already in place in Australia, and a number of other countries in Asia-Pacific and Latin America have either initiated programme or are seriously considering doing so (e.g., Indonesia, Malaysia, Thailand, India, China, Philippines, Ecuador, Chile, Colombia, Mexico). Additionally, recent developments in international trade have made the disease status of exporting and importing countries much more important from an economic standpoint. The absence of a given disease in an importing country may form the basis for blocking shipments of live aquatic animals and their products from countries where the disease is documented to occur. However, in order to support such a barrier, the importing country must be able to demonstrate in a convincing fashion, through past history and current monitoring programmes, that the country is indeed free of the pathogen in question.

Fish health training programme at an Asian university

To address these problems effectively, quarantine workers and government policy makers must have access to accurate, comprehensive and up-to-date information on the known and potential pathogens occurring in their own countries (identities, hosts, distributions, pathogenicities, life cycles, zoonotic importance, etc.), as well as comparable information on the disease situation in the species of aquatic animal which is to be imported. This information is essential so that scientifically based risk assessments of the dangers posed to existing aquaculture and to wild fish and shellfish can be made. Such decisions must be timely, and they must be reached using standardised, rational and defensible decision-making procedures.

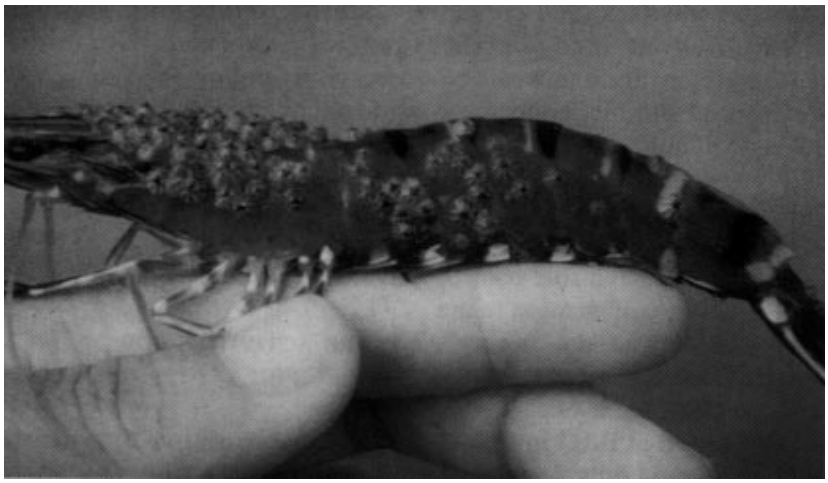
The need for such information has long been recognised in the Asia-Pacific region, and is reiterated in the reports of numerous workshops held by various donors and regional agencies such as FAO, International Development Research Centre of Canada (IDRC), Asian Fish Health Section of the Asian Fisheries Society (FHS/AFS), Network of Aquaculture Centres in Asia-Pacific (NACA), Australian Centre for International Agriculture Research (ACIAR), Asian Development Bank (ADB), Aquatic Animal Health Research Institute of Thailand (AAHRI), and the Department of International Development of the United Kingdom (DFID), dating back to at least 1978.

Over the past two years, FAO has been highly active in this area, through its efforts to implement the Code of Conduct for Responsible Fisheries, and is currently collaborating with NACA in the development of a comprehensive regional strategy on practical guidelines for the quarantine and certification of aquatic animals in the Asia-Pacific. These efforts have been developed though two recent regional workshops, an FAO "Expert Consultation on Diseases in Asian Aquaculture," which was held in Serdang, Malaysia in May 1995, and a "Workshop on Health and Quarantine Guidelines for Responsible Movement (Introduction and Transfer) of Aquatic Organisms", jointly organized by FAO, NACA and AAHRI, and held in Bangkok in January, 1996. During these workshops, one of the goals identified to be part of the FAO/NACA/ACIAR strategy (developed in collaboration with a number of other agencies such as AAHRI, DFID, FHS/AFS, and Office International des Epizooties (OIE)) is the development of a comprehensive information database on aquatic animal health, with the FAO charged to take the initiative in developing and establishing a prototype computerized information system. AAPQIS (Aquatic Animal Pathogen and Quarantine Information System) is the result of accomplishing this goal.

Epizootic ulcerative syndrome 'EUS' in freshwater fish

APPROACH

As a starting point, a prototype has been developed for the Asian region, where a comprehensive information database is most readily assembled, due to the information gathering activities of the FHS/AFS. For some key pathogens, global information has also been entered. Once the Asian component of AAPQIS (AAPQIS-Asia) is established (a joint FAO/NACA project), the system will be expanded, with minor modifications, to include similar networks in other regions of the world, such as Latin America, Africa, and the Mediterranean, through new partnerships and collaborations, and will be designed for eventual expansion to become a world-wide information network on diseases of aquatic animals. The AAPQIS will also be linked with other aquaculture databases of FAO which are being pursued through networking at the regional level, such as the GFCM Mediterranean aquaculture networks and supporting information system (SIPAM). It is also envisaged that AAPQIS regional databases will eventually be harmonised with those of the OIE. Certain features of AAPQIS will also be included in the upcoming FAO Atlas of Agriculture, Forestry and Fisheries which will also be available via the Internet.



External fouling on black tiger shrimp

Aquatic Animal Pathogen and Quarantine Information System (AAPQIS)

The AAPQIS will provide a mechanism for the comprehensive tracking and reporting of diseases and parasites on a regional basis. It can also be adapted for use by national governments for establishing national systems for disease reporting and tracking.

The information system will be delivered via an Internet/world-wide web (WWW) server(s); an initial server to be operated by NACA, a regional lead centre in Asia. Similar systems are currently being developed at FAO (the Pacific Plant Pathogen Information System (PPPIS: http://pppis.fao.org) and the South Pacific Commission Animal Health and Quarantine Information System (SPC/AHQIS)). The software framework developed to support these highly similar systems has been adapted to the specific information needs of fish health quarantine officers, diagnosticians, researchers and government policy makers to develop AAPQIS.

The "information highway" is expanding rapidly, and most lead centres in Asia and elsewhere in the world will soon have Internet connections. Use of the Internet offers many advantages, among them the ability for network users to share data and efforts. By contributing a relatively small amount of funds or effort to development of the AAPQIS, government departments and individuals will have access to the totality of information assembled by all network members. Use of the Internet also provides a mechanism through which the AAPQIS will have a life of its own. No single organization or person will have ownership; and the system will not be dependent on long term support from a single donor to keep it functioning. As long as the network members see the system as useful, it will continue to function. In the short term, those users who do not have Internet access can be provided with AAPQIS in CD ROM format. In this manner, local area networks can be established.

Among the capabilities anticipated to be included in AAPQIS are:

Pathogens/parasites: the system will permit users to easily find information on pathogens and parasites reported from any region or country. A variety of types of information can be included: taxonomic and systematic information, hosts, geographical distributions, pathogenicities, OIE disease status, economic and zoonotic importance, biology, difficulty of identification, list of taxonomic experts capable of confirming identification, possible treatments, line drawings, photomicrographs, etc. The system will permit the construction of dynamic distribution maps, allowing users to see the currently known distribution of any pathogen, initially on a regional scale, and eventually at the national and global scales.

Hosts: Users will be able to obtain current information on the pathogens and parasites reported from any fish, crustacean, mollusc or other commercially important invertebrate, at the national and regional levels, and eventually, on a global basis. It is envisioned that the system will draw on the species database of FishBase (ICLARM/EC/FAO), permitting users to readily obtain current information on host taxonomy, common names, distributions, introductions, etc.

Country check: Users will be able to obtain a list of pathogens and parasites known for an imported host from a particular country. They will also be able to automatically compare this list with the list of pathogens/parasites known from the same host from their own country, allowing them to quickly determine if there are pathogens likely to be of concern in a given lot or shipment of animals.

Country lists: It will be possible to generate a current listing of all parasites/pathogens listed by host for any country.

References: A literature database, including all references used to construct the pathogen/parasite database will be maintained. For the Asia-Pacific Region, this database will include the fish health literature which is being compiled by the Fish Health Section of the Asian Fisheries Society.

Other components: These will be added based on the needs of the user community. They could include information on the status of **Quarantine Legislation** in each country, lists of **Institutions** and **Researchers** working on fish health, accessible by country or region, with direct Internet connection to them; **Fora** for discussion of specific problems, **Newsletters** (e.g., newsletters of the Asian Fisheries Society, Fish Health Section; the American Fisheries Society, Fish Health Section; Aquatic Animal Health Research Institute; International Ichthyoparasitology Newsletter; etc.); etc.

The structure of the database is being developed by FAO through collaboration with country focal points who are fish health researchers and/or the responsible quarantine officers from the various countries. Once the structure has been finalized, country focal points and other interested parties, both within and outside a region, will be able to contribute to developing and maintaining the database. A series of checks, using experts who will "adopt" a given species or taxonomic grouping, along with referees (recognised world experts), will assure the accuracy of information entered into the database. Interested users, both within and outside a region, will be able to comment on, criticize, contribute to and correct information contained in the database by referring comments and information to the moderators for their consideration.

Initial database security will be achieved by having a single "data master" who will have sole control over the final entry of changes to the master data base. The "data master", who will be an internationally recognized fish health expert, will initially be based at FAO in Rome. Once the system is fully functional, it will be possible to transfer the "data master" responsibility, and perhaps the server itself, to the regional lead centres, such as NACA for Asia-Pacific.

Expected network members and users:

- National fisheries and veterinary departments charged with implementing programmes for quarantine and certification for aquatic animals.

- National policy makers charged with assessing individual country's needs with regards to quarantine and certification programmes for aquatic animals.

- International and regional agencies involved with either research or policy formulation on aquaculture and fish health.

- Fish health workers, diagnosticians and scientists, both within governments and universities, and in private sector aquaculture.

Future activities for Asia-Pacific:

Initial demonstration to potential contributors/users within the Asia-Pacific Region is being planned for January 1998 through a training workshop, to be held in Bangkok under a FAO regional technical co-operation project to be implemented by NACA. Following the workshop, existing software will be modified to accommodate specific country requirements and initial country-specific data entry will then take place. In order to facilitate accurate and smooth data gathering and the data entry process, key national institutions in Asia-Pacific with capability to act as national servers need to be equipped. It is expected that funds for purchasing computers, costs of Internet connection, CD preparation and distribution, and maintenance will be obtained from various sources.

Snakehead fish with typical 'EUS' infection

EXTERNAL ASSISTANCE TO THE AQUACULTURE SECTOR I N DEVELOPING COUNTRIES

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[2] Policy and Planning Division

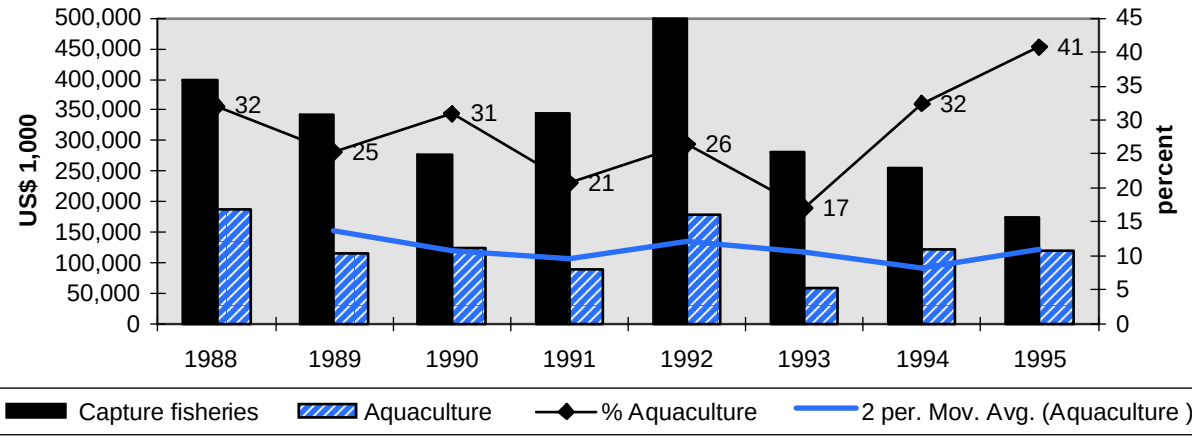
Information on grants and loans for aquaculture research and development is maintained within the Fisheries Project Information System (FIPIS) by FAO from data supplied by donor agencies. In FIPIS, funds committed to projects are allocated entirely to the year in which the projects became operational. Therefore, data presented here for each year refer to the number of projects commenced that year and the total funds committed to these projects. The following is an analysis of current information in the system. Some data returns from donors are incomplete for 1995, so the analysis should be considered provisional.

Total official aid to aquaculture research and development in 1988-95 was about US $ 995 million, expressed in current value terms, and represented about 28 % of the total committed to the aquaculture and fisheries sectors (US $ 3.6 billion). The average annual input was about US $ 124 million per year, from an average annual input of US $ 446 million for both sectors. With the exception of two years (1991 & 1993) annual inputs during the period (funding for new aquaculture projects) were fairly steady with a range of US $ 120 - 188 million.This is also true of the sector's share of total funding, which has ranged from 25 - 40 %; the maximum value being the result of a sharp drop in funding for capture fisheries in 1995 (Figure 1).

About 578 projects were initiated during the period, accounting for 26 % of the total number of projects in fisheries and aquaculture. An additional 54 projects with aquaculture components were also initiated during the period. The number of fisheries and aquaculture projects commenced annually declined gradually over the eight-year period from 379 in 1988 to 132 in 1995, and from 265 to 111 in the case of aquaculture projects.

Development banks were consistently the main source of external funding for aquaculture during 1988 - 95 (Figure 2). They accounted for 69 % of the funding and 40 % of the projects, while bilateral sources contributed 17 % of funding an accounted for 6 % of projects. Multilateral sources contributed 34 % of projects and 7 % of funding. Projects executed by FAO, which were supported by the FAO Technical Co-operation Programme, Trust Funds and the United Nations Development Programme, amounted to 5 % of funding and supported 18 % of projects initiated in the period. A further 2 % of projects came from other UN agencies (2 % of funding). In 1994, the last year for which complete data is available, the banks and

Figure 1. Funding for aquaculture and fisheries R&D, 1988-95



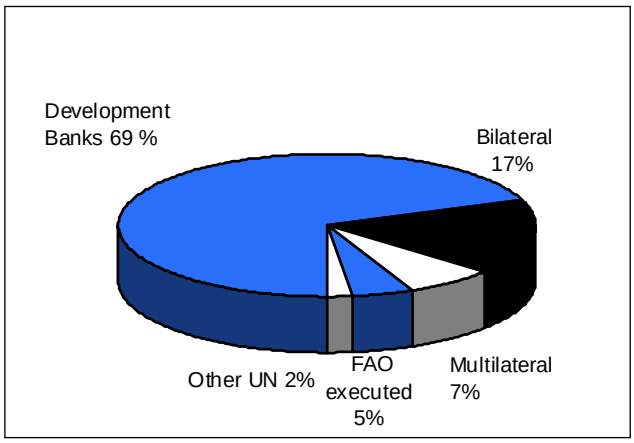


Figure 2. Aid to aquaculture by donor, 1988-95

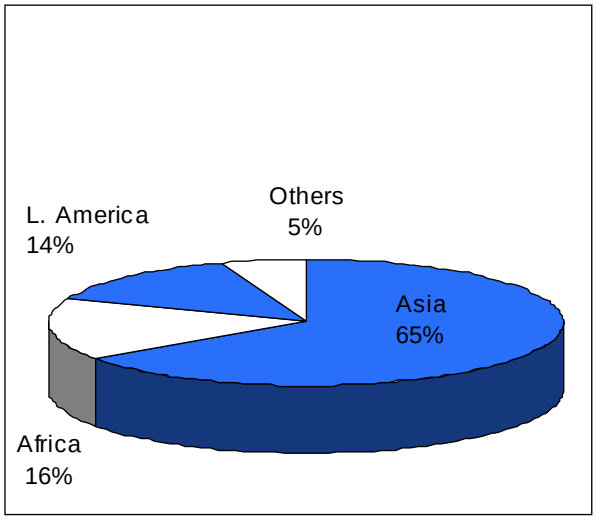


Figure 3. External aid to aquaculture by region 1988-95

bilateral agencies accounted for 91 % of funding (74 and 17% respectively). Data so far available for 1995 show increasing dominance of funding by the development banks (92 %) with the meagre balance contributed by bilateral (3 %) and multilateral (5 %) sources.

The Asian and African regions consistently received the greatest measure of support with regard to the number of projects commenced and the funds allocated (Figure 3). Of the total number of projects reported to FIPIS for the period 1988 - 1989, the Asian region accounted for 65 % of commitments and 38 % of the projects, while African countries were the recipients of 16 % of commitments and about a quarter of the projects. Of the remaining regions, only Latin America commanded a substantial part of aid, with about 14 % of funds and 17 % of projects.

Interestingly, average annual aid to Oceania (US$ 1.5 million) was higher than that to the Near East & Mediterranean (US$ 1.3 million), the Caribbean & Atlantic (US$ 0.6 million), and Europe (US$ 0.2 million). Assistance through global and inter-regional projects accounted for 2.3 % of aggregate funding for the period, and 10 % of projects.

The major beneficiaries of aquaculture aid during 1988 - 95 (i.e. countries receiving at least 1% of total aid) are shown in Figure 4. India, China, Bangladesh and Mexico, which have received major loans from development banks during the period, accounted for about 64 % (about US$ 638 million) of external aid to aquaculture.

The two notable trends in external assistance to aquaculture, as seen from FIPIS data, are the continuing dominance of development banks and the decrease in commitments of aid to aquaculture in Asia (Figure 5).

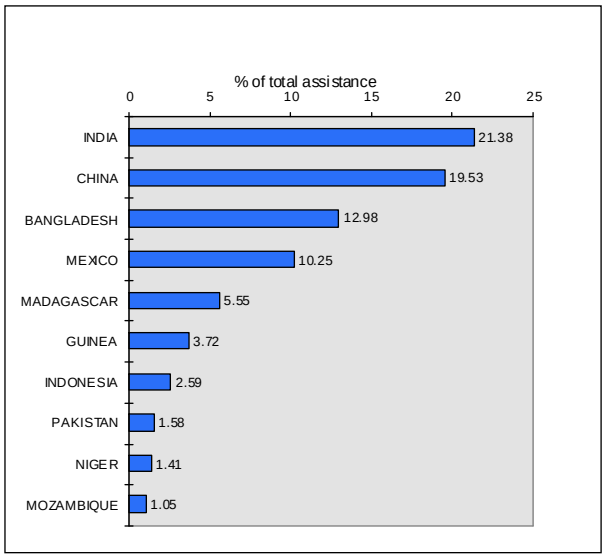


Figure 4. Main beneficiaries of external aid to aquaculture, 1988-95

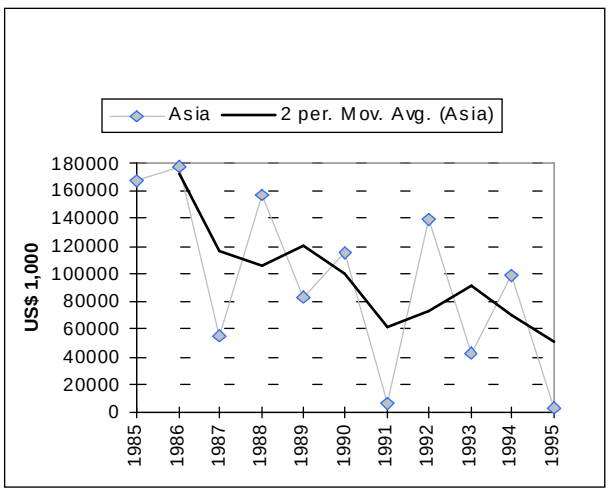


Figure 5. External assistance to aquaculture in Asia, 1988-95

The FAO/DFID Expert Consultation on Inland Fishery Enhancements:

Conclusions, follow up and related work underway

James McDaid Kapetsky[1] and B. Born[2]

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BACKGROUND

The potential for enhancement of fish production from inland waters has been considered a priority area of activity by the Inland Water Resources and Aquaculture Service of FAO for some time. A number of steps have been taken to build a solid foundation from which to provide advice to Members and to the FAO Field Programme. For example, R. Welcomme catalogued introductions and an updated and expanded version soon will be placed on the FAO Fisheries Home Page, appropriate management strategies have been evaluated by FAO Andre Mayer Fellow Dr. V. Sugunan and FAO consultant D. Edwards has analyzed ways being used to increase benefits from inland fisheries in nine Asian countries. Recently, R. Welcomme and D. Bartley evaluated present techniques for the enhancement of fisheries.

At the same time, experience on the implementation of enhancements has been built up to varying degrees in different parts of the world through field projects of which the FAO Belgian Trust Fund Project on the management and utilization of small water bodies is noteworthy for the inventory and characterization of opportunities and for the integration of information for enhancements with other kinds of development activities. Enhancement projects in Bangladesh (e.g., DFID, IFAD/DANIDA) continue to provide very useful information on performance while exploring the limits of technical, administrative, economic, and social arrangements for implementation.The outcome of the Japan/FAO International Conference on the Sustainable Contribution of Fisheries to Food Security, Kyoto, Japan, December 1995[3], has given further impetus to enhancements. The Kyoto Declaration recognized four specific avenues for the enhancement of fisheries, i.e. stocking and restocking, assisting fishers to organize themselves, promoting community management schemes, and establishing user rights in open access. The Kyoto Action Plan also calls for the rapid transfer of know how in enhancement.

Recognizing the increasing significance of the enhancement of fisheries for its member countries, and in order to promote better understanding of how the various technical, socio-economic and cultural factors involved in implementing inland fisheries enhancement programmes must fit together to achieve success, the Inland Water Resources and Aquaculture Service of FAO, in close collaboration with the Department for International Development (DFID) of the United Kingdom, organized an Expert Consultation on Inland Fisheries Enhancements (ECIFE) that was hosted by the Government of Bangladesh.

The Expert Consultation, held in Dhaka, Bangladesh, 7-11 April 1997, was attended by 42 participants from 13 countries and representatives at the technical level of international organizations and projects including DFID, GTZ, GOPA (Gesellschaft für Organisation, Planung und Ausbildung), FAO, ICLARM, IFAD/DANIDA and the World Bank.

The FAO contributed by providing the technical secretariat for the planning and organization of the meeting and sponsoring experts. The agenda of the meeting was jointly planned with the DFID. The DFID sponsored the attendance of some participants, provided the local organization and covered the local costs for participants not associated with international organizations. Both organizations closely collaborated in the preparation of the report.

CONCLUSIONS OF THE ECIFE AND REPORT

The conclusions of the ECIFE have been condensed to outline form and are set out in the adjoining text box.

Report and Supplement. The official report of the ECIFE is in press and will be available on request. Editing of the presented papers by FAO retiree Dr. Tomi Petr is nearly complete. The papers will be produced as a separate bound supplement to the report by the DFID and the distribution, towards the end of October, will be by FAO.

FOLLOW UP TO THE ECIFE AND RELATED WORK UNDERWAY

Inventory and Characterization of Enhancements. The ECIFE addressed an important need for the further implementation of inland fishery enhancements: it placed them in a world perspective qualitatively, within technological, social, economic and administrative contexts, and it raised many issues that need to be addressed. The provision of both quantitative and geographic frameworks of experience on inland fishery enhancements would be a logical follow-up. Therefore, in anticipation of the outcome of the ECIFE and with the recent arrival of Bram Born, FAO Associate Professional Officer, an inventory and characterization of inland fishery enhancements commenced. The objective is to describe enhancements by type, by kind of water body in which they are implemented, by target species and by location and country. This is an essential step in an eventual global evaluation of benefits, impacts and prospects for inland fishery enhancements.

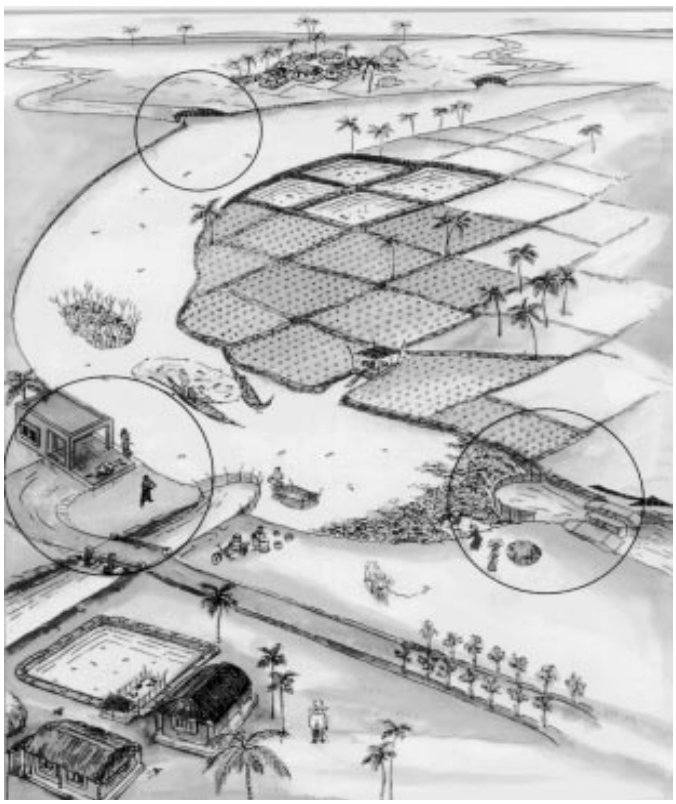
Inventory and Characterization of Inland Water Bodies. In general three kinds of models are required for evaluation and planning of inland fisheries. One is needed to predict fisheries potential under natural conditions. Another is needed to predict fishery potential under various kinds of enhancements to compare the benefits with those from unenhanced fisheries. The third is required to predict losses of potential yield due to general environmental degra-dation so that mitigation or rehabilitation is properly scaled and financed.

These models are needed for all kinds of water bodies, and they need to be applied to individual waters, or groups, within drainage basins and within and among national jurisdictions.

In order to put this modeling capability to work, there are two essentials:

- Inland water bodies have to be inventoried and characterized with respect to factors that affect fishery potential
- Existing models have to be improved to more synoptically and more accurately predict inland fishery potential.

Work is underway in the Inland Water Resources and Aquaculture Service in cooperation with the FAO GIS Centre to adapt the Global Land Cover Characteristics Data Base for the inventory. The Marine Resources Advisory Group at Imperial College, London is undertaking an expansion of its earlier water body characterization on contract to FAO. The modeling improvement effort will follow.



Cover page of an extension booket on maintenance of ox-bow lakes for fisheries produced by the Bangladesh Rural Advancement Committee and DANIDA Technical Assistance

Environmental Impacts of Enhancements. A related current activity, one that is being addressed with some urgency as called for by the ECIFE, is the environmental assessment of impacts of inland fishery enhancements. In short, there is a need for a better understanding of the environmental impacts of inland fishery enhancements, the status of environmental assessments of inland fishery enhancements and the mitigating or rehabilitative activities that have been carried out subsequent to their implementation. A synthesis of the global literature is being carried out as a first step. Further steps could include a practical set of guidelines to assess the impacts of enhancements and to gauge the need for environmental assessments.

Looking longer term at enhancements and the special kinds of impacts associated with them, Dr. Paul Siri and a number of collaborating scientists from various academic institutions are proposing a colloquium to examine issues related to inland and coastal fishery enhancements. Topics under-pinning sustainability and conservation of genetic resources together with environmental risk assessment modeling will be organized thematically to address concerns regarding the implementation of enhancement projects. The proposal for this meeting is a direct outcome of the ECIFE, the conclusions resulting from it, and the follow-up analysis at FAO conducted through the Partnership Programmes.

This meeting would bring together scientists with the ecological perspective of the effects of introductions and stocking on the environment and scientists familiar with the current status of enhancement potential and its role in attempts to address sustainable food security. The meeting would be finalized in two important ways that would further the goals of the Expert Consultation. First, a series of papers would be submitted for publication in a peer reviewed scientific journal. Second, the meeting would end with a facilitated dialogue culminating in points of certainty and uncertainty so that a group consensus statement can be attained. Both of these products would create a benchmark for strategic planning and scientific validation. These measures would be consistent with the Convention on Biological Diversity, the Code of Conduct for Responsible Fisheries, and the recommendations coming forth from enhancement sponsors and donor organizations.

FAO participation is under discussion and will be formalized in due course.

Technical Guidelines for Responsible Fisheries. Finally, the conclusions of the ECIFE are important and timely input for the inland fisheries portion of the Technical Guidelines for Responsible Fisheries that is now being drafted by Robin Welcomme as a companion to the Technical Guidelines for Responsible Aquaculture that have been recently published by FAO.

[3] *The Kyoto Declaration and Plan of Action. International Conference on Sustainable Contribution of Fisheries to Food Security, Kyoto, Japan, 4-9 December 1995. Organised by the Government of Japan in collaboration with the Food and Agriculture Organization of the United Nations. Published by Fisheries Agency, The Government of Japan. 22p.*

KEY ECIFE CONCLUSIONS (condensed from the draft report of the ECIFE by Paul Siri)

1. Enhancement of fisheries resources is likely to be accompanied by change.

2. Significant production increases via enhancements are possible with associated benefits but resource limitations and institutional constraints are likely to moderate the pace of enhancements.

3. Proper resource management of the fishery and the ecosystem, often through the use of traditional systems, is necessary for maintaining resource equilibrium which is necessary for long-term sustainability.

   Governments need to recognise both traditional and non-traditional management approaches prior to the formulation of new fishery laws and regulations.

4. Institutional constraints may be equal to or greater than technical limitations.

APPROACHES TO ENHANCEMENTS

1. Since enhancements can substantially alter the environmental, institutional and economic attributes of the system, approaches to enhancements should be led by principles of participation by all stakeholders integrating technical, institutional, social and economic analysis.

2. Intervention should be carried out following a process framework including examining options and alternatives to

enhancements. Expected benefits and costs along with uncertainties surrounding these should be evaluated using interdisciplinary methods of analysis.

3. Outcomes of intervention should be monitored with feedback for an adaptive management approach to improve policies and procedures.

Stocking

1. Presently, few countries are in a position to conduct significant stock enhancement without subsidies due to limitations in the availability of cost-effective mass production of young fish.

2. Under many conditions yield can be positively correlated with density and area of water body to be stocked. Additionally, data show that rates of return can be economically viable.

3. Generalised productivity models must be used conservatively due to the variability in aquatic systems. To be effective such models need to be site-specific and the data must be empirically derived.

Modelling

1. Strategic planning requires three types of predictive models:

- Fisheries potential under natural conditions.
- Potential enhancement benefits compared to no enhancement.
- Losses of potential yield due to habitat degradation.

2. Stock enhancement modelling has four primary applications:

- Understanding processes regulating potential yield from water bodies;
- Determining relationships between fish yield and indicators of stocking input;
- Providing information for optimizing stocking programme success;
- Minimizing potential adverse impacts.

3. Modeling is a tool in formulating technical components of enhancements but must be used in conjunction with the evaluation of cultural and social issues when assessing implementation risks and benefits.

4. Risk assessment models may contribute to the planning process and reduce the chances of programme failure.

5. Cage culture represents an aspect of an enhancement trend towards increasing intensification and needs to be examined as an option oriented towards high value market products which may pose a competitive disadvantage in food economies geared towards poorer segments of human populations. Cage culture is an appropriate enhancement option for a number of water bodies and has additional potential in seed production.

Information and Monitoring

1. Globally, inadequate information is a constraint. Nationally aggregated poor quality data coupled with poor coverage and a lack of information at local levels (to support enhancements) are parts of the problem.

2. Another problem is a lack of comparability and compatibility among data sets and clear definitions of fisheries activities creating difficulty in separating aquaculture data from inland capture fisheries.

3. Social and economic data, in addition to fisheries data, are necessary to support enhancements.

4. Resource limitations underpin many of the reporting problems in developing areas. Governments and NGOs should strive to simplify the data collection and reporting process.

5. Longer term monitoring is critical so that the results of an intervention can be properly analyzed thereby contributing to the process framework on which to base future decisions.

6. Geographical Information Systems (GIS) are a powerful decision support tool that can contribute significantly to the process framework.

ENVIRONMENT

1. Enhancement measures may lead to changes in ecosystem structure and processes and impacts may not be limited to a given water body but may extend throughout the watershed and into transboundary waters.

2. Enhancement activities may also change the disease status of aquatic organisms in ecosystems. Fish health/aquatic system impacts need careful attention particularly in respect to the introduction of exotic species/strains and should be implemented according to internationally recognized codes of practice.

A contingency/mitigation plan for ecologically significant disease events should be considered before enhancements are initiated.

3. There is an important distinction between perceived and actual problems when examining environmental conditions. Enhancement project impacts are often difficult to assess due to an incomplete understanding of aquatic systems.

4. Careful documentation of impacts and mitigating measures is urgently needed. There is a clear need to provide environmental assessments on all fishery enhancement activities, including aquaculture, which identify potential impacts and mechanisms for mitigation.

Genetic resource issues

1. The genetic and species diversity in wild populations should be conserved, protected, and utilized in inland fishery enhancement and development.

2. Where appropriate, genetic techniques should be used for monitoring dispersal of released fish and to probe for introgression with wild populations.

3. Recommendations and guidelines on genetic resource management and utilization should be implemented but it is recognized that in many cases it will be difficult due to inadequate resources or incomplete information.

4. It may be desirable to establish nucleus breeding centers actively managed and supported by government or industry.

5. Efforts should be made to disseminate information and educate managers and stakeholders as to the principles and benefits of genetic resource management.

SOCIAL, ECONOMIC, AND INSTITUTIONAL ASPECTS

1. Social, economic, and institutional aspects of societies may contribute as much to the success of enhancements as physical and biological factors.

2. Enhancements can increase the economic surplus resulting from an efficiently operated intervention; however the principal objective of an enhancement should be the maximization of societal benefits.

3. The assignment of property rights and limitations of access are preconditions for sustainable enhancement of aquatic resources.

4. NGOs can play an important part in enhancements in promoting and safeguarding equitable distribution of the resulting benefits and they can have an important catalytic role in the transition from government ownership to community-based or private management.

5. The move towards community-based or private management of fisheries usually requires extended time scales since participatory approaches are implicit and take longer to implement.

PRECAUTIONARY APPROACH

1. Enhancements require a balance between fish production and the conservation of the environment and this will usually occur in situations where knowledge is inadequate, uncertainty exists and with limited resources. Enhancements should be preceded by planning and risk assessment.

2. Risk assessment should be involve ecological, genetic, and socio- economic factors.

3. Elements of the precautionary approach that may be applied to potential enhancement projects include:

i) identification of the potential adverse impacts;

ii) establishment of targets for the enhancement project (i.e. goals) and limits to adverse impacts caused by the enhancement; and

iii) establishment of contingency plans once limits are approached so that an agreed upon plan of action can be established in the event adverse impacts become unacceptable, although it should be recognized that many impacts may be irreversible.

4. Efforts to balance fisheries enhancement with the interests of other users of the water body and conservation goals require an integrated aquatic resource strategy to minimize conflict and risk.

Recent Trends in Global Aquaculture Production :1984 - 1995

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INTRODUCTION

The growth of the aquaculture sector and its potential development, as well as changes in the fisheries sector as a whole, is closely monitored by the Food and Agricultural Organization (FAO), the only international agency to hold a global time series database on aquaculture and capture fisheries.

The potential of aquaculture to meet the challenges of food security and to generate employment and foreign exchange is clearly demonstrated by the rapid expansion of this sector which has grown at an average annual rate of almost 10% since 1984 compared with 3% for livestock meat and 1.6% for capture fisheries production. In the wake of this expansion, however, aquaculture, at times has been equated synonymously as shrimp farming and has recently been given a biased negative press both in peer reviewed articles and the popular press. Consequently, the relative importance and contribution to food security of the over 250 aquatic species farmed globally has been blurred.

What have the major production achievements from aquaculture been in the last few years?

In this commentary, the recent production of the major cultured species and the key features of recent developments in aquaculture production are reviewed to provide an overall perspective, based largely on data provided by countries to FAO.

The Contribution of Aquaculture to Total Aquatic Production

In recent years, the supply of fish has steadily increased and in 1995 total world production of finfish, crustaceans and molluscs from capture fisheries and aquaculture reached 112.9 million tonnes (t). The inclusion of plants to aquatic production raises the total production in 1995 by a further 7.8 million tonnes (t) to 120.7 million t, an increase of around 15.6 million t since 1989 (Figure 1).

Much of the increase in annual global aquatic production, however, is attributable to aquaculture. The actual annual share of aquaculture depends on whether aquatic plants are included or not. For cultured finfish and shellfish the annual contribution to total finfish and shellfish production rose linearly from 11.7% in 1989 to 18.5% in 1995 (Figure 1).

The annual growth rate of cultured finfish and shellfish production over the last 5 years increased from around 5 % over 1990-1991 to

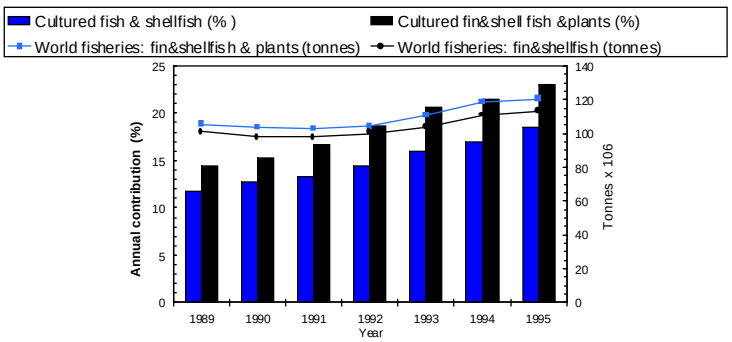


Figure 1. Contribution of aquaculture to annual global aquatic production

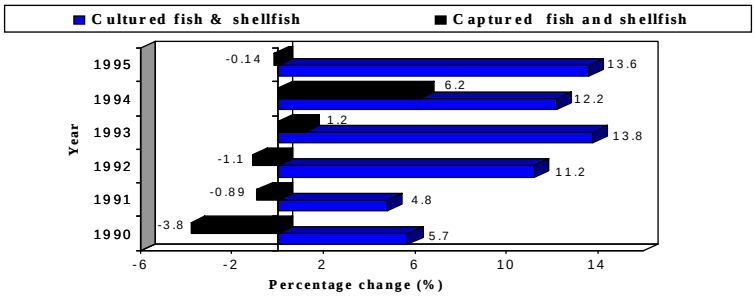


Figure 2. Rate of change over previous year

around 14% in 1994-1995. In contrast, with the exception of the increase in 1993-1994 which is probably attributable to small pelagics, data reported for capture fisheries show near zero or negative growth (Figure 2).

By 1995, the total production of cultured finfish, shellfish and aquatic plants which was valued at US$ 42.3 thousand million (billion) reached a record 27.8 million t, an increase of around 9.6% and 5.2% over 1994 production in quantity and value, respectively (Figure 3).

In keeping with recent trends, the increase over 1994 for finfish and shellfish averaged 13.6% and 7.4% for quantity and value, respectively. Much of the reported increase originated from the Low-Income Food-Deficit Countries (LIFDCs), in particular China, and reflects the continuing national trends of increased use of aquatic resource and management to further diversify production of species and technologies used.

Contribution of Aquaculture to Total National Aquatic Production in Principal Countries

Although the global contribution of aquaculture, by quantity, to total world aquatic production averaged 23% in 1995, the relative importance of aquaculture to national aquatic production varied greatly and ranged from 7-60% for the top 14 producing countries (Figure 4). In keeping with recent trends, the significance of aquaculture in terms of tonnage to national aquatic production in 1995 was greatest in China, accounting for 60% of total national production, nearly twice that of either France, India, Korean Republic or Philippines (Figure 4).

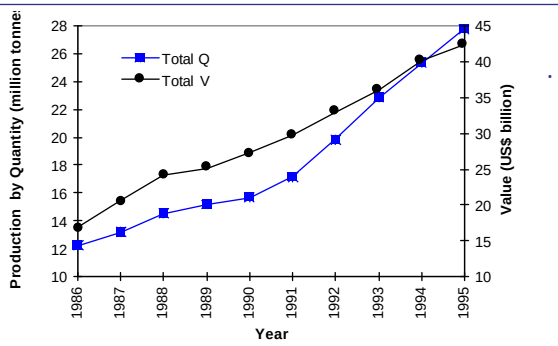


Figure 3. Global trends in aquaculture production

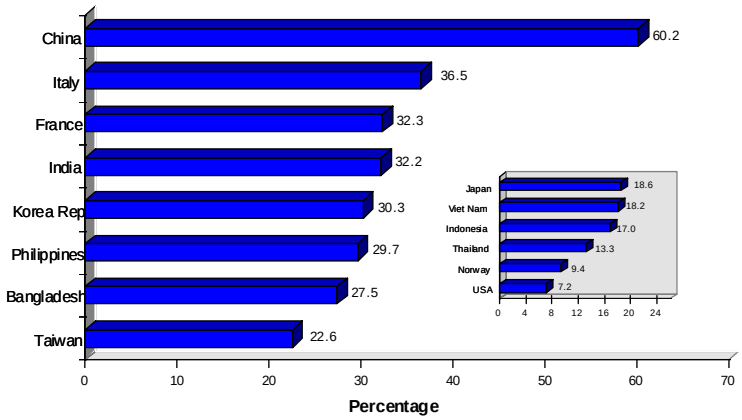


Figure 4. Contribution (%) of aquaculture to national aquatic production

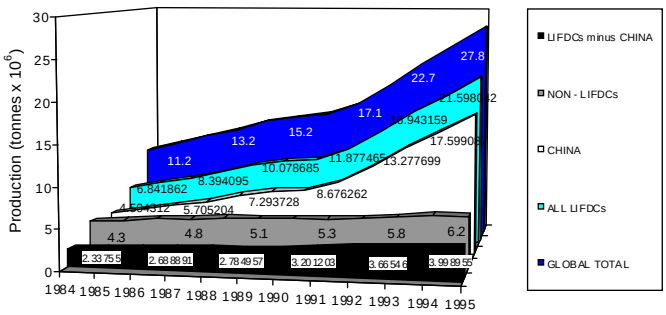


Figure 5. Annual global changes in the total aquaculture production in LIFDC's

A considerably lower contribution to national aquatic production was reported by Thailand (13.2%), Norway (9.4%) and USA (7.2%) in 1995 (Figure 4-inset). Global production of aquaculture continues to be dominated by Asia, which in 1995 accounted for over 90% of world output. China, India and Japan accounted for 63.4, 5.8 and 5.1% of total world aquaculture, respectively (Figure 5). Contributions by other major producers were lower, with Korea, Philippines, Indonesia and Thailand accounting for 3.7 (1 million t), 2.9 (0.8 million t), 2.6% (0.7 million t) and 1.7% (0.5 million t) of world total, respectively.

The ranking of the countries has changed over the last five years. Whilst the position of China (1st), Korea (4th), Philippines (5th),

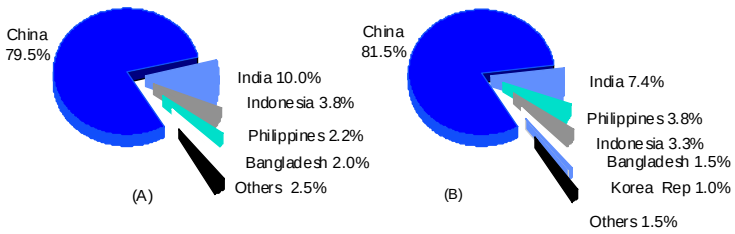
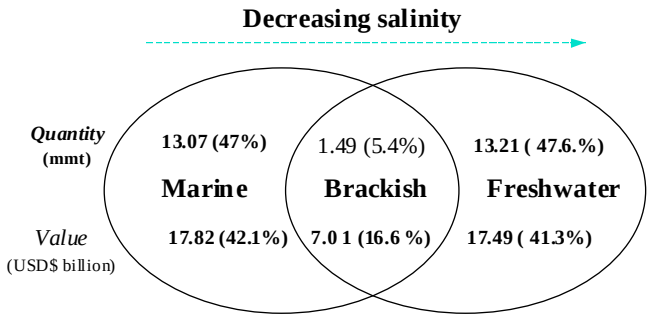


Figure 6. Contribution of the top 5-6 countries total (A) finfish and shellfish and (B) finfish, shellfish and aquatic plant production within LIFDCs



Total quantity: 27.77 million tonnes (mmt); Total value: USD$ 42.32 billion

Figure 7. Contribution of key environments to global aquatic production

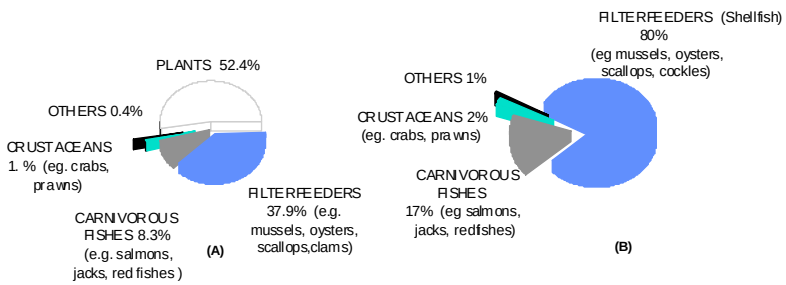


Figure 8. Reported use of world marine environment for (A) total aquatic and (B) finfish and mollusc production in 1995

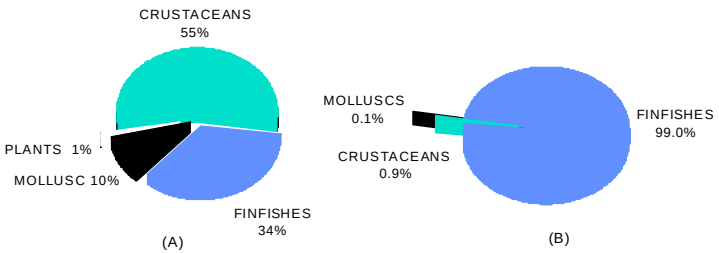


Figure 9. Global use of (A) brackish water and (B) freshwater environment for the production of major groups of aquatic organisms

Indonesia (6th) remained unchanged since 1991, India replaced Japan as 2nd and Thailand displaced USA to take the 7th position in 1995. Although a few developed countries feature amongst top producers (Figure 5), aquaculture production is predominately an activity in the LIFDCs (Figure 5).

By 1995, 21.6 million tonnes, or around 78%, of world total finfish, shellfish and aquatic plant production originated from LIFDCs. The growth rate of the aquaculture sector within LIFDC's between 1984 and 1995 was nearly six times faster than that for non-LIFDCs.

Aquaculture production within the 67 reporting LIFDCs, however, is greatly skewed. Around 98.5 % of all aquatic production within LIFDCs originated from just six countries with China accounting for around 82% (Figure 6). In addition, since the overall average annual growth rate is greatly influenced by the rapid expansion of aquaculture in China, the rate of expansion of the sector within the LIFDCs as a whole is distorted. Between 1984 and 1995 Chinese aquaculture expanded at a average annual rate of 13.6%/yr. In contrast, when China is excluded, the equivalent average annual growth rate for all the other LIFDCs countries was only 5%. In 1995, total aquaculture production from within LIFDCs excluding China was only 4.0 million tonnes an increase of 1.7 million tonnes since 1984 (Figure 5). Whilst showing potential for expansion, this slow growth rate within the LIFDCs is likely to be due to a combination of reasons. Amongst others these may include countries being landlocked, low national priority of aquaculture, small and inappropriate coastline, limited and lack of adequate water supply, poor infrastructure and limited capacity of institutions and technical and financial constraints.

Reported Use of Culture Environments for Aquaculture Production[1]

Although the controversy on the merits and use of coastal lands for aquaculture continues, data reported to FAO on the global pattern of environment used for culture suggests that aquacultural output from brackish water environments has only increased by 2.6%/yr. in the last five years, compared with an annual average increase of 10.8% and 10.6% for freshwater and marine environments.

In 1995, brackish water environments accounted for only 5.4% and 16.6% of total aquatic production by quantity and value, respectively, compared with around 47% by quantity and 41-42% by value from each of freshwater and marine environments (Figure 7).

Moreover, when aquatic plants are excluded from total aquaculture production, the contribution of finfish and shellfish from freshwater environments continues to dominate output and in 1995 accounted for around 63% of the total tonnage of cultured finfish and shellfish By contrast, culture from brackish and marine environments contributed only 7.1 and 30%, respectively.

The proportion of total aquaculture production by weight and value originating from marine waters is high (Figure 7). The reported data, however, suggest that over 90% of mariculture production is centered around primary users of nutrients (i.e. aquatic plants and filter feeding invertebrates) and only 8% for mainly carnivorous finfish species and 1% for crustaceans (Figure 9-A). When only aquatic animals are considered, around 82% of the production, is accounted for by filter feeding shellfish, and only 17% by mainly carnivorous finfish and only 2% of production from mariculture by crustaceans (Figure 8). In addition to the above groups generating nearly US$ 18 billion in 1995, the predominant use of aquatic plants and filter feeders in mariculture may also contribute to minimizing the levels of nutrient enrichment of coastal waters resulting from agriculture and other human activities.

The world brackish water environment is being used to produce a diverse range of aquatic products (Figure 10-A). Although crustaceans, mainly prawns, acounted for 55% of the production fom brackish waters in 1995, 44% of production was attributable to finfish such as the redfishes, tilapias, various diadromous fishes and molluscs. In contrast, the freshwater bodies were used predominantly to produce low value freshwater species such as carps and tilapias (Figure 9).

Major Reported Culture Groups and Species of Aquatic Organisms

The contribution of major culture groups to aquaculture in 1995 was similar to that in 1994. Production of finfishes continues to be the dominant global aquaculture activity in 1995, accounting for about 53% by weight and 55% by value (Figure 10).

As in previous years, freshwater finfishes, in particular the Chinese and Indian carps, accounted for the greatest share (45.6%) of total aquaculture production. Although higher in value, the diadromous and marine finfishes collectively accounted for only 7% of total weight. Aquatic plants on the other hand, which were valued at nearly US$ 6 billion, contributed a quarter of total production. As in 1994, crustaceans, whilst only accounting for 4.1% of total aquatic tonnage, were the second most important cultured group accounting for 17.3% of total value (Figure 10).

Recent Developments of Reported Production of Cultured Species and Species Groups

The overall trend of diversifying the number of cultured species and simultaneously increasing the production of mainstream species continued in 1995. The actual number of species utilized for aquaculture may in fact be considerably higher than reported. This is evident from the rapidly growing and undesirable practice of

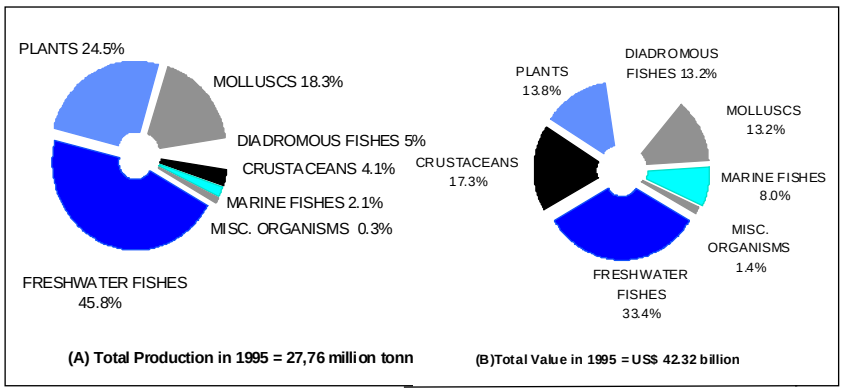


Figure 10. Production in (A) tonnage and (B) value of major cultured groups of aquatic organisms in 1995

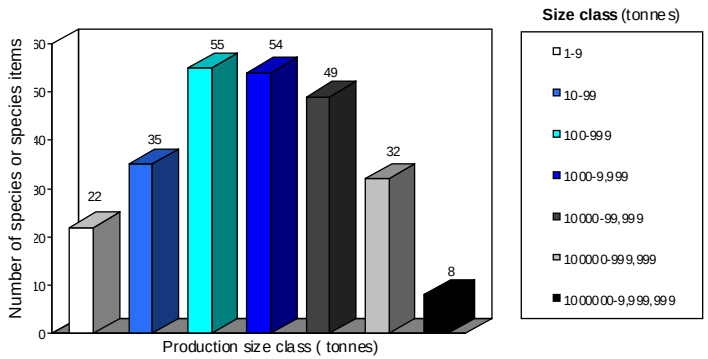


Figure 11. Log frequency distribution for species or species items reported in 1995. Grouped by global production size classes (all entries above one tonne)

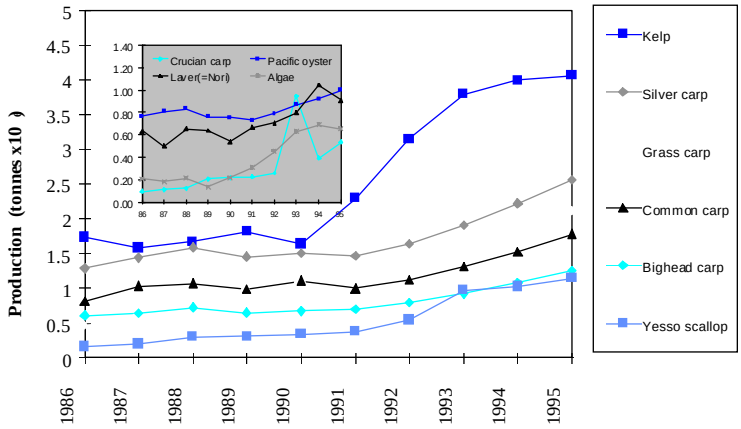


Figure 12. Global trends in farmed production of major aquatic species (insert with same units)

reporting unclassified species to FAO.

Of the 300 plus cultured species or species groups that have been reported to FAO since 1984, just over 250 were reported in 1995. Moreover, the world contribution of each species or species group to overall production is far from uniform (Figure 11). In 1995, 65% of all reported species or species groups contributed up to 10,000 t each to global production. Only 32 species contributed between 100,000 and 1 million t and just eight over 1 million t each (Figure 11). The highest rate of growth and reported global production of cultured aquatic organisms for 1995 was the kelp, *Laminaria japonica*, totalling just over 4 million tonnes (Table 1). Moreover, three of the top ten aquatic species produced are plants (Figure 13).

Apart from the unknown composition of the unclassified finfishes, all the above species for 1995 and those of the top 10 over the last decade represent organisms low in the food web, i.e. they are either filter feeders, herbivore/ omnivores or plants (Figure 13).

The ranking of the top eight species in 1995 showed little change over the last decade and the ranking of the top 4 species remained unchanged over the last five years (Figure 12). Although highest in value, the production of shrimps and prawns, in terms of tonnage, does not feature amongst the top dozen or so farmed aquatic species. In fact the major species of cultured prawns, *Penaeus monodon* was ranked 14th in 1995 (Table 2). In addition, the production of *P. vannamei*, and *P. chinensis*, which are predominantly cultured in Ecuador and China, respectively, were ranked 39th and 42nd (Table 2).

A few notable major changes could be discerned between 1994-1995 from the data on aquaculture production collated by ISSCAAP groups. These include an increase of 250% in the total production of turtles (ISSCAAP group no 72) from 5,440 t in 1994 to over 19,079 t. Similarly, the total production of sea spiders and crabs and the miscellaneous marine molluscs groups reported in 1995 increased by 97% and 196%, respectively, compared with 1994. The vast majority of all these increases were attributable to Chinese aquaculture. Chinese production of freshwater turtles, *Trionyx* spp, rose from 4,400 to 17,500 t and the reporting of unclassified marine crabs and unclassified marine molluscs rose from 10,000 to 48,000 t and 188,000 to 559,000 t, respectively.

Although the overall global production of total finfish and shellfish, has increased by 13.6% between 1994 and 1995, this conceals changes and often declines in national production. Thailand's aquaculture output, for example, declined from 514,000 t in 1994 to 464,000 t in 1995, an overall decrease of 9.7%, mainly of freshwater species. This was mainly due to a 80-90% reduction in reported production of *Cyprinus carpio* (common carp) and *Hypophthalmichthys molitrix* (silver carp), a 68% drop in *Labeo rohita* (rohu), a 40-50% decline in *Puntius gonionotus* (silver barb), *Pangasius pangasius* (pangas catfish), *Macrobrachiium rosenbergii* (giant river prawn) and *Oreochromis niloticus* (Nile tilapia). These large

decreases, however, were somewhat offset by a 66% increase in production of the green mussel, *Mytilus smaragdinus*, from 26,000 t in 1994 to 43,500 t in 1995 and a modest rise of 13,000 t or 5% of *Penaeus monodon*. Other countries reporting noticeable decline in production of finfish and shellfish in the same period included the Philippines, Spain, Netherlands, Faeroe Islands and Japan.

Opportunities for diversification and culturing new species to exploit new national and international markets were also evident from several first time reports of species and rapid increase in production of selected species by countries in 1995. This was most evident in China which reported for the first time, the production of 37,500 t of mandarin fish, *Siniperca chuatsi*, a carnivorous freshwater perch-like fish which is widely distributed in Chinese reservoirs.

In addition, the reported production of the river crab, *Eriocheir sinensis*, has increased 4-5 fold in the last five years to 42,000 t in 1995.

Although the production of freshwater turtles, *Trionyx* spp., was reported for the first time in 1994 (4,400 t), a more significant production of 17,500 t was reported in 1995.

Countries in Europe also reported the production of new species in 1995 for the first time. France reported 197 t of the Japanese carpet shell, *Ruditapes philippinarum* and Germany 1,200 t of unclassified clams. In addition, the UK and Russian Federation reported 120 and 100 t of the Mozambique tilapia, *O. mossambicus* and channel catfish, *Ictalurus punctatus*, respectively.

Table 1: Reported world production of the top eight species or species groups in 1995.

Common name	Species name	Production (tonnes x106)
Kelp	*Laminaria japonica*	4.055
Silver carp	*Hypophthalmichthys molitrix*	2.555
Grass carp	*Ctenopharyngodon idellus*	2.103
Common carp	*Cyprinus carpio*	1.783
Unclassified freshwater fishes	*Osteichthyes*	1.275
Bighead carp	*Aristichthys nobilis*	1.257
Yesso scallop	*Pecten yessoensis*	1.144
Pacific cupped oyster	*Crassostrea gigas*	1.001

Table 2: Production and ranking of penaeid species in 1995. Ranking based on all aquatic species and species groups reported for 1995.

Species and species Groups reported for 1995				
Species	**Common name**	**Production (tonnes)**	**% of Penaeid total**	**Overall ranking**
P. monodon	Giant tiger prawn	502, 701	56	14
P.spp (unclassified)	Penaeus shrimps n.e.i	162,162	17.4	32
P. vannamei	Whiteleg shrimp	105, 378	11.3	39
P. chinensis	Fleshy prawn	78, 820	8.8	42
P. merguiensis	Banana prawn	33,995	3.8	56
P. stylirostris	Blue shrimp	9, 872	1.0	89
P. indicus	Indian white prawn	2, 374	0.3	126
P. japonicus	Kuruma prawn	2, 240	0.2	127
Penaeid total		897, 542	96.3	
Total of shrimps and prawns		932, 000		

[1]*For purposes of this article,* ***freshwater culture*** *is the cultivation of aquatic organisms where the end product is raised in freshwater; earlier stages of the life cycle of these species may be spent in brackish or marine waters.* ***Mariculture*** *is the cultivation of the end in sea water; earlier stages in the life cycle of these aquatic organisms may be spent in brackishwater or freshwater.* ***Brackishwater culture*** *is the cultivation of aquatic organisms where the end product is raised in brackishwater; earlier stages of the life cycle of these species may be spent in fresh or marine waters. Brackishwaters are characterized by large seasonal fluctuations in salinity.*

The author thanks David Ardill, Richard Grainger, Albert Tacon, Maurizio Perotti and Anton Immink for their helpful comments and suggestions.

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PROJECTS AND OTHER ACTIVITIES

Mario Pedini, U. Barg, M. Martinez, Z. Shehadeh and H. Naeve

FAO-NACA Workshop of the study: "Survey and Analysis of Aquaculture Development Research Priorities and Capacities in Asia"

The workshop of the study: Survey and Analysis of Aquaculture Development Research Priorities and Capacities in Asia was organized by FAO and NACA and held at the SEAFDEC-NACA headquarters on 21-23 May 1997. The objectives of the study, in which 14 countries and territories in Asia participated, was to assist in maximizing the contribution of research to aquaculture development, promote regional collaboration in aquaculture research, and focus the attention of donors and development agencies on regional research and priorities (see also *FAN* No. 12, April 1996).

The overall purpose of the workshop was to formulate a regional action plan to address priority aquaculture development research issues. Specifically, it was aimed to: (i) verify and adopt the draft Regional Synthesis of the FAO/NACA Survey and Analysis of Aquaculture Development Research Priorities and Capacities in Asia, which was completed in early 1997, (ii) identify/agree on research themes for regional co-operation and the countries interested in participating in them, (iii) prepare project concept papers for regional activities, and (iv) recommend follow up actions.

The workshop was attended by 10 of the 14 countries/territories which participated in the Survey (Hong Kong, DPR Korea, Malaysia and Nepal were unable to attend), as well as seven regional and international organizations, other than FAO and NACA, and one group from the private sector.

The survey and analytical methodologies and limitations of collected information were described and the findings and conclusions, as reported in the Regional Synthesis of the study, explained by the project consultant, Ms. Yong-Ja Cho. The discussion focused on the constraints to development and research, national aquaculture development priorities, existing research efforts and research capacities and opportunities for regional collaboration. While providing further insight into national aquaculture R&D needs and priorities, the discussion, and summary national presentations which followed, confirmed the main conclusions of the Regional Synthesis.

Over 80% of the 330 on-going aquaculture R&D projects reported by participating countries are concerned with technologies and systems; health and environmental management; production of seed and feed; genetic improvement and species diversification. Few projects (< 3%) are concerned with socio-economic and management aspects. The thrusts of donor-funded projects show similar patterns as the national efforts, with a good majority supporting technology-oriented research. Institutional issues ranked high among constraints to aquaculture development, alongside bio-technical issues. Although the workshop initially was inclined to address only technical constraints (presumably due to the perception that most institutional constraints were not "researchable", as well as the bio-technical specialization of most participants), it subsequently decided to consider institutional issues and included them in proposed regional co-operative activities.

Main institutional constraints to research included: (i) weak institutional linkages and co-ordination among related national agencies/programmes, (ii) inadequate consultation with planners, implementers and users of research results and (iii) inadequate information for planning. Lack of appropriate methods and mechanisms for information delivery and sharing within the region was also identified as a major constraint at national and regional levels.

Although the themes proposed for regional collaboration were largely approved, the weighting given to the themes was not totally supported by participants. Based on national statements on constraints to research and development, it was concluded in the Regional Synthesis that priority should be given to closing knowledge gaps and building tools and information bases that would help support management decisions. Accordingly, institutional, policy and socio-economic issues were given parity with bio-technical issues. However, participants gave higher priority to bio-technical

issues (57% of recommended regional activities). Nevertheless, the workshop did recommend three out of seven regional activities (43%) with a focus on development and management issues in aquaculture and on information needs.

Themes identified for regional co-operation included: institutional issues, information sharing and dissemination, environmental management, health management, nutrition and feeds/feeding strategies, and seed production/ broodstock development for aquaculture and stock enhancement. Although bio-technical themes for regional co-operation were presented in a disciplinary format, it was understood that many of the technical issues were inter-related and research should be based on a systems approach which calls for an interdisciplinary effort.

The workshop noted that aquaculture research had significant potential to contribute to social and economic development goals. This potential has not been realized due to various constraints, many of which were highlighted in the Regional Synthesis and by the workshop. Institutional strengthening and changes in institutional arrangements for aquaculture research may be required to increase impact of research and its contribution to national development. The participants recommended that national priority be given to strengthening research capacity, and that well-targeted external assistance could effectively supplement national efforts to re-orient aquaculture research programmes.

It was also noted that management of aquaculture had become a complex task, involving all levels of government and many disciplines. A concerted effort is required to build up tools and knowledge bases that will enable the sector to address economic, environmental, legal, social as well as technical issues. There is a need to further emphasize intersectoral, multidisciplinary and precautionary approach to management and development of aquaculture.

Although the need for systems research is becoming more widely accepted, the interdisciplinary research efforts required for this approach have not progressed very far. Bilateral and international assistance to accelerate the transition, through training on the planning and management of interdisciplinary research and pilot project would be very timely at this juncture.

Many issues and constraints revealed by the survey are similar to those pointed out by the SIFR study, suggesting that little progress had been made in addressing management and socio-economic issues relating to aquaculture development since the late 1980s. Much of this was probably due to the lack of an enabling environment at the institutional level, the inherent difficulty of overcoming compartmentalization and vertical management approaches, and the absence of compelling pressures to motivate change.

Regarding mechanisms for regional co-operation, the workshop gave preference to networking based on existing regional mechanisms (e.g. NACA), and suggested that lead centres for networks be identified, as necessary, to complement existing NACA centres.

In considering follow-up action on workshop results, participants recommended that concept papers for the identified regional activities should be prepared by NACA & FAO and circulated widely with the workshop report. The two organizations should also bring the workshop recommendations to the attention of their regional bodies(FAO)/Governing Council (NACA) for consideration in the elaboration of their programmes of work, and take earliest possible action to develop full proposals to help initiate/fund identified regional activities in a step-wise fashion.

COLOMBIA

One of the components of the ongoing TCP project “Analysis of Strategic Components of the Colombian Fishery Sector: Formulation of Policies” (see also FAN No. 14, December 1996), is the study of economic and social prospects for the development of fresh water aquaculture in the country. A workshop on this subject was held on 26 - 27 June 1997 as a preparatory activity for the formulation of a national plan for the promotion of aquaculture for the period 1998-2002. Dr. Manuel Martinez-Espinosa, FAO HQ, participated in the meeting as part of the technical backstopping of the project.

Representatives from the Government, universities, co-operatives and private sector attended the workshop and presented background papers for discussion. Each of four small discussion groups dealt with one of the main species or species groups cultured in the country: Colosssoma, trout, tilapia and new potential species. Another group analyzed general issues affecting fresh water aquaculture activities. Key elements of the meeting report to be issued shortly include:

Policies institutions: decentralization, new role of the State in the development of rural aquaculture; partnership with universities, private sector, NGOs.

Environment: integrated watershed management; clear environmental regulations for specific species-production systems, as opposed to one generalized regulation for all species and systems; site selection for ponds.

Technology: More energy-efficient feeding strategies; low quality and high price of locally available industrial feeds; excessive use of drugs; insufficient knowledge methods for the prevention and control of diseases.

Economics: Joint Government-private sector economic and financial feasibility studies for various production models; improvement of credit policies; increasing awareness of the need for competence in managerial aspects of production.

Social aspects: Development of rural aquaculture within the decentralized state scheme and in partnership with universities, private sector, NGOs.

Marketing: Joint Government-private sector study of fish commercialization by zones of the country; creation of cold chains to facilitate marketing; reduction of intermediaries and monopolies.

It was repeatedly pointed our that the country has problems of insecurity. Local disruptions strongly affect aquaculture development as well as other food production activities.

Leaving aside rural aquaculture with its characteristic set of problems, it emerged from the presentations and discussions that, in general, fresh water fish culture in Colombia is making little use of natural food production in ponds and is not applying any strategy to enhance fish production such as use of organic fertilization and polyculture. A monoculture technology based on the stocking of fingerlings that are fed with expensive commercial feed to be harvested and exported does not seem to be an economically sustainable activity. Fingerling production does not seem to present problems in the case of *Colossoma* but this is not the case for red tilapia, which is imported at high cost and tends to lose the red color trait after a few generations. In the case of trout, 70% of the ova are still imported to compensate for the low quality of locally produced ova.

It is becoming more obvious with time, in Colombia and elsewhere in Latin America, that the exclusive focus of development activities on maximum profit is not always compatible with sustainability, from the economic and environmental points of view. There must be a pond management technology somewhere in between the two more known extremes (i.e. the high energy high cost, high resource use, industrial approach as opposed to the traditional Chinese way) that could meet economic, energy, social and environmental demands. Developing such an approach is the challenge that must be met.

CROATIA

A new TCP project has been approved for Croatia for the rehabilitation and development of fisheries and aquaculture. The project will have a duration of 10 months and includes the services of an aquaculture international investment specialist (2 months) who will be supported by two local experts dealing with marine aquaculture (3 months) and inland fisheries and aquaculture production systems (3 months). Cultivation of fish and shellfish has a century long tradition on the Adriatic coast. However, intensive fish and shellfish farming started in 1980.

On the basis of current capacity of spawning facilities (5) and fish fry imported from ltaly and France, 20 fish cultivation sites annually produce 1,500 mt of high quality fish, mostly seabass and gilthead seabream. The main shellfish breeding facilities are located in Limski Kanal, the Krka river estuary, and the Mali Ston bay. In over 80 aquaculture sites (mostly family farms), 800-1,000 mt of mussels, and 800-1,000,000 pieces of oysters are produced annually.

The main mussel and oyster cultivation sites as well as the facilities for their processing were located in the area of Mali Ston Bay. These facilities were badly damaged during the recent war. Before the war, the Mali Ston Bay was the most important location for shellfish farming and annual production was about 1,500 - 2,000 mt of mussels, and more than 1,000,000 pieces of oysters.

Inland aquaculture is based, on one hand, on salmonid farming (mostly trouts) in cold water with a production of about 400mt (40% of pre-war production) from 5 farms, and, on other hand, on the activities of twenty large farms producing about 4,200 mt of fish, of which nearly 90% is common carp. The production of carp is reported to have declined by about two thirds between 1983 and 1995 mainly as a consequence of destruction of facilities in the course of recent hostilities.

The objective of this technical assistance is to formulate a policy and related investment strategies for

the immediate rehabilitation of capture fisheries and the aquaculture sector which in the case of aquaculture will also imply a techno-economic assessment. The aquaculture investment expert will analyze available information on both inland and marine aquaculture, with particular reference to private sector capacity in term of research, training, and development, and investments made in production structures; identify for the main cultured species major constraints (physical, environmental, institutional, financial and legal) for the rehabilitation of both the inland and marine aquaculture sub-sectors; evaluate the capacity to adapt to competitive production and marketing conditions, in particular taking into consideration production costs compared to other Mediterranean countries; and prepare with the other international and national consultants, scenarios for sustainable aquaculture development including investment strategies, schemes and projects for each sub-sector. The project will conclude with a national workshop in which the conclusion of the various consultants will be presented and discussed.

MAURITIUS

A new TCP project has been approved for the elaboration of a ten year development plan for the fisheries sector in Mauritius. The new project has a duration of 8 months and includes also assistance for aquaculture with the inclusion of a specialized consultant who will spend three weeks in the country.

The objective of the assistance is to elaborate a development plan for the fisheries sector with regard to institutional and legal aspects, economic and marketing issues, the artisanal and industrial fisheries, fish processing, aquaculture, research requirements, training and education, fisheries protection and coastal zone management for the next ten years for Mauritius, Rodrigues and the outer islands.

The Consultant, who will take care of the aquaculture component of the project, will review the status of aquaculture in the country, and assess possibilities for increased production. Aquaculture has been a tradition in Mauritius, a small island of volcanic origin in the South West Indian Ocean with a very large EEZ (1.6 million square kilometres). In particular, the production of *Macrobrachium* started in the country in the late seventies and accounted in 1995 for a total of 55 mt out of the 176 mt recorded as aquaculture production. Other cultured species of relevance are oysters (18 mt in 1995), tilapias (62 mt in 1995) and carps (some 35 mt in 1995).

TONGA

A new TCP project has been approved for the Kingdom of Tonga to implement a fisheries sector study. The project has a duration of ten months. The objective of the project is to enable the Government of Tonga to enhance its capability to better manage the fisheries sector and to put in place more appropriate and comprehensive policies and programmes for inshore and offshore fisheries management, and aquaculture.

The project will cover the services of four international consultants: a fisheries specialist/Team Leader (4 m/m), an economist (3 m/m), an institutions specialist (1.5 m/m) and an aquaculture specialist (0.75 m/m); advisory technical services including a legal consultant (1 m/m) and a post harvest specialist (1 m/m); support personnel and one FAO Headquarters technical backstopping mission. The project will also cover the cost of official travel, equipment, a study tour and a final workshop, and general and direct operating expenses.

The Kingdom of Tonga is a small island developing state (SIDS) in the central South Pacific. It has a land area of 720 square kilometres, an exclusive economic zone of 700,000 square kilometres and a 1986 population of 95,000. Tonga is an economically-disadvantaged country having limited opportunities for land-based development and, as a result, the fisheries sector is critically important both for food security and the generation of national income from fish exports. The Government has given high priority to the fisheries sector as a means of promoting national economic development. In recognition of the current and projected importance of Tonga's fisheries sector, a Ministry of Fisheries was established in 1991 to oversee the management and development of inshore and industrial fisheries and aquaculture.

The consultant aquaculture specialist will be in the country for three weeks. He will: Provide a historical summary of aquaculture development in the country, including the value of aquaculture to the economy and the scope and value of technical assistance provided to the country; evaluate appropriate research and extension needs for aquaculture; assess the extent to which aquaculture can be developed in the country for domestic and export markets and the amounts of development effort to be channelled into aquaculture relative to other aspects of fisheries development, including an assessment of the national and international constraints; evaluate investment potential for the private sector and outline an appropriate role for the sector in the further development of

aquaculture, taking into consideration previous studies and projects in Tonga and in neighbouring Pacific Island countries; propose an appropriate programme for aquaculture development, for 5 and 10 years' periods, taking into account relevant social, economic and technical considerations, including financial projections for the proposed development; identify potential links to appropriate overseas aquaculture centres, and assess the potential for reef enhancement.

VIETNAM

The Success of UNDP/FAO Project VIE/93/001 "Freshwater Fish Culture Extension"

The UNDP/FAO Project VIE/93/001 "Freshwater Fish Culture Extension" has shown very satisfactory results in establishing an aquaculture extension service network in northern Viet Nam, encompassing the Transfer of Technology Center at the Research Institute for Aquaculture No.1 (RIA No.1) in Bacninh Province , 4 Sub-Centers (in Sonla, Bach Tru, Phu Tao and Thanh Hoa Provinces) and 24 Demonstration Farms, in addition to 12 selected VAC (integrated family farming units) sites representing four different agroclimatic zones of the northern part of the country which are also being used for demonstration purposes.

This project is being considered as one of the most successful UNDP/FAO projects in Viet Nam. Not only is the aquaculture extension service network fully operational, but aquaculture techniques and approaches for aquaculture extension have been disseminated to farmers, fish farm managers, extensionists, and aquaculture technicians since beginning of 1995. The Project provided training on aquaculture to more than 4400 farmers, 120 demonstration farmers, about 1450 extensionists, and specialized technical field personnel, including 60 aquaculture extensionists and 120 aquaculture technicians and fish farm managers. The Project conducted 170 training courses for farmers and 22 courses for extensionists and technicians, as well as 6 field workshops.

A large number of extension materials has been developed, produced and distributed (a total of 46,900 copies), including one manual on aquaculture extension and 15 technical extension bulletins covering a wide range of aquaculture technologies suitable for northern and central Viet Nam.

The Project has succeeded in attracting great interest in aquaculture, and many farmers are either improving their aquaculture methods or learning to apply fish culture practices mainly in ponds and rice fields, and also in cages. The "trickle down" approach to aquaculture extension is being followed, where the demonstration farmers trained by the Project conduct demonstration of the recommended culture technology package and in turn show the results to the neighboring farmers designated as fellow farmers. Extensionists support the farmers by visiting them at regular intervals and encourage them to show their practice and share their experience with their fellow farmers. Major emphasis is thereby given to farmers' participation in aquaculture extension, based on farmer to farmer approaches and exchange of experiences among farmers.

Given the very significant demand for technical know-how and knowledge on aquaculture among many farmers, the aquaculture extension network also established collaborative associations with local units of organizations like the Vietnamese Women's union, Farmers' Association, Youth Association, VACVINA and Provincial Agriculture Extension Centres (PAEC).

The success of the project is based primarily on the hard work and dedication of the national experts, as well as on the excellent extension skills of the Project's Lead Consultant. It may be considered to further promote such approaches to aquaculture extension, in neighbouring countries and elsewhere.

The project commissioned a study on socio-economic aspects of freshwater aquaculture practices in northern Viet Nam, which analyzed factors leading to the improvement and adoption of aquaculture practices among farmers in rural communities. The Faculty of Agricultural Economics, Hanoi, studied the various types and levels of aquaculture / agriculture integration in different agro-ecological zones of northern Viet Nam, including lowland, midland and highland regions and the northern provinces of central Viet Nam. Based on the socio-economic survey, Chung and co-workers concluded that :

- The most common and efficient model for aquaculture/agriculture integration is livestock- horticulture-fish culture, followed by rice-fish culture (or VAC farming, the acronym in Vietnamese), then aquaculture-livestock husbandry (primarily pig rearing), and finally aquaculture/horticulture integration;

- VAC farming appears to be the best model of aquaculture/agriculture integration, in terms of on-farm input use, productivity and gross margins;

• VAC farming systems help farmers obtain higher returns, achieve best use of on-farm inputs, lessen their dependence on purchased inputs and sustain patterns of farm resource use;

• Aquaculture plays an important role in these integrated farming systems, in providing farm income, using on-farm inputs, creating employment and reducing risks for the farm household;

• These systems play an important role in food supply, job creation and sustainability of the rural economy. They also provide opportunities and directions for farmers to diversify the traditional rice-based production patterns into more sustainable farming systems that enable them to obtain better quality of life with less environmental damage and health risk.

Several priority areas for technical collaboration and financial assistance for increased fish production through aquaculture and inland fisheries were identified during recent discussions by officials of the Ministry of Fisheries, national experts and FAO/HQ staff. It is suggested that future efforts be focused on technical assistance to Vietnamese experts and institutions in specialized fields such as fish health management, supply of good quality seed, aquafeeds and feeding, environmental management of aquaculture development, and inland fisheries enhancement in reservoirs and lakes.

Additional development projects would be desirable in order to assist the very poor people living in the mountain areas, as well as ethnic minorities. In addition, there are significant problems of migration and resettlement of more than one million people in the highland provinces of northern Viet Nam. These people are in urgent need of alternative economic activities. Highest priority is therefore being given to poverty alleviation, food production and job creation in these areas. Aquaculture in ponds and cages as well as fishery practices in reservoirs and lakes, are seen as very suitable and viable opportunities to enhance production of much needed animal protein. These practices also generate significant economic incentives to farmers given the high demand for fish. In addition, the creation of alternative sources of food and income through aquaculture and fishing can help to reduce ongoing deforestation in mountainous areas resulting from unsustainable logging practices by very poor people.

Given the increasing demand for fish, the proven viability of fish production in present integrated aquaculture-agriculture farming systems, and the great acceptance of these methods by the farmers, there appears to be much scope in expanding the activities of the established aquaculture extension network. More support is needed to expand the coverage of this network, with a view to carry out additional extension activities, particularly at the district levels of all target provinces, as well as at the level of communes in mountainous regions.

TOWARDS SAFE AND EFFECTIVE USE OF CHEMICALS IN COASTAL AQUACULTURE

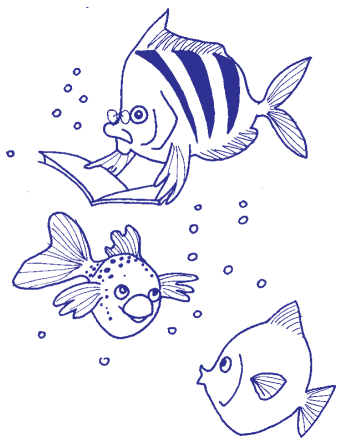
News from the 27th Session of the IMO/FAO/UNESCO-IOC/WMO/ WHO/IAEA/UN/ UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), Nairobi, 14-18 April 1997

GESAMP, through its Working Group on Environmental Impacts of Coastal Aquaculture, identified over 50 chemicals or chemical classes used in coastal aquaculture. For each chemical or class, it provided brief information on their use, including geographic location of principal use, and the potential for environmental impact and human health.

GESAMP concluded that most aquaculture chemicals can be used safely if proper precautions are taken, and the potential for adverse environmental and or human health effects result from misuse (e.g. excessive dosages, inadequate effluent control). There are, however, a few chemicals that are used in certain industry segments for which there is an inherent substantial risk to the environment or human health. Some governments have already banned use of these substances, and their continued use elsewhere deserve close scrutiny. Efficacious alternatives are urgently needed.

GESAMP provided recommendations on the safe and effective use of chemical compounds in coastal aquaculture. While the overriding consideration should be to minimise use of these chemicals, it is recognized that use of aquacultural chemicals is essential and virtually unavoidable. Regulatory mechanisms need to be put in place (and enforced) for registration and control of the use of aquacultural chemicals in order to protect human health, the natural environment and the sustainability of the industry itself.

The study is expected to become available in November 1997 as *Reports and Studies, GESAMP* No. 65.



NEW FAO PUBLICATIONS

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FAO Fisheries Department. 1997. Aquaculture production statistics 1986-1995. *FAO Fisheries Circular* No. 815, Rev. 9. Rome, FAO. 195p.

This is the most recent issue of the annual publication. It provides a compilation of aquaculture production statistics for fish, crustaceans, molluscs and other aquatic animals, residues and plants. The following combinations of production statistics are presented: by species and by country; by country and by species; and by species and by environment. Values of production expressed in terms of US dollars are provided by country, species and species group, thus providing more detail than previous issues of this Circular. Although the FAO aquaculture database is for the period 1984-95, this publication contains data for 1986-95.

Coche,A.G. (comp.). 1997. An indexed list of FAO publications related to aquaculture, 1960-1997. *FAO Fisheries Circular* No. 924. Rome, FAO. 71p.

A bibliographic list of about 600 selected FAO documents related to aquaculture, published during 1960 - 1997. Author, geographic, taxonomic and subject indices provide assistance in locating information. The revised list is an attempt to bring together most of the material related to aquaculture which has been published by FAO and its Regional Bodies since 1960. It does not include the numerous technical reports prepared as part of various technical assistance projects.

Lavens, P., and P. Sorgeloos (Eds). 1996. Manual on the production and use of live food for aquaculture. *FAO Fisheries Technical Paper* No. 361. Rome, FAO. 295p.

The cultivation of fish and shellfish larvae under controlled hatchery conditions requires not only the development of specific culture techniques, but in most cases also the production of and use of live food organisms as feed for the developing larvae. The present manual describes the major production techniques currently employed for the cultivation of the major types of live food commonly used in the rearing of larvae, as well as their application potential, in terms of their nutritional and physical properties and feeding methods. The manual is divided into sections dealing with the major groups of live food organisms used in aquaculture: micro-algae, rotifers, *Artemia*, natural zooplankton, copepods, nematodes and trocophores.

GESAMP. 1996. Monitoring the ecological effects of coastal aquaculture wastes. *Reports and Studies, GESAMP*. No. 57. Rome, FAO. 38p.

This is the result of a study which has been prepared on the basis of the work of the GESAMP Working Group on Environmental Impacts of Coastal Aquaculture. The report discusses scientific aspects of the monitoring required to assess and manage the ecological effects of coastal aquaculture wastes from the perspective of environmental protection. The scope is restricted to particulate and soluble waste and does not include consideration of the chemicals used in aquaculture. The text consists of seven sections: Introduction, Monitoring the Effects of aquaculture Wastes in the Context of a Management Framework for Coastal Development, the Use of Models in Environmental Impact Assessment, General Principles of Monitoring, Monitoring Practices, Hypothetical Monitoring Programmes and References.

FAO. 1997. Metodos sencillos para la acuicultura: Construcción de estanques para la piscicultura en agua dulce. Construcción de estanques de tierra. *Colección FAO: Capacitación*. No. 20/1. Rome, FAO. 355p.

This is the Spanish version of the training manual which was issued earlier in English and French. The contents are organized in six sections: General Background, Site Selection and General Planning, Basic Materials for Construction, Earthmoving Methods, Preparation of the Construction Site, and Fish Pond Construction.

FAO Fisheries Department. 1996. Integration of fisheries into coastal area management. *FAO Technical Guidelines for Responsible Fisheries*. No. 3. Rome, FAO. 17p.

The dependency of the marine fisheries sector, including coastal aquaculture, on the coastal area makes it particularly susceptible to activities which result in coastal environmental change which may have major impacts on the sector. At the same time, the fisheries sector can affect other coastal activities, e.g., through competition for space. The need is apparent, therefore, to consider the development and management of the fisheries sector within the context of coastal area management and development planning, i.e., in the context of the protection and management of the resources, the environment and the activities of the coastal area.

These guidelines are provided as explanatory material to Article 10 in the Code of Conduct for Responsible Fisheries. Article 10 concerns the Integration of Fisheries into Coastal Management in order to assist in achieving the rational use of scarce coastal resources. Integrated coastal management (ICM) usually refers to the process of resources management in the interface between the sea and the land, but the principles of integrated management also apply to the water/land interface of large inland water bodies. The fisheries sector is taken, in the Code and these Guidelines, to refer to both capture fisheries and aquaculture, unless one or the other sector is specifically mentioned. The Guidelines are preliminary and will be evaluated and revised as information becomes available through their use in the implementation of Article 10 of the Code.

FAO Fisheries Department. 1997. The state of world fisheries and aquaculture 1996. Rome, FAO. 125p.

This new bi-annual publication is intended to provide consolidated global information about recent developments in the sector and possible future trends for policy makers and planners. The first section reports on trends in world production, utilization and trade of fish and fishery products (recent developments in aquaculture are reviewed separately). The section reviews recent developments affecting four major issues in fisheries: fishing capacity; by-catch and discards; environmental degradation; uncertainty and risk. It ends with a brief outlook for the fisheries sector.

The second section presents a study of marine fishery landings data for the period 1950 - 1994, involving time series of about 200 major resources. The potential for further development is examined for each ocean. The third section contains a review of recent developments in fisheries and aquaculture by geographical region. In the fourth section, the fishery activities of 14 countries, including those activities carried out in co-operation with FAO, are reported in a summarized form.

FAO Fisheries Department. 1997. Fisheries and aquaculture in the South Pacific: Situation and outlook in 1996. *FAO Fisheries Circular*. No. 907. Rome, FAO. 41p.

This is the fifth in a series of summaries providing detailed analyses of the state and fisheries and aquaculture in eight different regions. The contents and format of the circulars were described in the previous FAN issue (No. 15, April 1997).

Tacon, A., and B. Basurco (Eds). 1997. Feeding tomorrow's fish: Proceedings of the joint CIHEAM/ FAO/IEO workshop of the CIHEAM Network on Technology of Aquaculture in the Mediterranean (TECAM), Mazarron , Spain, 24-26 June 1996. Zaragoza, Spain. 307p.

This CIHEAM publication presents the proceedings of the TECAM workshop jointly organized by the Mediterranean Agronomic Institute of Zaragoza (CIHEAM-IAMZ), the FAO Fisheries Department, and the Instituto Ispanol de Oceanografia (IEO), which was attended by 27 participants from 11 Mediterranean countries. The proceedings include 18 papers on various aspects of aquaculture nutrition and feed development. A concluding section summarizes discussions and conclusions and lists the major issues and needs, relating to aquaculture nutrition and feed development, raised by the participants during the final discussion session of the workshop.

STAFF CONTRIBUTIONS TO EXTERNAL PUBLICATIONS, MEETINGS, ETC.

Barg, U., Dunn, I., Petr, T. and R.L. Welcomme. 1996. Inland fisheries and water management. pp. 439-476 *In*: A.K. Biswas (eds) Water resources: Environmental Planning, Management and Development. McGraw-Hill, New York.

El-Sayed, A.-F.M. and A.G.J. Tacon. 1997. Fishmeal replacers for tilapia: A review. pp. 153-182. *In*: Tacon, A.G. J., Basurco, B. (eds). 1997. Feeding tomorrow's fish - Proceedings of the workshop of the CIHEAM Network on Technology of Aquaculture in the Mediterranean (TECAM), 24-26 June 1996, Zaragoza, Spain. pp. 205-224.

Kapetsky, J. and U. Barg. 1997. Land quality indicators from the viewpoint of inland fisheries and aquaculture. pp. 127-130. *In*: FAO. 1997. Land quality indicators and their use in sustainable agriculture and rural development. *FAO Land and Water Bulletin.* No. 5. Rome, FAO. 212p.

Rana, K. J., R. Grainger and Adele Crispolde-Hotta. Current Methods and Constraints for Monitoring Production from Inland Capture Fisheries and Aquaculture. Paper presented at the Expert Consultation on enhanced inland fisheries, 7-12 April 1997.

Rana. K. J. 1997. Applications of low temperature biology for the management of genetic resource management. Paper presented at the First International Meeting: Population Genetics and Aquaculture in Africa, 1-4 April 1997. Grand Bassam, Côte d'Ivoire.

Rana. K. J. 1997. Global trends of aquaculture: an FAO statistical perspective. Paper presented at the First International Meeting: Population Genetics and Aquaculture in Africa, 1-4 April 1997. Grand Bassam, Côte d'Ivoire.

Rana, K. J. 1996. World trends in aquaculture production with emphasis of Asian aquaculture production. Presented at The Round Table Discussion on Aquaculture Supplement for the World Census of Agriculture 5-7 November 1996. Bangkok, Thailand.

Rana, K.J., R. Grainger and J. Viseur. 1996. Background to the aquaculture supplement for the world census of agriculture 2000. Presented at The Round Table Discussion on Aquaculture Supplement for the World Census of Agriculture, 5-7 November 1996. Bangkok, Thailand.

Rana K.J., R. Grainger and J. Viseur. 1996. An aquaculture supplement to the programme for the world census of agriculture 2000. Paper presented at the APCAS meeting in Japan. October 1996.

Tacon, A.G.J. 1997. Feeding tomorrow's fish: keys for sustainability. pp. 11-34. *In*: Tacon, A.G. J., Basurco, B. (eds). 1997. Feeding tomorrow's fish - Proceedings of the workshop of the CIHEAM Network on Technology of Aquaculture in the Mediterranean (TECAM), 24-26 June 1996, Zaragoza, Spain.

Tacon, A.G.J. 1997. Fishmeal replacers: Review of antinutrients within oilseeds and pulses - A limiting factor for the aquafeed *Green Revolution*?, pp.153-182. *In*: Tacon, A.G. J., Basurco, B. (eds). 1997. Feeding tomorrow's fish - Proceedings of the workshop of the CIHEAM Network on Technology of Aquaculture in the Mediterranean (TECAM), 24-26 June 1996, Zaragoza, Spain.

Tacon, A.G.J. 1997. Feeding tomorrow's fish - the Asian experience, pp.20-42. *In*: K.P.P. Nambiar & T. Singh (eds). Sustainable aquaculture. Proceedings of INFOFISH-AQUATECH '96 International Conference on Aquaculture, 25-27 September 1996, Kuala Lumpur, Malaysia. INFOFISH, Kuala Lumpur, Malaysia.

Tacon, A.G.J. and D.M. Akiyama, 1997. Feed ingredients, pp.411-472. *In*: J.D.D'Abramo, D.E. Conklin & D.M. Akiyama (eds). Crustacean Nutrition. Advances in World Aquaculture, 6: World Aquaculture Society, Baton Rouge, USA

Tacon, A.G.J. and B. Basurco, (eds). 1997. Feeding tomorrow's fish. Cahiers Options Méditerranéennes, Vol. 22. Zaragoza, Spain, 307p.

Tacon, A.G.J. and S.S. De Silva, 1997. Feed preparation and feed management strategies within semi-intensive fish farming systems in the tropics. Aquaculture, 151:379-404.

Tacon, A.G.J. 1996. Feed formulation and evaluation for semi-intensive culture of fishes and shrimps in the tropics, pp.29-43. *In*: C.B. Santiago, R.M. Coloso, O.M. Millamena & I.G. Borlongan (eds). Proceedings of the National Seminar-Workshop on Fish Nutrition and Feeds, Tigbauan, Iloilo, Philippines. Aquaculture Department, Southeast Asian Fisheries Development Centre, Iloilo, Philippines.