Key Problem Areas in World Aquacultural Development

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Interest in the large-scale development of aquaculture as a manageable food production system has intensified considerably during the past decade. The escalation of development efforts stems, by and large, from 1) the need to produce additional fish protein to meet the demand of rapidly increasing populations; 2) the fact that production from aquaculture is related to manageable inputs, e.g., control of the production process makes aquaculture less susceptible than capture fisheries to unpredictable natural influences; 3) the leveling off of world catch from conventional capture fisheries and 4) the expected reduction in catch by certain major fish-consuming countries brought about by the extension of economic zones of other countries in marine waters.

Recently, there were calls for regional and international action to support aquaculture as a prime investment area, and to both supply the funds needed to accelerate development and cause the allocation of primary resources to this end by national governments. Donor non-government agencies are also being encouraged to provide substantial support for research in aquaculture to improve existing technology and resolve major production problems.

Although the increase in production from aquaculture in the past few years has been significant in some countries, the overall growth rate has been less than anticipated. The factors which account for the slow growth are characteristic of emerging industries—an amalgamation of technical, economic, institutional and cultural barriers. To date, technical problems have received the most attention and biologists have, by and large, dominated the aquacultural field. Inadequate attention has been devoted to other, equally important problem areas and to the interplay among them. In some respects, development-related activities are ahead of science and technology in international aquacultural efforts as a result of strong interest in, need for and potential of controlled fish production.

Unlike agriculture, a strong base of research knowledge does not exist for aquaculture.

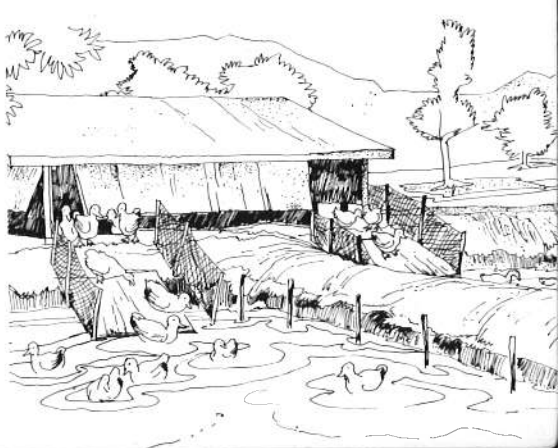
Technical Constraints

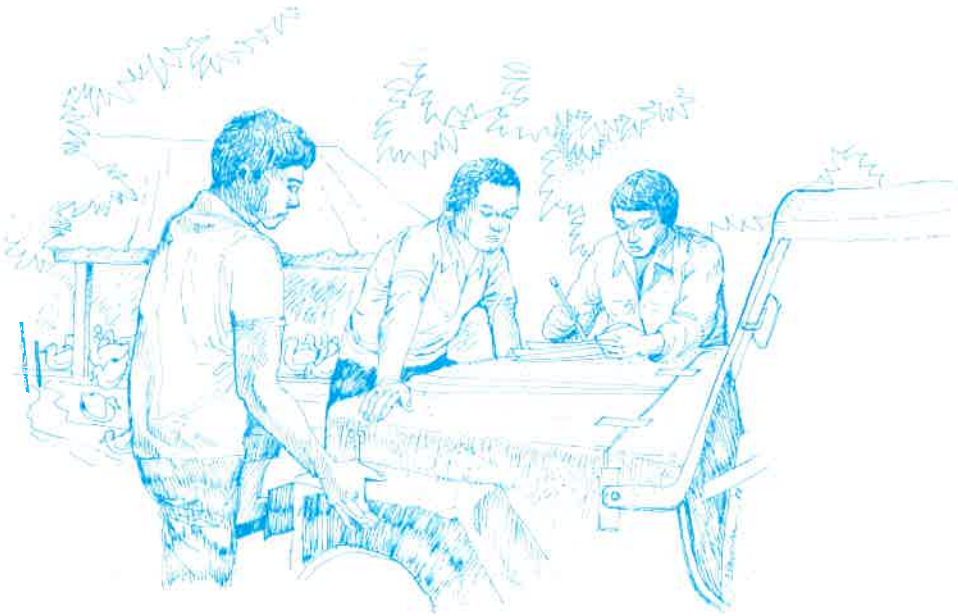
The technical problems are, perhaps, the easiest to identify. Traditionally, aquaculture has been restricted largely to Asia where practices have been developed through trial and error, and passed on through generations. Existing production methodology is empirical, with a narrow scientific base. It draws on raw materials generated from agriculture (e.g., for supplementary feed) and the natural environment (seed stock). Production technology is unwritten and highly site-specific and is passed from producer to producer on an informal basis.

The ongoing drive to expand and intensify these traditional systems calls for expanded supplies of seed, greater use of supplementary and/or nutritionally complete feeds, and methods to prevent and control diseases. Meeting these needs presupposes a combined knowledge of breeding and physiology, feeding habits and nutritional requirements as well as of pathogens and immunogenic mechanisms of cultured species. With few exceptions, this wealth of information does not exist for species of interest to developing countries even though it is available for many species native to the temperate zones. The growing realization of the urgent need for this data base has precipitated repeated recommendations for international support of relevant research.

To be responsive to these needs, an international research program must not only focus on immediate requirements but also anticipate future problems that may be created by internal and external

Below and above: integrated poultry-fish farming has great potential.





Interviewing fish farmers during an ICLARM study on aquaculture economics. Limited availability of information on proven production methods is an added constraint.

influences on the industry. On the basis of problems that are beginning to surface, it can be anticipated that expansion of aquaculture, particularly freshwater aquaculture, will be limited by scarcity of resources used in agriculture and husbandry of terrestrial animals: land, water, feed and fertilizer. Continuing increase in production will then have to be achieved by increasing production per unit of scarce resource. This can best be accomplished by 1) integration of agricultural and aquacultural food production systems, e.g., animal-fish or crop-fish systems, and use of irrigation reservoirs and distribution systems for fish culture; 2) increased use of efficient species and varieties; 3) increased use of cage- and pen-culture systems; 4) increased culture of air-breathing fishes which can be stocked at high densities; 5) increased use of brackish-water and marine production systems to avoid competition for fresh water and arable land; 6) aquatic ranching and intensive management of special environments such as large reservoirs; 7) improved nutrition through better diets and 8) development of genetically improved strains of cultured species.

All these approaches call for additional basic knowledge of several types. Research efforts in four critical areas are required to generate the data: description and control of reproductive cycles, definition of nutritional requirements, improvement in understanding the ecology and behavior of cultured species and improvement in methods for the prevention and treatment of diseases.

Information and Training

The shortage of trained production specialists has been a major obstacle to the development of all types of aquaculture. Training is needed for large numbers of technicians to sustain commercial production and for a second group of production specialists to disseminate essential information to small fish farmers. Presently, a number of institutions and governments are addressing this issue but on a small scale or in an *ad hoc* fashion only.

The limited availability of information on proven production methods is an added constraint. Information on existing methods must be collected and translated into usable, practical form. The need is crucial since the immediate expansion of aquaculture will depend on a much wider use of the best existing technology. The response to this need by development agencies and research institutions has been a perplexity of poorly coordinated, short-term and inadequate efforts which to date are not supplying needed information to either producer or extension agent. In the long term, aquacultural technology must be consolidated into a concise body of principles, knowledge and theory, and suitable criteria for its dissemination must be developed and introduced into the educational centers.

Trends, Development Prospects and Economics

The goals of national development plans, or the context in which aquaculture is to be practiced and the role it is intended to play, will determine the type of aquacultural systems to be used, the nature of the research required to support and improve the chosen systems, and the overall infrastructure and policies required to successfully underpin development.

Because complementary and competitive relationships exist between aquaculture and other sectors of the economy, a realistic appraisal of aquaculture's development prospects requires an examination of more than historical trends from which extrapolations are made. The dynamics of change in any economy suggests that there are three major areas

ICLARM Director General Ziad Shehadeh *(L)* discussing aquaculture projects with authors Richard Neal and Ian Smith *(R)*.

from which forces that influence aquacultural development may emanate. These are: 1) the relative economics of rearing and marketing various species, 2) the relative economics of agriculture and other sectors that either require the same inputs used by aquaculture or compete with it in the same market place and 3) the expansion of non-agricultural sectors that produce positive or negative impacts on aquaculture. Technical, economic and institutional factors in all three of these areas therefore play a role in determining the future of aquaculture.

Because aquacultural production in most countries is in private hands who respond to the profit motive, the relative economics of production is the determining factor in the choice of species. For example, depending upon production costs and market demand, a higher-valued species with low production per unit area may be chosen over a lower-valued species with high production per unit area. Already, in several countries of Southeast Asia, brackishwater pond areas that have traditionally supplied milkfish *(Chanos chanos)* for domestic markets are being converted to production ponds of penaeid shrimp for the international market.

Mussel stakes, Thailand: Aquaculture competes with other sectors that require the same inputs or compete with it in the market place.

The relative economics of aquaculture and other agricultural and fishery sectors is also an important consideration. Aquacultural products compete in domestic and international markets with both agricultural proteins and capture fishery products. With demand increasing as population increases and supply from capture fisheries leveling off as limits to stock exploitation are reached, prices of aquatic products are already rising rapidly. There arise conflicts (as are already occurring in Europe) between fish farmers seeking to increase aquacultural production and fishermen who see increased aquacultural production leading to lower prices than would have otherwise prevailed.

The extent to which aquaculture will successfully compete for limited resources depends in part on the relative efficiency with which aquacultural producers convert inputs into products and upon the extent to which integrated agro-fish farming systems lead to complementariness in place of conflicts.

The Larger View Necessary

Finally, the activities of other sectors completely external to aquaculture, fisheries and agriculture may either indirectly constrain or enhance aquacultural development prospects. For example, the development of port facilities and associated industrial complexes in the coastal zone may result in pollution severely inhibiting aquaculture. On the other hand, such structures may open up markets for aquacultural products raised nearby.

The challenge is for funding institutions to allocate more and for administrators to come up with appropriate approaches to development.

All these considerations imply that a broad economic overview of aquaculture's 'fit' in each country is likely to yield a more realistic appraisal of the sector's potential than would a view that is either narrowly technical or biological.

The Challenge

The failure of research institutions to plan and execute multidisciplinary approaches to development is one of several reasons aquaculture has not developed at anticipated rates. A second, related reason is the failure of funding agencies to support such approaches proposed. In some cases, limited technical approaches have led to misdirected development efforts and waste of resources. While there seems to be no lack of funding for aquacultural development and technology transfer, support for research has been seriously neglected. Unlike agriculture, a strong base of research knowledge does not exist for aquaculture.

Meanwhile, ICLARM is endeavoring to provide leadership in the identification of fruitful areas for research and the allocation of scarce research resources along appropriate lines in developing countries. Key problems, the resolution of which will have major regional if not international impact, have been identified as priority areas for ICLARM research. Opportunities for cooperation and collaboration at all levels of development planning, research planning and research implementation are actively being solicited.

Carp pond with two aerators: Technical, economic and institutional factors shape aquaculture's future.

It is clear that aquaculture is an integral part of wise resource use as well as part of the efficient food production systems for a hungry world. The challenge is both for funding institutions to allocate more and for administrators, researchers and public planners to plan appropriate research and development activities and allocate such funds wisely to speed up this process of food production.○