Towards Sustainable Aquaculture in the ASEAN Region

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In 2004, aquaculture production from the ASEAN region comprising 10 countries, namely, Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam, was 6,298,399 mt valued at 8,746,084 thousand USD. The region's total aquaculture production contributed about 11% by volume and 12.4% by value to the world's total aquaculture production volume and value, respectively (Table 1 and Table 2). The average growth of the region's aquaculture production over the five-year period from 2000 to 2004 was 14.5% (Table 1) while the average growth rate of the world's total aquaculture production over the same period was 6.8% (FAO SOWA 2006).

The region's aquaculture production systems are located in freshwater, brackishwater or marine environments. Of the three production systems, mariculture contributed most to the volume of production followed closely by freshwater aquaculture (Figure 1). In 2004, the major mariculture and brackishwater culture species were seaweeds, penaeid shrimps (*Penaeus monodon*, and *P. vannamei*, kuruma prawn, banana prawn, etc.), milkfish, oysters, mussels and other bivalves, groupers, sea bass, snappers, etc. Freshwater aquaculture was dominated by tilapia, carps, catfishes, gourami, snakehead, freshwater prawn, etc. (Figure 2).

Table 1. Aquaculture production in the ASEAN region, by volume (mt)

Country	2000	2001	2002	2003	2004
Brunei Darussalam	113	99	157	160	708
Cambodia	14,430	17,500	18,250	26,300	37,675
Indonesia	993,727	1,076,749	1,137,151	1,228,559	1,468,612
Lao PDR	42,066	50,000	59,716	64,900	64,900
Malaysia	167,898	177,021	183,990	192,160	202,227
Myanmar	98,912	121,266	190,120	252,010	400,360
Philippines	1,100,902	1,220,456	1,338,394	1,448,504	1,717,028
Singapore	5,112	4,443	5,027	5,024	5,406
Thailand	738,155	814,121	954,567	106,4378	1,172,866
Vietnam	513,517	608,098	728,041	967,502	1,228,617
Total	**3,674,832**	**4,089,753**	**4,615,413**	**5,249,497**	**6,298,399**
World's Total	45,657,773	48,555,041	51,971,882	55,183,013	59,408,444

Source: FAO FISHSTAT PLUS 2006

Table 2. Aquaculture production in the ASEAN region, by value ('000 USD)

Country	2000	2001	2002	2003	2004
Brunei Darussalam	502.0	473.3	715.1	747.3	3,159.1
Cambodia	28,274.8	28,835.7	27,510.3	35,726.0	42,165.0
Indonesia	2,268,269.8	2,418,615.2	1,494,529.9	1,715,901.1	2,162,849.6
Lao PDR	88,128.3	100,000.0	119,432.0	129,800.0	129,800.0
Malaysia	255,974.3	320,042.7	283,019.5	302,652.5	328,357.9
Myanmar	781,368.0	380,217.0	576,970.0	775,331.0	1,231,230.0
Philippines	734,018.0	719,179.5	695,412.0	668,514.0	794,711.5
Singapore	9,913.4	8,533.7	6,882.5	9,150.9	8,596.3
Thailand	2,513,845.9	1,752,064.1	1,574,990.9	1,462,966.0	1,586,626.0
Vietnam	998,817.9	1,355,712.7	1,611,949.0	1,983,331.0	2,458,589.0
Total	**7,679,112.0**	**7,083,673.9**	**6,391,411.2**	**7,084,120.6**	**8,746,084.4**
World's Total	56,687,908.8	58,689,246.4	61,103,566.6	65,298,295.3	70,302,473.3

Source: FAO FISHSTAT PLUS 2006

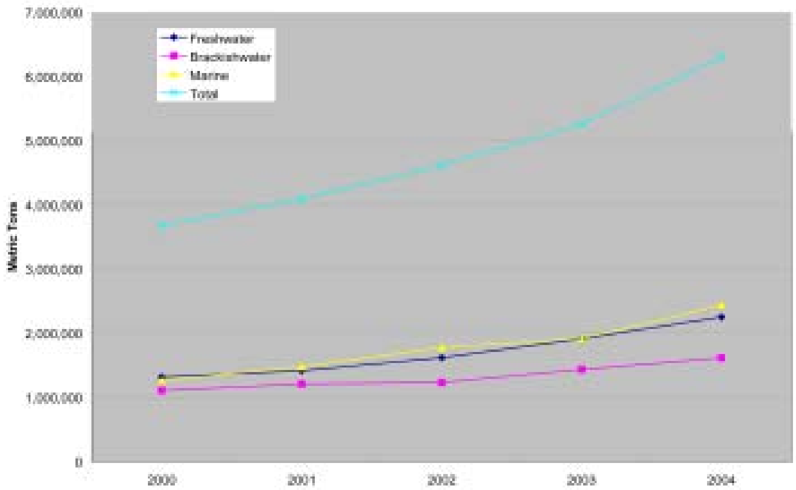


Figure 1. Aquaculture production volume (mt) in the ASEAN region by culture environments (Based on FAO FISHSTAT PLUS 2006)

dependent on the aquaculture industry. Women also make significant but often undervalued contribution to the aquaculture labor force, but there has been no recent information on this from the region. Nevertheless, it is clear that the aquaculture industry in the region contributes to food security, employment and foreign exchange generation.

Fish has always been an integral part of the traditional diet in the ASEAN countries. Assuming that in 2005 the total population in the region was 555.5 million (UN 2005 estimate), and assuming further that the apparent total per capita fish consumption remains constant at 23.4 kg (SEAFDEC Technical Document, ASEAN-SEAFDEC Conference, 2001), this means that the people from the ASEAN region need about 13 million mt of fish by 2005. Considering that the annual average growth rate of fish production from aquaculture is 14.5%, about 7.2 million mt of fish could be contributed from aquaculture in 2005 or about 55% of the fish requirement of the people in the region could be provided through aquaculture.

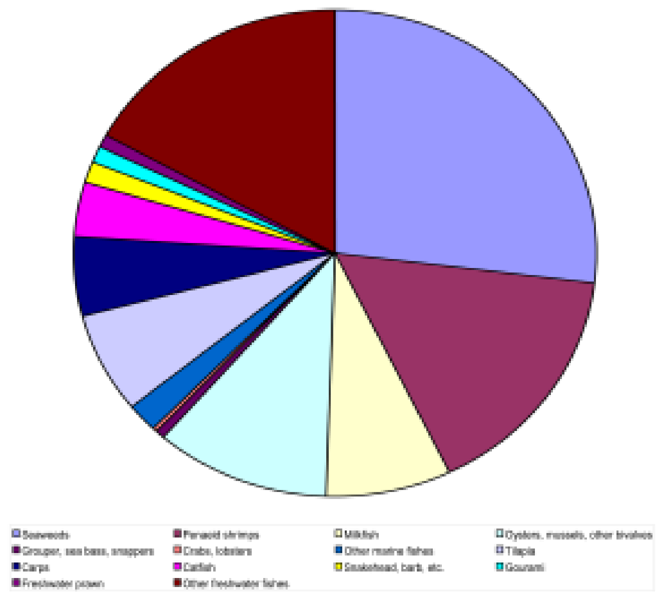


Figure 2. Aquaculture production in the ASEAN region by important commodities in 2004 (Based on FAO FISHSTAT PLUS 2006)

The impact of aquaculture on livelihood/employment cannot be easily quantified as there is no current uniform statistics in the region on the number of people directly employed or

Sustainable Aquaculture: Issues and Concerns

Aquaculture has the greatest potential to fill the gap between supply and demand for fish products. In order to make aquaculture a long-term strategy to contribute to the region's further growth and development, aquaculture should be sustainable, which means that it should not only be technically feasible and economically viable but should also be environment-friendly and socially equitable. There are key issues and concerns, however that should be addressed to make this possible.

In 2001, ASEAN and SEAFDEC organized the "Conference on Sustainable Fisheries for Food Security in the New Millennium". It was a consensus and awareness-building exercise on the issues arising from a series of consultations conducted in each ASEAN country prior to the Conference. It was designed to help develop regional fisheries policies and plan activities for achieving sustainable fisheries and increased supplies of fish and fishery products in the region. It covered the sectors on fisheries management, aquaculture and utilization of fish and fishery products. The Conference "Resolution on Sustainable Fisheries for Food Security for the ASEAN Region" was adopted by the ASEAN Ministers responsible for fisheries and the subsequent Plan of Action was adopted by their respective Senior Officials. The key technical issues and concerns as well as opportunities for sustainable aquaculture, based on the Conference proceedings, are discussed in this paper within context of aquaculture in the ASEAN.

Low quality and inconsistent supply of seeds

Seasonality and inconsistency of seed supply

The foundation of the aquaculture industry is the supply of seeds. The traditional source has been the wild fry or fingerlings that depend on the productivity of natural habitats. However, many of these habitats have become degraded resulting in scarcity of seed supply. This constrains aquaculture operations. To overcome these difficulties captive broodstocks have to be established. Such is the case for the broodstock of tiger shrimp, which are still mainly obtained from the wild and spawned in captivity.

Lack of technology for producing pathogen-free tiger shrimp broodstock drives some people in the shrimp industry to import exotic species that are advertised as pathogen-free. There is evidence in certain countries where introduction of so-called pathogen-free exotic shrimp species resulted in outbreak of a disease that was non-existent before the introduction. For captive broodstock of marine and freshwater species maturation and spawning is still mainly seasonal. Standardized and reliable techniques still have to be developed for year-round seed supply.

Captive broodstock have to be fed the right type and amount of diet to produce quality seeds. While nutrient requirements for many species have already been determined, basic knowledge gaps still remain. A variety of feeds are given to shrimp and fish larvae in hatchery rearing. These larval diets consist of combinations of formulated feed and live food organisms. In order to enhance the quality of hatchery-reared fry, there is a need to optimize diets, ensure their consistent quality, and should be cost effective. In anticipation

Captive P. monodon *as broodstock for larval production (top); and grouper fingerlings in the hatchery (right)*

Recommendations on supply of good quality seeds

1. Promote development of domesticated broodstock of economically important species
   a) Identify and prioritize species to be developed
   b) Encourage private sector production of good quality seeds through incentives like R & D support, marketing assistance and facilitating access to domesticated broodstock
2. Support and encourage R & D institutions to undertake programs in production of high quality seed on consistent and sustainable basis
   a) Develop domesticated broodstock with high levels of heritability of desirable traits
   b) Promote collaboration among government agencies, R & D institutions and industry
   c) Increase awareness on the genetic fitness of seed for stock enhancement and interactions and impacts on wild populations
3. Strengthen technology transfer mechanisms
   a) Simplify application of technology appropriate for small-scale hatcheries.
   b) Increase awareness of negative impacts of uncontrolled introduction of seed to open water bodies

of the availability of low-cost high quality and consistent supply of seed produced from captive broodstock, social implications on the wild seed industry need to be considered. Marginal fishers who depend on collection of wild seeds as livelihood will be most affected. Alternative livelihood opportunities needed to be instituted.

Impacts of releases of cultured seed stocks

Aquaculture stocks are increasingly used to enhance production in natural waters as degradation of habitats and excessive extraction of fishery stocks continue. There are concerns however, which must be addressed when releasing domesticated stocks to natural waters. These relate to genetic and ecological impacts of hatchery-bred stocks on wild stock populations. Seeds for aquaculture purposes requires characteristics of high survival and optimal performance under culture conditions. These characteristics are products of breeding protocols appropriate for domestication and not for release to the wild. The genetic requirements of stock for release differ from those for domestication.

The fitness to survive in the wild is the more important characteristic of seeds for release. Uncontrolled releases of hatchery stocks into the wild may result in introgressive hybridization in wild stocks. There are evidences that support the threat of these impacts on natural genetic resources. However, considering the need to enhance declining stocks, there are approaches that can be taken to minimize potential ecological impacts of the introduction of seeds. An example is the release of species native to the water body from where their broodstock originated. A policy and regulatory

The AQD technology verification laboratory, where R&D activities on aquaculture development are undertaken

framework should be developed to ensure more responsible stock enhancement programs.

In order to enhance the supply of good quality seeds, R&D on captive broodstock of economically important species should be intensified. Governments should develop policy and regulatory frameworks that recognize basic differences in reproductive protocol for producing seed for aquaculture and seed for stock enhancement. These frameworks should also provide for measures to mitigate loss of economic opportunity to marginal fishers who derive income from collection of wild seeds. The technology transfer mechanisms should be strengthened and this requires a more proactive role for government agencies, and research institutions in collaboration with the private sector.

Environmental Degradation

The ASEAN region has registered the rapid growth of aquaculture over the past two decades. This could be attributed to expansion in area and intensification of aquaculture systems. Expansion of aquaculture areas included conversion of large tracts of mangrove forests and swamps, and even coconut plantations, into fish and/or shrimp farms. For example, the total mangrove area in the Philippines decreased from 450,000 hectares in 1920 to only about 141,700 hectares in 1988 (Aypa and Bacongis, 2000). The resultant impacts are social and ecological. Loss of forestry and fish and fishery products, including wild seeds have implications on income of coastal dwellers derived from these resources. Ecological impacts include alterations to patterns of silt retention, land formation, erosion and loss of protection from storm surges. After damages have been done, it is now generally agreed that mangrove areas are poor sites for aquaculture because of acid sulfate soil problems.

Intensification involves high stocking of the cultured species per unit of production area. This requires feed inputs since the natural food organisms within the culture system cannot support the food requirements of the cultured fish. Feeding increases nutrient loads from fecal and non-fecal excretion and unconsumed feeds. Chemicals such as therapeutants, pesticides, herbicides, and inorganic nutrients are also commonly used to enhance productivity. When released directly into natural bodies of water these wastes and chemicals have polluting effects when the volumes exceed the carrying capacity of these waters.

Conversion of mangroves for shrimp farming in Thailand

It has also been a common practice for aquaculture farms to develop in clusters concentrated within a small geographic area like enclosed coastal waters with poor water exchange. This often leads to self-pollution where one farm's effluent becomes another farm's or even the same farm's intake. These problems may be attributed to lack of properly planned and regulated aquaculture development that should have a balance between economic development and environmental considerations. Since aquaculture development makes use of many resources like mangroves, water or sea areas that are common property, mechanisms should be in place to ensure that aquaculture development is planned in close consultation with other resource users. Approaches can include integrated coastal zone management with specific conditions on location and intensity of aquaculture, establishment of buffer zones and other considerations.

There are now available technologies and practices that would make aquaculture operations environment-friendly. The most effective approach is to prevent or reduce the discharge of pollutants. These technologies include integrated recirculating systems and treatment of wastes before discharge. Development of environment-friendly feeds with optimum nutritional characteristics and improvements in feed management can also minimize environmental impacts. The best approach to a successful aquaculture venture is to culture at the highest stocking density possible without degrading the environment. The trend toward environment-friendly aquaculture is also evident in the activities of the various aquaculture agencies and institutions in recent years.

However, these apparently still have no impact as serious environmental problems in the sector still remain. Limited budgets and the overriding desire to produce more impede

Recommendations on environment-friendly aquaculture

1. Promote development of environment-friendly aquaculture by encouraging the integrated system approach within the farm and in harmony with the environment
2. Support and encourage R&D institutions to undertake programs on advancement of environment-friendly technologies, to include formulation of non-polluting feeds and innovations in culture practices
3. Promote these technologies among the private sector through effective training, extension and demonstration
4. Encourage the private sector to adopt the Codes of Conduct for responsible aquaculture by developing economic incentives
5. Review and effectively implement regulations pertaining to penalizing environmental offenders
6. Develop zoning and resource-use plan based on the environmental carrying capacities of zones

the development of a totally environmentally responsible aquaculture sector. The profit motive orientation, voluntary nature of the code of practice for aquaculture, and weak monitoring and enforcement capabilities constrain the adoption of environment-friendly practices. Another is the people's attitude of careless disregard toward the environment and the ineffective enforcement of regulations to penalize the violators. In addition, some people, who are prepared to adopt environment-friendly practices, could not do so because of lack of financing in the re-construction of their farms to suit the innovations.

Research on environment-friendly technologies should be intensified, to include formulation of superior diets and innovations in culture practices that minimize polluted effluents. These innovations should be promoted among the private sector through effective training, extension and demonstration. The adoption by the private sector of the codes of conduct for fisheries and aquaculture should be hastened by developing economic incentives.

Importantly, there should be zoning and resource-use plan based on environmental carrying capacities of zones. Incentives should also be provided to encourage farmers to locate their farms within designated zones through the provision of infrastructure, training on best management practices, access to credit and marketing support and other related assistance.

"Fish Meal Trap"

Many cultured fish are carnivorous and require fish protein in their diets. Other types of fish, although less reliant on fish protein, also require fish products in their diets to satisfy certain nutritional requirements. This requirement is provided by feeding lower-value fish or fish meal-based feeds. The aquaculture industry is now at the stage where its further growth depends on the availability and supply of fishmeal and other fish-based products. This raises the issue of whether this is an effective way of using fishery products compared with using the same resources for direct human consumption. It is to be noted that a large proportion of total fishmeal supplies also goes to the formulated feed for terrestrial animals. This demand for fishery products is forecast to increase further to feed the cultured fish and other animals as well as humans.

For the sustained growth of the aquaculture industry it is imperative to look for suitable and cost-effective substitutes for fish meal and fishery products in fish diets. Research studies have shown the potential of alternative protein sources as fishmeal substitutes. Agricultural proteins, like vegetable and animal meals, have been incorporated in diets of several species and found to be cost-effective. Through biotechnology the potential of producing single-cell proteins with desired nutritional characteristics has been demonstrated. Enzyme treatments have also been shown to improve nutritive value of plant ingredients.

Recommendations on getting out of the "fish meal trap"

1. Review and implement policy and regulatory framework that addresses the issue of quality criteria and standards of manufactured aquaculture feeds
2. Encourage and support R & D initiatives to reduce dependence on fishmeal or other fishery products
   a) Encourage collaboration among R & D institutions and among different expertise in fish physiology and nutrition, crop science, biochemistry and chemical engineering
   b) Intensify research on suitable and cost effective substitutes for fish meal by using low-cost agricultural products
   c) Enhance nutrient characteristics of low-grade materials through biotechnology
   d) Improve feed formulations and feeding practices to reduce pollution in the farm and in effluents
   e) Integrate R & D efforts of private sector with those of national agencies and determine the optimal level of investment
3. Strengthen extension and technology transfer mechanisms that would include education on environmental impact of using inappropriate feeds and feeding practices and overfeeding

There are still other concerns in fish nutrition research that need further attention. One is how to raise the involvement of the feed producing private sector that is a direct beneficiary of the fish nutrition R&D. Another issue is at what optimal levels of funding and effort and in what particular areas of work should public agencies commit and concentrate on in terms of fish nutrition R&D given that the private sector, particularly the large scale feed producers and aquaculture operators, are also into it on their own.

There should be mechanisms to involve and integrate the R&D efforts of the private sector with those of the governments and determine the optimal level of investment into the program. There should also be a policy and regulatory framework that addresses the issue of quality criteria and standards for manufactured feeds. Furthermore, there should be proactive extension and technology transfer mechanisms that include education on environmental impact of using inappropriate feeds, feeding practices and overfeeding.

Diseases

One of the major concerns resulting from the rapid but poorly regulated development of aquaculture is the frequent occurrence of infectious diseases that have been bringing damage to crops amounting to hundreds of million USD. This concern includes disease control, food safety and environmental integrity.

Disease diagnosis and control

Identification and control of diseases requires reliable diagnostic methods. Diagnosis may be done with simple visual and microscopic examination for parasites or with more sophisticated tools and techniques such as cell lines of host animals and molecular-based techniques for viral diseases. Rapid assay field kits have been developed for a number of bacterial diseases. Improved diagnostic techniques should be pursued particularly for pathogens that are of high significance in the country. Operationalizing on-site fish health management industry-wide requires transfer of knowledge and awareness to farmers. This involves extension and delivery of health management concepts to the various sectors of the industry through formal and informal education. It is also necessary to build the capabilities for disease diagnosis at farm level in order to apply prevention and control measures.

For disease control, chemicals and therapeutants like pesticides, anti-fungal agents, antibiotics and disinfectants are commonly used. Very often these substances are administered by farmers not knowing that some are very toxic to humans. Improper use induces development of resistant pathogens in the cultured species, the human consumers and the environment. To minimize risks techniques for the proper use of these substances should be taught to farmers. Or better still disease control methods that are safe, like vaccination should be developed. This will reduce the use of anti-microbials.

In most instances, the occurrence of diseases in aquaculture systems is attributed to bad management practices that bring about deteriorated culture conditions. In order to prevent disease outbreak, innovations should be done. For example, the installation of influent reservoirs was found effective in controlling viral diseases. The use of "green water" and of beneficial bacteria as probiotics or bioaugmentation agent has been found effective in controlling luminous bacteria in shrimp ponds. The mechanism however, on why these innovations are effective are not clearly understood. These knowledge gaps need to be filled. These preventive measures have clearly high potentials to obviate the need for chemical inputs but there should still be considerable efforts toward further development and refinement.

Recommendations on controlling fish diseases and safeguarding quality of aquaculture products and environmental integrity

1. Develop improved diagnostic techniques for disease agents that are of high significance
   a) Harmonize diagnostic techniques to ensure standardized reporting.
   b) Implement mechanism for referral systems and designation of service reference laboratories
2. Develop human capabilities for disease diagnostics and control
   a) Identify qualified experts as members of coordinating team to provide essential services during disease outbreaks
   b) Provide mechanism for linkages between researchers, extension workers and farmers to build capabilities at farm level
3. Increase awareness of negative impacts of use of chemicals in aquaculture
   a) Establish policy and effectively implement regulation on the use of chemicals in aquaculture to include quality standards, labeling requirements and designated applications
   b) Teach farmers on proper use of chemicals
4. Support and encourage innovations in culture practices to prevent disease outbreak
   a) Promote physical and biological approaches to prevent disease outbreak in culture systems, integrating the culture of other economically important species
   b) Strengthen technology transfer mechanism to disseminate environment-friendly practices to farmers
5. Support research efforts on
   a) genetic improvement with disease resistance
   b) alternative disease prevention methods like vaccination, use of probiotics and bio-augmentation agents
6. A quality assurance and monitoring system should be developed and effectively implemented to ensure that aquaculture products are safe for human consumption and satisfy standard quality criteria
7. Effective implementation and enforcement of regulations regarding introduction and transfer of aquatic organisms that pose potential threat to (a) health of cultured and wild stocks, and (b) biodiversity. Accepted procedures are provided in the FAO "Asian regional technical guidelines on health management for the responsible movement of live aquatic animals" and the "Beijing consensus and implementing strategy."

Reporting System

An important component of a well-coordinated fish-health management program is a timely and efficient reporting system that would alert the various sectors of the industry on outbreak of any disease. This surveillance program should include human capability and laboratory resources to conduct diagnosis; standardized laboratory methods; reliable recording; proper management and reporting of data; and efficient flow of information from point of collection to the decision or policy-making level.

Public Health and Environment

Prevention of disease outbreaks should be the standard industry practice. However, in certain instances, it may be necessary to treat the cultured fish with antibiotics or other chemicals as a last resort. The presence of chemical residues and harmful microorganisms in the final fish products should be examined to ensure that these are safe for human consumption. A quality assurance and monitoring system should be developed and effectively implemented. The use of chemicals in aquaculture should be regulated and controlled.

Many of the chemicals now being used have not been evaluated with respect to their effects on non-target species and the aquatic environment, such as stability and persistence, formation of residues, accumulation in cultured fish, native biota and toxicity to non-target species and farm workers. This evaluation requires extensive research efforts. The presence of chemical residues and pathogens in the region's exported fish products can have negative implications on international trade and on the region's capability to meet international standards for food safety and quality. This should be given utmost attention since non-tariff barriers are now increasingly imposed by importing countries.

Ensuring continued growth and sustainability of aquaculture requires that culture management practices be adopted to produce healthy fish, to maintain environmental integrity and to ensure that aquaculture products are safe for human consumption. There should be effective implementation and enforcement of regulations regarding introduction and transfer of aquatic organisms that pose potential threat to (a) the health of cultured and wild stocks, and (b) biodiversity. There should be proper risk analysis prior to granting permission. The FAO "Asian regional technical guidelines on health management for the responsible movement of live aquatic animals" and the "Beijing consensus and implementation strategy" provide the accepted procedures for the risk analysis.

Samples of diseased marine fishes cultured in cages

There should be appropriate support for human and facility capacities to undertake fish disease diagnosis and control. Research efforts should be intensified in the following areas: (a) genetic improvement of stocks with disease resistance; (b) alternative disease prevention methods through probiotics, and bio-augmentation agents; and (c) more innovative culture practices that do not rely on chemicals. There should also be regulatory measures on the registration and classification of all chemicals used in aquaculture including quality standards, labeling requirements and designated applications. Most importantly, measures should be taken to ensure that aquaculture products meet food safety requirements.

Biotechnology

Biotechnology has been recognized as a promising strategy for attaining increased productivity in aquaculture. The benefits, however, should be carefully balanced against any risks to humans and the environment.

Biotechnology use in aquaculture

Hormones are commonly used in aquaculture to induce spawning of broodstocks, to enhance growth or for sex inversion. These hormones are mass-produced through recombinant DNA technology and industrial microbial fermentation. One area where biotechnology can also contribute to improvement of fish growth is through the use of probiotics. When incorporated into fish diets these enhances digestibility and nutrient availability. Beneficial microorganisms can also be used to hasten the breakdown of organic polluting substances in culture systems and metabolize them into benign compounds. The development

Recommendations on biotechnology

1. Develop critical mass of highly qualified experts, provided with necessary research infrastructure and adequate funding support
2. Encourage and support R & D programs that are targeted at improving productivity and sustainability of aquaculture to include:
   a) use of hormones
   b) probiotics and bio-augmentation
   c) immuno stimulants
   d) disease resistance
   e) disease diagnosis
3. Undertake awareness-raising initiatives including consultation with the various aquaculture stakeholders on the benefits and risks associated with the use and application of biotechnology products. The "ASEAN Guidelines on Risk Assessment of Agriculture-Related Genetically Modified Organism (GMOs)" address the issues on effects of GMOs on the environment.

of these improved strains of microorganisms can be hastened by the use of biotechnology, like selection through gene identification and genetics engineering. Biotechnology is also potentially useful in the search for alternative raw materials as replacement for fishmeal in fish diets. Research advances have demonstrated that the nutritional quality of some low-grade agricultural by-products can be enhanced through application of biotechnology.

Genetically Modified Organisms (GMOs)

While at the moment, aquaculture-based GMO research is not an urgent concern, it will expectedly become one in the future. Preemptive actions should therefore be considered with respect to food safety and human health, the environment and social impact from the use of GMOs in aquaculture. There should be open disclosure of information addressing the genuine concerns of the public with respect to benefits and risks of biotechnology. Ownership rights, particularly patenting of products and processes resulting from biotechnology research is an important issue confronting both developed and developing countries. The concerns related to this issue include monopolization of knowledge, restricted access to germplasm and increasing marginalization of majority of the population.

Despite ongoing concerns related to human and environmental safety of biotechnology products it appears that biotechnology can help in increasing productivity in aquaculture. But in order to realize the benefits from the various applications of biotechnology, it is required to develop the human and physical capacity to support the R&D programs and undertake awareness-raising initiatives related to the application of biotechnology. A well-coordinated national aquaculture biotechnology network is necessary to enable collaboration among various institutions concerned with biotechnology research and avoid duplication of efforts, thus optimizing use of limited research funds. It is also necessary to undertake awareness-raising activities including consultation with the various aquaculture stakeholders on the benefits and risks associated with the use and application of biotechnology products.

Strengthening institutional support

Institutional and regulatory frameworks have a very important role to play in enabling and supporting sustainable development and management of aquaculture. These provide the structure by which aquaculture related activities are governed. In order to effectively promote, support and regulate sustainable aquaculture, an institutional framework should be directed towards the objectives of an aquaculture policy.

Recommendations on strengthening institutional support

1. Improve the capabilities of some R & D institutions to conduct quality research and contribute to aquaculture development
2. Encourage fisherfolks to take on greater responsibility in developing and conserving fishery resources
3. Develop a clear and implementable aquaculture industry plan in consultation with all stakeholders to include:
   a) Land and water areas allotted to aquaculture
   b) Appropriate species for specific areas
   c) Carrying capacities of specific areas
   d) Infrastructure requirements
   e) Financial requirements
   f) Training and extension requirements
   g) R & D requirements
   h) Others

It should provide mechanisms for the involvement of non-governmental entities, i.e. the private sector, farmers, etc., in the management of aquaculture and in the enforcement of laws and regulations applicable to aquaculture. It should provide appropriate incentives aimed at developing and implementing best management practices, supporting implementation of effective environmental requirements and supporting maintenance and restoration of the environment. It should provide for regular monitoring and assessment of the aquaculture sector management using criteria provided for under the framework.

Sustainable Aquaculture: Opportunities for Development

Having been confronted with the foregoing and persistent issues and concerns SEAFDEC and the ASEAN through the ASEAN-SEAFDEC Fisheries Consultative Group (FCG) collaborative mechanism, approved the implementation by SEAFDEC Aquaculture Department (AQD) of important aquaculture projects intended to initially address the major issues and concerns. The projects offered opportunities for the development of sustainable aquaculture in the ASEAN region.

Mangrove-Friendly Shrimp Culture Project

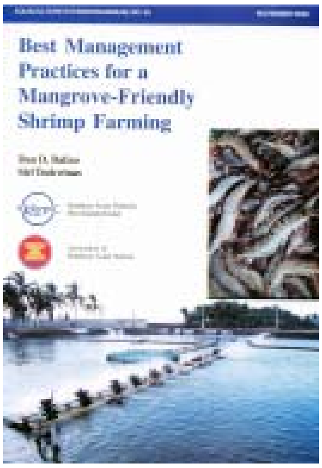
The five-year project, which started in May 2000, was aimed at developing sustainable shrimp culture technologies that are friendly to mangroves and the environment. During the span of five years, pilot demonstration activities were successfully implemented in Thailand, the Philippines, Vietnam, Myanmar, Cambodia, and Malaysia, where the viability of the culture techniques was determined and when necessary, the techniques were refined to adjust to the country's specific requirements. It was the project's desire

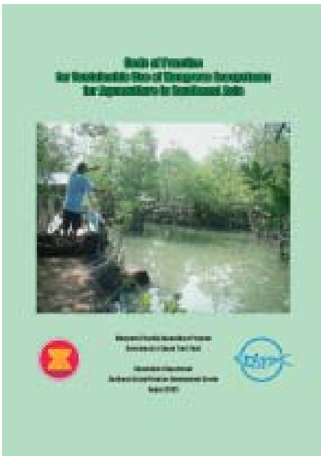
Mangrove-friendly crab culture project

for the countries to carry out on their own the shrimp culture innovations following the environment-friendly technology as suggested in the boxed Summary of Recommendations.

Parallel research activities were conducted at AQD to further refine the culture technology based on feedback and experience from the project's pilot demonstration sites. The techniques developed, verified and refined were disseminated through training at AQD and on-site in the member countries attended by a total of more than 100 participants. This number may be minimal with respect to the wide coverage of the project, but the knowledge gained by the trainees was also supplemented with extension manuals that were translated in major languages in the region for wider national usage. The training participants were expected to echo in their respective countries the knowledge they have derived from the project.

Another output of the project after a review of the policy issues relating to the use of mangroves for aquaculture in the region, was the publication and dissemination of the Code of Conduct for Sustainable Use of Mangrove Ecosystems for Aquaculture in Southeast Asia. The CoC took into consideration the principles prescribing the preferred ways of using mangrove ecosystems for aquaculture complementing certain articles in the Regional





Guidelines for Responsible Fisheries in Southeast Asia: Responsible Aquaculture. The Code includes recommendations for key legislation and enforcement mechanisms to ensure both responsible aquaculture and sustainable use of mangroves, considering that in the region, mangrove losses stemmed from the failures of policy as well as management and enforcement of protection measures.

Development of Fish Disease Inspection Methodologies for Artificially-bred Seeds

Implemented by AQD from 2000 to 2005, the project aimed to enhance disease diagnosis and health management of aquatic animals in aquaculture in order to promote healthy and wholesome trading of aquaculture products and the development of fish disease surveillance network for the region. As the main component of the project, research activities were conducted at AQD with some activities carried out in collaboration with the Department of Fisheries in Thailand and the SEAFDEC Marine Fisheries Research Department in Singapore.

The major achievements during the implementation of the project included establishment and standardization of diagnostic method for the White Spot Syndrome Virus (WSSV), which was responsible for the major collapse of the shrimp industry in the region during the mid-90s. The disease viruses found in cultured marine fishes, e.g., grouper, rabbitfish, were detected through the establishment of cell lines. These viruses have caused mass mortalities in marine fish culture. Husbandry techniques using live bacteria (probiotics) and "green water" culture technique were developed as alternative to chemotherapy to control luminous vibrosis in shrimp culture.

In order to secure safe supply of fish from aquaculture, the project developed and standardized the detection method for residual chemicals especially pesticides and antibiotics in aquaculture products. Specifically, the use of antibiotics in the region's shrimp aquaculture industry was closely monitored. In addition, the epizootiology of Koi Herpes Virus (KHV) was determined and the control of KHV was developed. KHV caused mass mortality of common carps cultured in the region posing threat to the region's freshwater aquaculture industry.

The established diagnostic methods have been disseminated to the region through manuals that reflect the findings from the research activities and the methods that have been established. Training, comprising a major component of the dissemination process, were conducted either formally at AQD or through AQD's On-line Training Program where the participants do not need to leave their work places as they can participate in the training through specialized modules developed by AQD using the internet.

What remains to be done now is the establishment of a well-coordinated surveillance program for timely and efficient reporting system on outbreak of any disease. The program, which includes development of human capability and laboratory resources to conduct diagnosis, is being facilitated through the second phase of the project which started in 2006, and is still ongoing. Meanwhile, the countries in the region that have gained knowledge through the project should continue their efforts in controlling aquatic diseases and safeguard the quality of their aquaculture products. Some suggestions on how to go about this are offered in the Summary of Recommendations.

Integrated Regional Aquaculture Program (IRAP)

Another opportunity offered to the ASEAN countries for their sustainable aquaculture development was the implementation of IRAP by AQD. The Aquaculture Component of the ASEAN-SEAFDEC Special Five-Year Program on Sustainable Fisheries in the ASEAN Region, IRAP was implemented from 2003 to 2005 with two components: (1) Aquaculture for Rural Development; and (2) Supply of Good Quality Seeds. IRAP was aimed at assuring a supply of quality seed stocks of various aquatic commodities; promoting environment-friendly aquaculture; and assuring that the development of aquaculture will benefit the rural populace through consultation, demonstration and dissemination of specific aquaculture technologies.

Since a number of species are being developed in the region for aquaculture in freshwater, brackishwater and marine environments, it was deemed necessary to prioritize the activities and species proposed by the ASEAN member countries (Table 3). In addition, common species with required technology identified by a number of countries were pooled in order to optimize resources, as in the case of the collaborative project on the genetic improvement and seed production of *Macrobrachium rosenbergii* implemented by Indonesia, Thailand, and the Philippines and coordinated by AQD as part of IRAP.

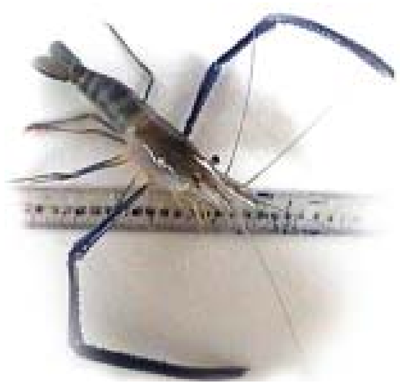


Table 3. Priority activities identified by ASEAN Member Countries for IRAP

Countries	Aquaculture for Rural Development	Supply of Good quality Seeds
Brunei Darussalam	Grow-out culture of *Macrobrachium rosenbergii*	Hatchery verification of *Macrobrachium rosenbergii*
Cambodia	Polyculture of indigenous freshwater fishes in ponds(e.g., *Pangasius* sp.)	Seed production of freshwater fishes (e.g., *Pangasius* sp.) as well important marine aquatic species
Indonesia	Catfish (*Pangasius* sp.) culture in rural areas	Genetic improvement of giant prawn (*Macrobrachium rosenbergii)* and seed production of abalone
Lao PDR	Aquaculture in rural areas (focusing on rice-fish culture)	Seed production of common carp, tilapia, etc.
Malaysia	Pen culture of tilapia, etc. (using improved technologies)	Production of disease-free grouper
Myanmar	Coastal aquaculture (grouper, sea bass and mud crab)	Seed production of marine fishes (e.g., grouper, sea bass and mud crab)
Philippines	Grow-out culture of *M. rosenbergii* in ponds	Genetic improvement and seed production of *M. rosenbergii*
Thailand	Cage culture of abalone and Babylonia shell	Genetic improvement and seed production of *M. rosenbergii*
Vietnam	Pond culture of milkfish and siganids	Seed production of milkfish and siganids

IRAP provided technical assistance in the pilot demonstration activities of the respective countries, where the services of appropriate ASEAN experts external to the participating country, were tapped to serve as technical resource persons. This ensured certain more advanced technologies developed by other ASEAN countries being easily adopted by another ASEAN country, making the transfer of technology faster. Through IRAP, the efficient mobilization of expertise in the region was successfully demonstrated.

Training, which was offered to assist the ASEAN countries in their respective pilot demonstration activities were of three types. The on-site training for technicians and farmers in beneficiary country utilizing expertise from other ASEAN countries with the requesting ASEAN country as host, maximizes the participation of more participants including the involvement of the host country's private sector, for a lesser cost. Training was also conducted at AQD for technologies that have been developed by AQD and conducted upon request from any ASEAN country. Attachment training was also arranged in other countries where specific technologies required by another country have already been developed, with the other ASEAN country as host and providing the necessary resource persons. This facilitated fast transfer of technologies from one country to the other countries in the region. During the on-site training, SEAFDEC's cost-sharing scheme was successfully promoted with the host country providing funds for the expenses of the trainees while IRAP provided the technical resource persons. The training sessions conducted through IRAP dealt with the various aspects of aquaculture involving a variety of aquatic species.

In the evaluation of IRAP in 2005, the ASEAN member countries expressed the need for some aspects of aquaculture to be developed further including the development of human capacity. The countries also recommended that in order to optimize resources, aquaculture technology packages known to be economically viable and well developed in one country should be considered for verification in another country. This was made as one of the basis for the development of the activities during the second phase of IRAP starting in 2006. Moreover, more activities related to human capacity building were also included in the plans for the second phase, which is ongoing.

Conclusion

Now that the countries have been equipped with the aquaculture technologies available through the initiatives of SEAFDEC, it is now the turn of the countries in the region to mobilize their resources to verify and adopt such technologies considering the suggested items in the Summary of Recommendations in their planning exercise. It is hoped that the projects implemented by SEAFDEC in the ASEAN countries after the Millennium Conference, paved the way for the sustainable development of aquaculture in the region.

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