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TOWARDS SUSTAINABLE AQUACULTURE IN THE PHILIPPINES

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Abstract

The Philippines has one of the highest per capita fish consumption in the world. However, in recent years the national total fish production could not meet this per capita requirement. There are three fishery resources, namely commercial and municipal fisheries and aquaculture, but only aquaculture offers the potential to fill the gap between increasing demand and supply. Further growth and development of aquaculture is faced with problems, which can jeopardize its sustainability. Sustainable aquaculture requires that these key constraints are properly addressed. It is only then that the potential for growth and sustainability of Philippine aquaculture can be realized.

Keywords: aquaculture, Philippines, food security, environment

Introduction

Fish has always been an integral part of the traditional diet in the Philippines, where about 15 million people, out of the ASEAN total of 65 million, are undernourished (Table 1). While the annual per capita fish consumption figure used by the government is 36 kg, the apparent per capita figure based on the 1997 FAO estimate was only 30.3 kg. Similarly, the figures were also lower at 28.4 kg in 1998 and 30.2 in 1999 (Table 2). The FAO estimates were based on Food Balance Sheets considering the net available fish supplies within countries. The FAO figures indicate that Philippine fisheries production could not meet the average per capita fish requirement. David (2002) noted that the growth rate of fisheries decelerated over time and was below the growth rate of population since the 1980s. Despite the lower figure on the apparent per capita fish consumption in 1997 fish contributed 42% of the total animal protein intake of Filipinos (Table 2).

Table 1. Prevalence of undernourishment in ASEAN countries

Country	Total population in 1997 (millions)	Number of undernourished people 1996-98 (millions)	Proportion of undernourished people of total population (%) 1996-1998	Proportion of undernourished people of total population (%) 1979-81
Cambodia	10.5	3.4	33	61
Indonesia	203.4	12.3	6	26
Lao PDR	5	1.5	29	32
Malaysia	21	0.5	...	4
Myanmar	43.9	3.1	7	19
Philippines	**71.4**	**15.2**	**21**	**27**
Thailand	59.7	12.2	21	25
Vietnam	76.4	16.5	22	33
TOTAL	491.3	64.7	13	26

Source: State of Food Insecurity in the World 2000 (FAO 2000a)

Table 2. Apparent per capita fish consumption estimates 1997-1999 (kg. live weight equivalent) and fish/animal proteins ratio in the ASEAN countries in 1997 (%)

	1997				1998	1999
Country	Apparent per capita fish consumption (kg)	Fish proteins (g per capita per day)	Animal Proteins (g per capita per day)	Fish/ animal proteins	Estimated apparent per capita fish consumption (kg)	Estimated apparent per capita fish consumption (kg)
Brunei Darussalam	21.8	5.9	42.7	14%	21.5	24.7
Cambodia	8.6	2.6	9.3	28%	7.8	20.1
Indonesia	18.2	6.4	12.1	53%	18.3	19.2
Lao PDR	8.9	2.6	8.7	30%	8.6	12.3
Malaysia	57.9	155	45.1	34%	55.0	58.6
Myanmar	16.0	4.1	9.2	45%	15.9	15.3
Philippines	**30.3**	**10**	**23.7**	**42%**	**28.4**	**30.2**
Singapore	28.5	7.5	48.9	15%	22.1	29.6
Thailand	33.7	102	24.6	41%	27.9	29.3
Vietnam	17.1	5.1	13.2	38%	17.8	19.4
Average ASEAN	22.9	7.2	16.8	45%	21.8	23.4

Source: FAO Food Balance Sheets including up-dated versions (by FIDI/FAO) of Laureti 1999. Estimate for Indonesia for 1998 and 1999 is based on production and trade data from FAO FISHSTAT Plus (2000).

Fish prices in recent years have risen more rapidly than those of other food products (Figure 1). The increasing trend in retail prices of eleven commonly consumed fish species in the Philippines from 1997 to 2001 is shown in Table 3. The rates of increase over the same period for these different species range from a low of 0.94% for tilapia and a high of 32.2% for *galunggong* (roundscad). This trend has serious implications on the affordability of the so-called poor man's diet. Many fish species that were considered staple food are now becoming luxury items.

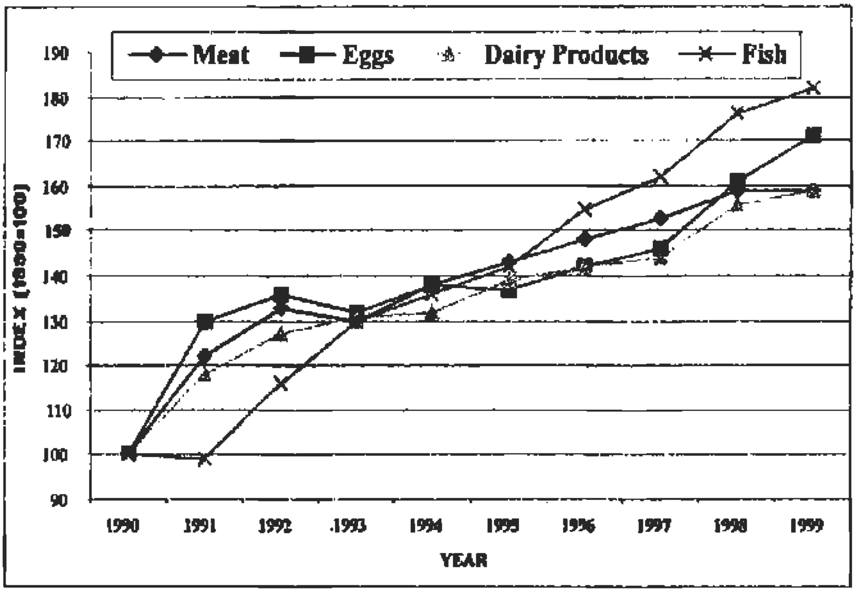

Figure 1. Price index of selected food items in the Philippines 1990-1998(1990=100)

Source: SEAFDEC Questionaires (2001). Index reculculated from the original base year 1994

Food security requires that household incomes are enough to purchase adequate food at reasonable prices. However, the contribution of fisheries to the attainment of food security involved, in most cases, activities that bring about negative impacts, i.e. overfishing, destructive fishing, pollution, mangrove destruction, etc. These impacts threaten the sustainability of fisheries production.

Table 3. Retail Prices of Selected Fish Species, Philippines, 1997-2001 (Pesos per Kilogram)

SPECIES	1997	1998	1999	2000	2001
1.Indian mackerel (alumahan)	60.88	61.68	64.76	67.46	70.72
2.Milkfish (Bangus)	74.55	79.58	79.58	81.45	82.50
3.Threadfin bream (Bisugo)	75.66	77.81	82.45	85.78	91.34
4.Caesio (Dalagang Bukid)	76.43	78.63	85.26	87.90	93.08
5.Anchovies (Dilis)	44.14	44.94	46.72	47.96	50.21
6.Roundscad (Galunggong)	44.97	47.42	53.41	54.90	59.44
7.Slipmouth (Sapsap)	58.93	59.92	60.64	68.39	71.58
8.Tiger prawn (Sugpo)	274.04	310.83	317.90	330.75	351.25
9.Tilapia	58.62	59.71	68.27	58.58	59.17
10.Frigate tune (Tulingan)	46.29	48.97	51.29	52.65	57.30
11.Blue crab (Alimasag)	74.22	77.35	82.24	88.75	97.96

Source: Agricultural Marketing Statistical Analysis Division (AMSAD), BAS, 2002

This paper reviews the performance of Philippine fisheries showing that aquaculture offers the greatest potential for increased fisheries production. It then discusses key issues and concerns that constrain increased aquaculture production and sustainability, identifies other potential areas for development and finally presents recommendations for the long-term sustainability of Philippine aquaculture.

Philippine Fisheries and Aquaculture

The Philippine fisheries production resources are classified as commercial, municipal and aquaculture. Municipal fisheries have been on the decline since 1992 and even if ever it recovers, it is unlikely that it would get back to its level before the 1990's (Figure 2). Commercial fisheries are leveling off and it is believed that increasing further capture efficiency would no longer be sustainable. Production from aquaculture surpassed municipal and commercial fisheries in 1996. Furthermore, on the average during the 1991-2002 period, aquaculture was the fastest growing sector even though its growth rates were negative in 1997 to 1998.

Aquaculture production in 2001 was 1.22 million metric tons valued at 36.88 billion pesos. It contributed 38.5% by volume and 34.4% by value to the total fisheries production volume and value, respectively. The 2001 production volume represents a 10.86% growth over the 2000 production.

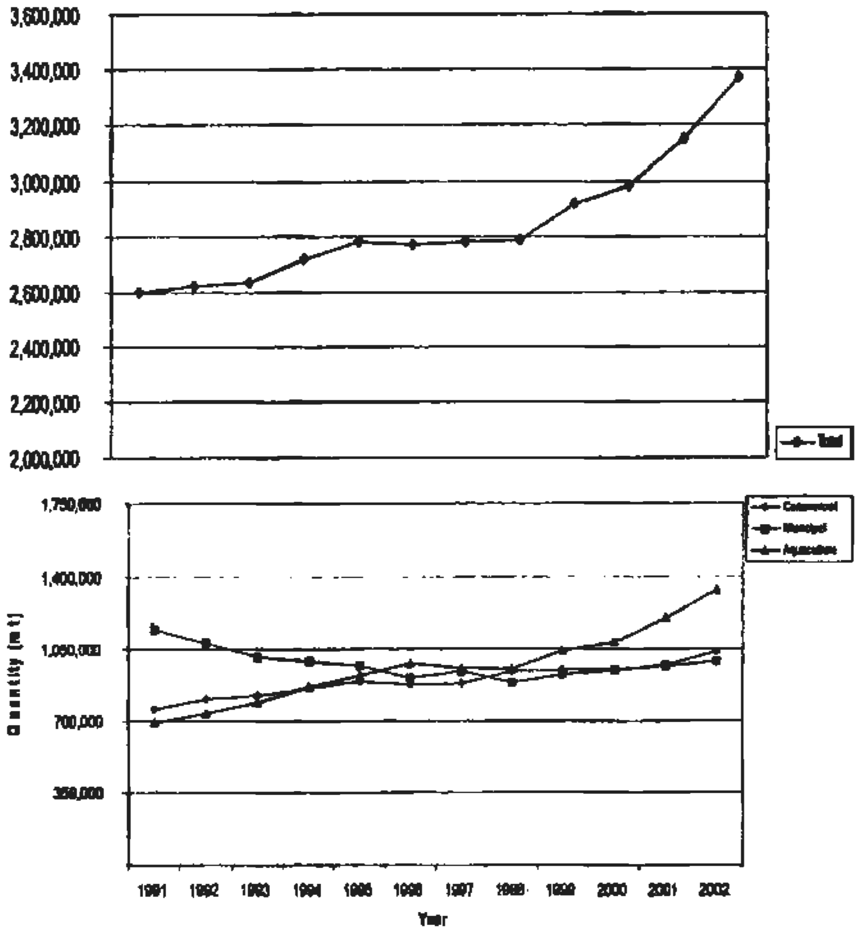

Figure 2. Total volume of fish production by sector, Philippines, 1991-2002
Source: BAS Fisheries Statistics of the Philippines 1997-2001, On- line Fisheries Statistics 2002

Philippine aquaculture production systems are located either in freshwater, brackishwater or marine environments. Of the three production systems, mariculture and brackishwater pond culture contributed most to the volume of production in 2001 (Table 4). The major aquaculture species were milkfish, tilapia, prawn, carp, seaweeds and oyster/mussels. Other species include mud crab, grouper, siganid, mudfish, catfish, snapper and lobster. Seaweed was the most important mariculture product contributing 64% to total aquaculture production while milkfish and prawns were the most significant in brackishwater aquaculture. Freshwater aquaculture was dominated by tilapia raised in ponds and cages.

Table 4. Production volume and value of Major Species by Aquacultural Systems (2001), MT

Species	Total Volume	Total Value ('000 P)	Freshwater			Brackish water			Marine		
	MT		Pond	Pen	Cage	Pond	Pen	Cage	Open	Pen	Cage
Milkfish	225,337	12,998,794	16	2,835	951	211,594				5,659	4,282
Tilapia	106,746	5,134,041	54,312	2,147	40,779	9,499				2	7
Prawn	40,698	13,600,020				40,698					
Carp	19,568	404,983	292	18,945	331						
Seaweeds	785,795	3,179,647							785,795		
Oyster/ Mussel	32,555	246,934							32,555		
Subtotal	1,210,699	35,564,419	54,312	23,927	40,779	261,791			837,472	5,661	42,189
Others	9,757	1,318,916									
Total	1,220,456	36,883415									

Source: Fisheries Statistics of the Philippines, 1997-2001

There was significant increase in production of some of the major species in the last few years. Milkfish production grew at an average annual rate of 10.5% from 1997-2001; tilapia at 16.0% from 1998-2001; seaweed at 4.9% from 1997-2001 and carp at an impressive 232% from 1997-2001.

In 2001, the total fisheries exports amounted to 159,069 metric tons valued at 22.7 billion pesos. Of the total exported products, 54,554 metric tons or 34% were prawns and seaweeds which are mainly aquaculture products (Table 5). This is equivalent to 43.3% of total fishery export value.

The impact of aquaculture on livelihood/employment cannot be easily quantified as there is no current statistics on the number of people directly employed or dependent on the aquaculture industry. The employment figure of 258,480 has been used by BFAR since 1987. Since that time there has been expansion in aquaculture production areas of different culture systems, such as pens and cages. De Jesus (2002) showed that during the period 1993-2000, the annual growth rate in fishpen area was 102.90%, in fishcage it was 84.11% while in fishpond it was 25.75%. The increase in fishpen and fishcage areas may be taken to mean new aquaculture ventures that involved setting up of new culture facilities. The increase in fishpond production area may however, include rehabilitation of previously developed but unutilized ponds, particularly in areas where farmers left their pond for some time because of lahar damage or frequent occurrence of fish/prawn diseases.

Table 5. Major Fishery Exports, 2001

SPECIES	VOLUME (mt)	VALUE ('000 P)
Shrimp/prawn	13,301	6,291,498
Tuna	56,752	5,871,128
Seaweeds	41,253	3,539,523
Others	47,763	7,021,059
Total exports	159,069	22,723,208

Source: Fisheries Statistics of the Philippines, 1997-2001

Even considering only the increase in the number of fishpens and fishcages, there would have been a significant increase in the employment figure as pen and cage operations are even more labor-intensive than in ponds.

In addition, the steady growth of the seaweed industry which was 9.38% annually during the period from 1981-2000 would have also contributed to the additional aquaculture labor force.

It should also be noted that women make significant but often undervalued contribution to fisheries, aquaculture, fish processing and marketing.

Clearly, the Philippine aquaculture industry contributes to food security, employment and foreign exchange generation.

Sustainable Aquaculture: Issues and Concerns

Aquaculture has been shown to offer the greatest potential to fill the gap between supply and demand for fish products. In order to make aquaculture a more meaningful long-term strategy to contribute to the country'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 on aquaculture, based on the Conference proceedings, are discussed in this paper within context of Philippine aquaculture.

1. Low quality and inconsistent supply of seeds

1.a *Seasonality and inconsistency of seed supply*

The foundation of the aquaculture industry is the supply of seed. 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. The broodstock of tiger shrimp 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 smuggle into the country 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 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.

There are several R&D institutions in the country that consider fish breeding as an important component of aquaculture development. Research on fish breeding has a long history at SEAFDEC AQD. It has been involved in developing technologies for the maintenance of broodstock and seed production for various fish species. Currently, it is conducting studies on genetic characterization of different generations of hatchery-bred tilapia and bighead carp, genetic analysis of other indigenous species, and genetic variation on wild population of prawns to serve as baseline information for the eventual captive broodstock development.

The current efforts on the development of improved breeds of tilapia by BFAR, CLSU, SEAFDEC and several groups from the private sector are encouraging signs for the tilapia industry. The entry of several major aquaculture companies into the milkfish hatchery business gives the major push for the industrialization of the milkfish hatchery. This is further enhanced by PCAMRD/DOST-BFAR program on establishment of core-satellite milkfish hatcheries in certain sites of the country.

A major problem in fish breeding R&D is insufficient funds for the purpose. The maintenance of broodstocks, hatcheries and related facilities in particular has been taxing for SEAFDEC AQD. It should be mentioned that for some time in the past, BFAR also maintained its National Bangus Breeding Program (NBBP) but was forced to privatize it due to funding problems related to maintenance. There is also a need to account for the activities of the private sector in fish breeding, particularly for some species like milkfish and tilapia, and integrate these into a national program for fish breeding. There should also be strict implementation of relevant laws related to import of exotic species into the country. While the efforts of BFAR on the confiscation and destruction of smuggled non-indigenous species upon entry in international airports are recognized, the cooperation of the private sector is also necessary.

1.b *Impacts of releases of cultural 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. A case in point is the introduction of tilapia in Lake Lanao which has decimated the endemic cyprinid species found nowhere else.

Beyond the impact of introduction of exotic species, seed 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 and eventually into outbreeding depression among genetically diverse wild stock populations.

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 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. These different species should be prioritized and scarce research funds be pooled to give more focus in the conduct of research and hasten generation of technologies. The government should take into account all fish breeding activities of the private sector and include this into the overall fish breeding and genetics program in the country.

Government 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.

2. Environmental degradation

The rapid growth of aquaculture over the past two decades was achieved through (a) expansion in area; and (b) intensification of aquaculture systems (de Jesus, 2002). Expansion of aquaculture areas included conversion of large tracts of mangrove forests and swamps, and even coconut plantations, into fish and/or shrimp farms. The total mangrove area in the Philippines decreased from 450,000 hectares in 1920 to only about 141,700 hectares in 1988 (Aypa & Bacongis, 2000). The resultant impacts are social and ecological. Loss of forestry and fish and fishery products, including wild seed 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.

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.

RA 8550, the Philippine Fisheries Code of 1998 and the Agriculture and Fisheries Modernization Act (AFMA) have various provisions for aquaculture that pertain to environmental sustainability. The trend toward environment-friendly aquaculture is also evident in the activities of the various aquaculture agencies and institutions in recent years.

Even with the many activities that are now being pursued, 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 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 of both the national and local governments 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. The system for penalizing environmental offenders in aquaculture should be reviewed and make it an effective deterrent for potential offenders as well as punishment for actual ones.

Importantly, there should be a national zoning and resource-use plan based on environmental carrying capacities of zones. The government should also provide incentives 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.

3. "Fishmeal 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 fishmeal-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.

In 2001, the Philippines' top imported fish product was fish meal (Table 6) sourced from Peru, Chile and the U.S.A. Imported fish meal was 84,546 metric tons, about 47% by volume and 41.5% by value, respectively, of the total fishery imports.

If prices of fishery products for human consumption become higher than that for fishmeal, this could divert supplies from fishmeal production into human food supply. This will then decrease the availability of fish-based resources for fishmeal production. For the sustained growth of the aquaculture industry it is imperative to look for suitable and cost-effective substitutes for fishmeal in fish diets.

Table 6. Major Fishery Imports, 2001

SPECIES	VOLUME (mt)	VALUE ('000 P)
Fish Meal	84,546	1,585,071
Tuna	19,340	442,296
Mackerel	23,123	355,861
Sardines	24,292	299,551
Squid/Cuttlefish	12,760	303,245
Others	15,933	829,186
Total imports	179,994	3,815,210

Source: Fisheries Statistics of the Philippines, 1997-2001

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.

Although research results so far are encouraging, the search for raw materials as substitutes for fishmeal is still faced with major difficulties. An example is phytate, one form of phosphorus in plants, which fish cannot digest. This form of phosphorus is excreted and adds to pollution. This highlights the need for more intensive R&D efforts.

There are still other concerns in fish nutrition research that need further attention. One is how to raise the involvement, particularly in funding, of the feed producing private sector that is a direct beneficiary of 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. Because of the limited resources for R & D, there should be mechanisms to involve and integrate the R & D efforts of the private sector with those of the government and determine the optimal level of investment into the program.

There should 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.

4. 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 millions of pesos. This concern includes disease control, food safety and environmental integrity.

4.a *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 allocate institutional, laboratory and human resources to form linkages between researchers, extension workers and farmers. These will 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, 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 is 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.

4.b *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 to be adopted by all laboratories involved in the program; reliable recording; management and reporting of data; efficient flow of information from point of collection to the decision or policy-making level.

4.c *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 farmworkers. This evaluation requires extensive research efforts.

The presence of chemical residues and pathogens in our exported fish products can have negative implications on international trade and on our 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 "Asia regional technical guidelines on health management for the responsible movement of live aquatic animals and the Beijing consensus and implementation strategy" provides the accepted procedures for the risk analysis.

There should be appropriate support for human and facility capacities to undertake fish disease diagnosis and control. This includes identifying qualified experts as members of a coordinating team to provide essential services during disease outbreaks. 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.

5. 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.

5.a *Biotechnology use in aquaculture*

Hormones are commonly used in aquaculture to induce spawning of broodstocks, to enhance growth or for sex inversion. These hormone preparations still have to be imported since these are not yet produced locally. These hormones are mass-produced through recombinant DNA technology and industrial microbial fermentation. It is of note that SEAFDEC Aquaculture Department is conducting research on this field and is starting production of recombinant fish growth hormones at the laboratory scale.

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 of these improved strains of microorganisms can be hastened by the use of biotechnology, like selection through gene identification and genetic 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.

5.b *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. The concerns on human health should be addressed by a concerted effort between government, academe and industry to engage in open dialogue with farmers and consumers. There should be open disclosure of information addressing the genuine concerns of the public with respect to benefits and risks of biotechnology.

The issues on the effect and interactions of aquaculture-based GMOs on the environment are already addressed through the provisions of the "ASEAN Guidelines on Risk Assessment of Agriculture-Related Genetically Modified Organisms (GMOs).

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. For example, there is wariness of multi-nationals seeking to patent any genetic material they find. The Philippines for its part has already developed guidelines on bio-prospecting, particularly voiding all deals giving multi-nationals the right to isolate and patent genetic material from Philippine flora and fauna.

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 within the country, support R&D programs and undertake awareness-raising initiatives related to the application of biotechnology.

A critical mass of highly qualified experts should be developed, provided with the necessary research infrastructure to conduct biotechnology-based R & D. 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.

6. 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. It should clearly identify the agencies and their respective responsibilities in relation to the development, operation and management of aquaculture. 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.

The two most important laws that currently serve as the policy bases for the development of the fisheries sector are RA 8550 or the Philippine Fisheries Code and RA 8435 or the Agriculture and Fisheries Modernization Act (AFMA). The RA 8550 was passed to properly develop, manage and ensure aquatic species and the fisheries sector. It identified the Bureau of Fisheries and Aquatic Resources (BFAR) under the Department of Agriculture (DA) to manage the aquaculture sector as well as the commercial fisheries. The Local Government Units (LGUs) manage the municipal fisheries. Other government institutions were also identified in relation to their functions as to R & D, training and extension, management, law enforcement and others.

From the time these two laws were passed up to the present, these have not been fully implemented due to under-funding. Besides, specifically, RA 8550 has some conflicting provisions, like for example, aquaculture in lakes is prohibited under one provision while specific guidelines on maximum lake area that can be used for aquaculture is provided for in another section. There are also provisions that are still being contested by opposing groups.

Even with RA 8550 and AFMA serving as legal and policy bases for aquaculture development as well as with the respective strategies and plans of the various institutions and agencies for their specific responsibilities, it appears that the policy and institutional frameworks have not been effective in addressing the concerns of aquaculture development. David (2002) presented an assessment of the performance of the agriculture sector that includes fisheries. She stated that "Overall, the policy and institutional framework governing the agricultural sector have not provided the appropriate incentive structure, enabling environment, and level and quality of public goods and support services necessary to promote an efficient and sustainable growth path."

Israel (1999) pointed out that one of the problems of the present institutional arrangement for aquaculture is the weak and poor collaboration among government R & D agencies. PCAMRD is tasked to plan, monitor, evaluate and coordinate overall fisheries R & D while the Bureau of Agricultural Research (BAR) and the Ecosystem Research and Development Bureau (ERDB) coordinate fisheries research of regional offices and line agencies of their respective departments. Potential overlapping exists among the three agencies because of similarity in functions and constituency. Attempt to thresh out this problem through Memoranda of Agreements (MOA) has been hampered by poor collaboration.

Another institutional problem is the possible duplication of functions of the National Fisheries Research and Development Institute (NFRDI), a new agency created under RA 8550 as the research arm of BFAR, and the PCAMRD. The issue of which agency and department should the task of managing, coordinating and implementing R & D fall is still unsettled and creates institutional inefficiencies.

One important issue relating to R & D in fisheries is under-funding. David (2002) noted that the research intensity ratio (RIR) for fishery research is low at only 0.35%. This figure is even lower (0.12%) especially if the international funding commitment to SEAFDEC AQD is excluded (Table 7). Overall, public expenditures for R & D represent only 0.4% of gross value added in agriculture compared with an average of 1% among developing countries and 2-3% among developed countries.

This brings into focus the role of SEAFDEC AQD in Philippine fisheries R & D. As a regional organization, SEAFDEC AQD program of work is formulated through consultation with member countries. Since all members are located in practically the same climatic zone and have similar species of interest, the regional needs are basically the same as the national needs. Besides, as host of the Aquaculture Department, the Philippine government can exercise the prerogative of having the national priorities included in AQD's program of work. This is institutionalized through the Philippine Technical and Administrative Committee for SEAFDEC AQD chaired by the Secretary of the Department of Agriculture. Furthermore, through a system of consultation and discussion with the industry and local R & D institutions, SEAFDEC AQD prioritizes its programs avoiding duplication of work with local institutions. SEAFDEC AQD's senior research staff consists of 29 with Ph.D.s and 30 with M.Sc.s. Research outputs are published mostly in international refereed journals. Mature technologies are commercialized in collaboration with BFAR, through the Joint Mission on Accelerated Nationwide Technology Transfer Program, as well as with the industry, NGOs LGUs, financial institutions and farmers. Experiences in technology transfer in the host country are later replicated in other member countries.

Table 7. Indicative estimates of research intensity ratio by commodity 1994-1996 (%)

	RIR
Overall (excluding SEAFDEC)	0.41
(including SEAFDEC)	0.45
Rice	0.25
Corn	0.05
Sugar	0.50
Coconut	0.30
Fiber crops	2.50-3.00
Cotton	25.00
Abaca	1.00
Tobacco	1.10
Livestock	0.15
Carabao	3.60
Other livestock	0.02
Fishery (excluding SEAFDEC)	0.12
(including SEAFDEC)	0.35
Forestry	3.50

Source: David, Cristina C. et. al. "Philippine Agricultural and Natural Resource Allocation Issues and Directions for Reforms," Discussion Paper No. 99-33, Philippine Institute for Development Studies 1998.

SEAFDEC AQD had significantly bigger expenditure support compared to others because of the large infrastructure and capital investment components associated with research. The budgetary allocation to SEAFDEC AQD does not consist only of direct research expenses but also includes salaries of R & D as well as support administrative staff, maintenance of facilities and operation of life support systems, training and information, technology transfer and other activities.

Using only the actual expenditures specifically just on research activities, Israel (2002) showed that SEAFDEC AQD had lower expenditures per completed and published research study compared with similar institutions in agriculture. After evaluating how individual R & D institutions perform one of their most important functions, that is, to generate written research output and have it adequately published he showed that some fisheries R & D institutions performed better than others. This highlights another issue of the need to improve the capabilities of some fisheries R &

D institutions to conduct quality research and contribute to fisheries development.

Another key constraint to aquaculture development is the weak linkage between research or technology generation and utilization. This is the major cause for the slow commercialization of newly developed technologies or innovations. This is manifested by the immense gap between the level of technology as developed in R & D institutions and the level of production technology actually used by farmers.

These institutional problems should be properly addressed soonest because in times of economic difficulty and budget deficits, additional funding into R & D and extension would be a drain from the government's budget and would not result in significant increase in productivity.

The reconstitution of BFAR into a line bureau after a long time as a staff agency now entails more comprehensive and more technical functions. With these more demanding functions, the capability of the regional offices should be strengthened. There should be upgrading of staff capability to conduct functions like providing development support services, advisory services and technical assistance on aquaculture-related activities.

RA 8550 also created the Fisheries and Aquatic Resources Management Councils (FARMCs) that shall be formed by fisherfolk organizations/ cooperatives and NGOs in the locality with the assistance of the LGUs. As of now, there are many coastal communities with still unorganized FARMCs. Even with the provision in the Code that before organizing FARMCs, the LGUs, NGOs, fisherfolk, and other concerned POs shall undergo consultation and orientation on the formation of FARMCs, there should still be continuing education to enhance internalizing of responsibilities especially by fisherfolks.

To strengthen the institutional framework for sustainable aquaculture, the government should decisively settle the conflicting and the contentious provisions in RA 8550 and the AFMA: clarify and streamline the overlapping/ duplication of functions of agencies; improve the capabilities of some fisheries R & D institutions to conduct quality research and contribute to aquaculture development; strengthen BFAR regional capabilities; and encourage fisherfolks to take on greater responsibility in developing and conserving fishery resources.

Opportunities for Future Development

The Philippine aquaculture industry has considerable opportunity for growth. The productivity of already developed areas has great room for improvement and there are still other areas that can be tapped for aquaculture production. These potentials for growth would not only make the Philippines self-sufficient in fish but would also create further opportunities for employment and foreign exchange generation.

The average productivity of brackishwater ponds in 2001 was only about 1.1 tons/hectare/yr. This figure is too low considering the state-of-the-art in production technologies for milkfish and prawn, which are two major species raised in brackishwater ponds. An environment-friendly zero-discharge recirculating prawn pond production system has been demonstrated to produce 5 to10 tons per hectare (Baliao, 2000). The holding capacity of intensive milkfish ponds, in order that the nutrient load in the discharged effluents would not exceed the assimilation capacity of receiving waters, was determined to be 5 tons per hectare (Sumagaysay-Chavoso, 2003). By just adopting the currently available improved and environment-friendly production technologies for milkfish and prawn, brackishwater pond production can be increased to at least five times the present production volume.

There are other resources that have not been fully tapped for aquaculture production. Yap (1999) suggested the promotion of (a) rice-fish culture in the country's irrigated rice farm areas: (b) mangrove pen culture; (c) cage culture in coastal or municipal waters; and (d) increase in production areas for oysters and mussels.

Rice-fish culture has high potential in the Philippines with some 1.5 million hectares of irrigated rice farms. This particular culture system had been introduced in the country earlier but there was lack of acceptance among farmers because of several reasons, like inadequate water supply from the irrigation system, incompatibility with the use of pesticide, relatively shorter culture period of rice compared with time needed for fish to grow to optimum market size, and lack of fingerlings at the time needed. With the government's intensified efforts in improving irrigation facilities and with appropriate production management practices that could address problems earlier encountered, there is now higher probability of success.

The culture of mud crab in net enclosures set in mangrove areas without cutting a single tree has been demonstrated by SEAFDEC AQD in several sites in the country. One hectare of such system can produce about 1,400 kg of crabs or a gross sales of about P280,000.

It has been estimated that only 3.9% of the available area are being used for oyster farming and only 4.6% for mussel farming (Yap, 1999). The main problem of the oyster and mussel farming is the red tide, which affects not the production system but only the wholesomeness of the product and thus its marketability temporarily. Effectively addressing the economic needs of the mussel and oysters farmers during that period can result in increased interest in the product and therefore the total production.

As the catch from municipal waters has been declining, fisherfolks can be encouraged to shift to aquaculture as an alternative means of livelihood. A possible venture is fish cage culture. With proper regulation, this can be made sustainable.

A constraint in the promotion of sea cages is the cost of the cages and the mooring system. This can be addressed by establishment of a mariculture park, a concept which envisions that the government or private entrepreneur provides the mooring facilities and other related infrastructure while aquaculture operators pay the lease for the mooring spaces they occupy. With this arrangement, government can effectively regulate the number and sizes of cages as the distances between the cages will be pre-determined by the location of mooring buoys and since no cages will be allowed to operate outside the park.

As land areas become more expensive due to competing uses, the sea remains as the last frontier for aquaculture development. Through the establishment of mariculture parks, this development can be made sustainable.

In addition, Philippine aquaculture should diversify to include not only food fish but also ornamental fish and other marine plants or organisms that are potential sources of pharmaceutical and other industrial products.

Technical expertise required

Over the years, the Philippines has been exporting aquaculture experts and technicians to manage and operate various aquaculture installations in different countries, like Indonesia, Iran, Saudi Arabia, Madagascar, India, and others. There is also a good number of fisheries schools, colleges and universities in the country offering degree and advanced courses in aquaculture. There is a highly qualified pool of scientists working in various R & D institutions, including the government-hosted SEAFDEC AQD. On top of all these is the strong tradition of aquaculture in the country which dates back to perhaps even before the arrival of Magellan.

Summary of Recommendations

On supply of good quality seeds

1. Promote development of domesticated broodstock of economically important species
   a) Identify and prioritize species that need government support
   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, R & D institutions and industry
   c) Understanding 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.

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 a national zoning and resource-use plan based on the environmental carrying capacities of zones.

On getting out of the "fishmeal trap"

1. Review and implement the 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 the private sector with those of the government and determine the optimal level of investment into the program.
3. Strengthen extension and technology transfer mechanisms that would include education on environmental impact of using inappropriate feeds and feeding practices and overfeeding.

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 "Asia regional technical guidelines on health management for the responsible movement of live aquatic animals and the Beijing consensus and implementing strategy."

On biotechnology

1. Develop critical mass of highly qualified exerts, 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.

On strengthening institutional support

1. Government should settle the conflicting and the contentious provisions in the Philippine Fisheries Code and Agriculture and Fisheries Modernization Act.
2. Clarify and streamline the overlapping/duplication of functions of agencies.
3. Improve the capabilities of some R & D institutions to conduct quality research and contribute to aquaculture development.
4. Strengthen BFAR regional capabilities.
5. Encourage fisherfolks to take on greater responsibility in developing and conserving fishery resources.
6. 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

The plan should include clear and specific objectives that are to be attained by corresponding specific and clear strategies.

Concluding Remarks

The prospects are bright for increased productivity and sustainability of Philippine aquaculture. There are now available technologies that are environment-friendly. There are research-based information that can guide all sectors of the industry to effectively plan and manage their respective activities. We have a highly capable pool of experts who can work on raising further the levels of productivity within sustainable limits. We are not lacking in natural resources. But we need to have all sectors of the industry to work together and address the industry's key constraints. We need to consolidate all these individual capabilities into a larger sense of community – the aquaculture community.

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