PHILMINAQ

Mitigating Impact from Aquaculture in the Philippines

PHILMINAQ final activity, recommendations and conclusions report

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Summary of the activities of PHILMINAQ and major achievements

The project has built competence within marine science for monitoring and modelling aquaculture impacts on the environment. This has been achieved by developing three levels of monitoring/ surveys, developing hydrodynamic and depositional models to be used as tools for planning (locating sites) and optimisation of production (carrying capacity of sites), and setting up a network of marine scientists nationally and between Philippine scientists and European scientists.

The project has built capacity within the Government agencies to manage sustainable aquaculture development. This has been achieved by encouraging inter-agency discussions (BFAR, DENR and DILG), developing a Joint Administrative Order for clarification of the roles and jurisdiction of the agencies for environmental management of aquaculture, developing Guidelines for Local Government Units for planning, managing, monitoring and controlling aquaculture development, developing a GIS database of aquatic ecosystems, sensitive habitats, etc., by training Government University staff in aquaculture impacts, monitoring methodology, predictive modelling of aquaculture impact and ways of mitigating impacts and encouraging networking between Philippine Regulators and their counterparts in Scotland and Norway.

The project has preparing a Guidebook for Local Government Units (LGUs), Better management practice guidelines for LGUs and better practice guidelines for small-scale fish cage and fish pen operators. It has prepared review papers on Environmental Impact studies for aquaculture projects in the Philippines, water quality criteria and standards internationally and regionally giving recommendations for changes to the Philippine water quality criteria for aquaculture. It is reviewing fish food quality standards internationally and regionally giving recommendations for changes to the Philippine feed quality for aquaculture.

Overview of Asian Aquaculture

Asia-Pacific represents the most important region for fisheries and aquaculture production. It has a number of states with the highest per capita consumption. The source of fish in the diet of rural people in this region is gradually changing. Rural populations that were once almost entirely dependent upon inland or coastal-nearshore capture fisheries for their food have seen the decline of fisheries resources through environmental changes and changing water management regimes. This trend is also accompanied by rising prices for fish.

Aquaculture production in the Asia-Pacific region

The Asia-Pacific region is the world's largest contributor to world aquaculture, producing 46.9 million tons1 or 91 % of global aquaculture production. In terms of production by value, the region’s share is slightly less, at 82 % of total value of global aquaculture production. Even when aquatic plant production is excluded (the vast majority of which originates in the Asia-Pacific area), the region still remains the dominant aquaculture production area, representing 89% of global aquaculture production by quantity and 80% by value.

The growth of aquaculture production in the region has been very strong for the last ten years, resulting mainly from increased production from China (annual growth rate of 13.8%).

Both inland culture and mariculture showed steady growth but the growth rate of the inland culture sector was more rapid. China alone reported to have produced 36.6 million tons or 79% of the world's aquaculture production in 2002 (including aquatic plants).

Even excluding China3, the Asia-Pacific region still remains an important production area for aquaculture, exhibiting steady growth regardless of the culture environment. In particular, output from inland culture doubled from 1 854 000 tons in 1990 to 4 478 000 tons in 2002. Such advances far exceed the growth of aquaculture in the rest of the world.

Southeast Asia
Aquaculture production in Southeast Asia is diversified, comprising 39% of freshwater fish, 29% of aquatic plants, 13% of crustaceans, 13% of marine/diadromous fishes and 7% of molluscs (by quantity). In terms value, highly priced crustaceans constituted an increased share of 49% of the total production, followed by freshwater fish at 35%. The growth trend is particularly strong for freshwater finfish culture, which has increased from 564 000 tons in 1990 to 1 556 000 tons in 2002 with an average annual increment of 83 000 tons. In the mariculture sub-sector, aquatic plants showed surprising production growth. Crustaceans have been a major cultured species throughout the sub-region, although this has declined since 2000, but appears to have picked up again beginning 2005.

Zanzibar weed (Eucheuma cottonii) is the most widely cultured aquatic plant in the region with a production of 778 000 tons in 2002. Apart from aquatic plants, Giant tiger shrimp (Penaeus monodon) maintained the position of top produced species until 2001, although very recently the massive increase in production of P. vannamei is challenging this position. P. monodon production decreased sharply in 2002, back to the production level of 1992.

Challenges and approaches
Three major challenges confront aquaculture: sustainable economic growth, environmental stewardship, and equitable distribution of benefits. An effective response to these challenges requires a coherent interplay of private investment and stewardship of public goods. By fostering partnerships and providing access to finance and resources, the international community can assist developing countries to meet these challenges along two intertwined axes of intervention: good governance and knowledge generation and dissemination.

Good governance and creation of an enabling environment
An effective governance framework will embrace policies and regulations molded by a clear vision of the future for aquaculture and a map to realize that vision.

The **policy framework** will address issues of equity and strategy including:

- principles for use and allocation of the public domain (lakes, reservoirs, sea areas and freshwater supplies),
- any socially-required balance between small-holder and large-scale aquaculture;
- coherence with other policies and strategies such as those on poverty alleviation, industrial
- development, water and land use, rights of indigenous peoples, or regional priorities;
- environmental sustainability, including mitigation of social and environmental

externalities;
- clear definition of the roles of the public and private sectors;
- sector leadership and coordination; and
- fiscal regime for aquaculture.

Ideally, a **national aquaculture plan and strategy** will mainstream aquaculture into key planning and policy instruments such as poverty reduction strategies, foreign direct investment policies and rural development strategies. It will create space for aquaculture in the physical planning processes and coastal zone and water management plans. A national plan has a vital role in creating an attractive investment climate and inter-agency coordination, essential to overcome the dynamic nature of an emerging industry where public authority is dispersed across sectors, agencies and disciplines. A participatory process to prepare such national strategies and plans builds awareness will guide diagnostics, forge a shared public-private vision and build partnerships among government agencies, and with the private sector, producer groups and NGOs.

Good governance will draw on **codes of practice and best management practices** (BMPs) to inform and implement policies and plans. Examples of these norms include: the FAO's Code of Conduct for Responsible Fisheries (CCRF) and its accompanying Technical Guidelines; the International Principles for Responsible Shrimp Farming, OIE's International Aquatic Animal Health Code, SEAFDEC's regional CCRF, the code of conduct for the sustainable management of mangrove forest ecosystems and others. Experience shows that while the application of these codes may raise production costs, the increased returns from healthy and sustainable aquafarms more than justifies the costs.

The **regulatory and administrative regime** will draw on the policies to set out the rights and obligations of fish farmers. The regime may specify among others:
- obligation to acquire permits or licenses to establish a farm, based on responsible physical planning for aquaculture, including zoning and safeguarding critical habitats
- measures to protect the environment, including environmental impact assessments, audits,
- environmental monitoring (including benchmarking) and internalizing the cost of environmental impacts
- control and enforcement mechanisms and penalties or means to redress damage
- formal processes for stakeholder consultation with adequate provisions for transparency and involvement of civil society organizations
- standards for aquaculture practices and animal health and certification systems for the health and safety of aquaculture food products and the quality of seeds and feeds

Mechanisms for sector governance

Promotion of aquaculture has largely met little problem in most parts of Asia. On the other hand, if a certain aquaculture venture turns out to be profitable, governments had often found it difficult to control or stop runaway development until a catastrophic mass mortality and other related problems occur. Viewed in this light, industry growth is self-limiting. The problem is not so much promotion as management. Beyond issuance of permits and licenses governments in Asia-Pacific are increasingly realizing the need to protect the environment and manage aquaculture resources in a sustainable manner. In New Caledonia for instance a rigid system of self-regulation applying to all prawn farmers (P. stylirostris) has been put in place in order for the industry to meet the high quality standards demanded of its niche markets in Japan and France.

In some countries, governments have introduced quality betterment systems and better practices for aquaculture and have supported the implementation of Hazard Analysis and Critical Control Points (HACCP), qualification and training of Good Aquaculture Production Practices (BPPA), ISO 9 000 certification (quality), ISO 14 000 certification (environment), rules and regulations, and product chains schemes. Similarly, in other cases, independent companies and producers associations have established standards and regulations or codes of conduct under Clean Production Agreements (APL) for salmon, shrimp and tilapia production, post larvae production, processing, etc. Steps are being taken to set up traceability systems for fisheries and aquaculture products.

Better management practices

One of the arguments for BMPs is that they pay for themselves. They would also benefit the environment, especially BMPs that include effluent treatment, less use of drugs, less use of trash fish, or less use of seed caught from the wild.

A research-extension pilot project in India on developing and promoting best health management practices among small shrimp farmers organized into self-help groups also highlights the importance of farmers being organized to be able to adopt cost-effectively best practices that improve their yield and the quality of their produce. The results are described in more detail in Section 6 (NACA Annual Report, 2005).

Co-management

Co management is an emerging trend and the concept has mostly been described through its application in the management of common resources and mostly at the community level. A review of co-management is included here to shed some light into the existing and potential ways by which it is applied to the aquaculture sector. This review is from L. Carlsson and F. Berkes. 2005.

Co-management is ‘the term given to governance systems that combine state control with local, decentralized decision making and accountability and which, ideally, combine the strengths and mitigate the weaknesses of each.

The World Bank has defined co-management as ‘the sharing of responsibilities, rights and duties between the primary stakeholders, in particular, local communities and the nation state; a decentralized approach to decision making that involves the local users in the decision making process as equals with the nation-state. The same definition was adopted by the World Conservation Congress: ‘a partnership in which government agencies, local communities and resource users, nongovernmental organizations and other stakeholders negotiate, as appropriate to each context, the authority and responsibility for the management of a specific area or set of resources’. This latter regards the State as only one among a set of stakeholders.

Two different models try to conceptualize co-management between “folk-managed” systems and state managed systems. On the one hand there is a ‘horizontal continuum from nearly total self-management to nearly total state management’. On the other there is a ‘vertical contracting out model of state management’ power, which is characterized by devolution of rights. These are not mutually exclusive and are based on a dichotomy comprised by something called the State and local resource users.

Recommendations for dealing with Social and Environmental Impacts
Internalizing costs. Better and more responsible management practices would avoid or mitigate the impacts on society. Such practices are enforced by legislation or adopted on a voluntary basis; they should have to be based on acceptable science-based standards and subject to monitoring. Compliance with regulations and adoption of better management practices would necessarily entail cost to aquaculture. Having the aquaculturist shoulder the cost of preventing the farm effluent from polluting the environment is essentially not passing on that cost to society. The farmer can install and pay for pollution abatement measures, or he is taxed and the revenue is used to support measures that either encourage farmers not to pollute or clean up the pollution or compensate society for the damage caused by pollution.

Adoption of better management practices. The results from a shrimp health management project in India of NACA and the Marine Export Development Authority of the Ministry of Commerce, in which better health management practices were adopted by organized farmer groups, give support to Clay’s statement that BMPs pay for themselves. It is described in more detail under Section 8.

Better yields and profitability apart, and contrary to a number of reservations (C. Bene. 2005), the projects are providing indications that BMP adoption is not a problem for small-scale farmers that are well-organized. Being organized has enabled them to attain economy of scale to be able to adhere to best practices. Technical assistance from government is increasing their awareness, and organizational capacity and, if not yet marketing skills, the growing awareness that in being organized and responsible, they are in a stronger position to transact with suppliers and buyers. They are not yet participating in a certification and labeling scheme, but that is the next step envisioned for the project, and which the farmers themselves have asked to be initiated.

BMPs have been argued as a technical solution and, as such, ignore the political and social issues related to shrimp farming. Apart from the fact that the BMPs (in the Indian shrimp health management project) do not focus only on technical solutions, the projects have engendered harmony and cooperation among players in the market chain.

While Clay says BMPs can pay for themselves, he does advocate support for small farmers to make the transition into better management practices, rather than leaving this to the market alone. Government subsidies in the short term would provide incentives for their adoption, adding that regulatory and permitting systems can also encourage the identification and adoption of these practices.

Integrating aquaculture in rural development plans. There are negative consequences from aquaculture that are not the result of bad practices but are associated with power structures in the community and the capacities of institutions. Among these are the exclusion of the poor from taking part or in being physically removed from aquaculture, resource appropriation by elites and the politically powerful sectors, and conflicts and violence. The negative consequences associated with a weak institutional context include poor linkages, coordination, and coherence between sectors, unclear or overlapping mandates, unclear public/private sector responsibilities, uncertainties in tenure, property and user rights, weak regulatory regimes and enforcement capacity, rent seeking, ineffective communication, and little involvement of primary stakeholders in policy and programme formulation concerning the sector. Without some form of intervention short term financial perspectives tend to dominate environmental and social issues (Graham Haylor and Simon Bland. 2001. "Integrating Aquaculture into Rural Development." In R.P. Subasinghe et.al. Technical Proceedings of the Conference on Aquaculture in the Third Millennium. NACA Bangkok and FAO Rome)

In this regard, Haylor and Bland argue for such interventions to be strategically planned. A generic recommendation is to integrate aquaculture in rural development planning which should come with sound governance, strengthening of institutions including farmer associations, provisions for multi-stakeholder participation, be people-oriented, and with a multi-sectoral agenda.

Creating opportunities for the participation of the poor. Few aquaculture development initiatives reach the poorest. Aquaculture, the argument goes, requires resources such as land, ponds, water, credit, and other inputs, by definition those involved in aquaculture are not the very poor. In this regard, an FAO/NACA consultation in 2002 collated experiences that clearly demonstrate that if aquaculture is properly planned there are considerable opportunities for poor people's entry (Friend, R. F. Funge-Smith, S. J., 2002. Focusing Small-scale Aquaculture and Aquatic Resource Management on Poverty Alleviation. FAO RAP/NACA, Bangkok Thailand.).

When aimed at poverty reduction, development assistance should be targeted carefully by clearly defining the intended beneficiaries and devising appropriate strategies to help them benefit. The assistance needs to recognize specific and prevalent features of poverty among the intended beneficiaries, including the means of overcoming key barriers for entry into aquaculture and adoption of technologies, and to mitigate risks to which the poor are particularly vulnerable. The ADB (2004) studies of small-scale freshwater aquaculture in Bangladesh, Philippines and Thailand yielded strategies for targeting the small and poor households, as follows:

> **Access to land and water.** Access to land and water is the key requisite for fish farming. Conventional aquaculture development initiatives that emphasize the promotion of technology and provision of targeted extension services are unlikely to reach the functionally landless and the extremely poor. Without access to land and water, the poorest are unlikely to engage in fish farming directly.

Access to other livelihood assets. Access to financial and human capital assets is necessary for households to benefit from aquaculture. The ability to pay for pond development and fish farming, including seed and feed, requires financial capital, access to credit or both. Human capital, in terms of basic education and capacity to learn, is required for people to gain from training and extension services.

Leasing a pond. When the landless gain access to water bodies or ponds through lease or other access arrangements for fish farming, secure access rights are critical. Without binding and long-term agreements on access rights, fish farmers are vulnerable. Demonstrated profitability of fish farming may also increase the price of pond leasing because of an increasing demand for fishponds by entrepreneurs. With annual pond leases going very high, the financial barrier for entry into aquaculture by the landless is significant. Further, the profitability of fish farming may entice landowners to operate fishponds on their own or through caretaker arrangements, and this affects the possibility of renewal of pond leases for landless people without long-term and secure tenure rights.

Pond Sharing. With the growing rural population and large number of dependents per family (typically, a family has 5–8 members), land inheritance leads to a multiple ownership of fishponds, presenting an array of issues related to co-ownership and collective action among shareholders. Arguably, many of the issues related to underutilized or derelict fishponds stem from the social dimensions of multiple ownership, when cost sharing, benefit distribution, and assignment of responsibilities and accountabilities for pond management become difficult.

Living marginally with risks. Marginal farmers or the marginally poor with access to limited amounts of land can still benefit from small-scale aquaculture but they have significant constraints in accessing resources. Most direct beneficiaries of fish seed and grow out technologies in Bangladesh are not the poorest people. Small-scale landholders with fishponds may have limited assets and may not be categorized as marginally poor or the poorest, but most small-scale landholders are only precariously above the poverty line.

Labor and cash inputs. Although fish farming technologies can offer potential solutions for the landless poor who can secure access to water bodies, there may be socioeconomic constraints: feeding fish in small cages may require several hours of daily labor for food gathering, preparation, and feeding; and returns from fish farming are often highly seasonal. When the scale of operations increases, feed requirements cannot be always met by pond fertilization and collection of feed from the immediate vicinity. Supplementary feed may require cash outlays, which the poorest cannot easily afford. Lack of cash and difficulties in accessing credit are major barriers for the poor to undertaking aquaculture on their own. Different interests in the use of the water bodies may result in social conflicts; the poor frequently lose out under such circumstances.

Theft. Fishpond owners and cage operators often face the threat of poaching. Risk from theft increases when fishponds or cages are far from farmers' households. Surveillance requires labor inputs for which the returns are not immediate. These constraints have limited the feasibility of fish farming to some extent, especially among households headed by females, who, on their own, are unable to protect their assets against an unfavorable social environment.

Stakeholders' involvement in governance. In the ultimate, preventing conflict is the most effective way of addressing social impacts. This brings into focus the concept and practice of stakeholder involvement in policy making, planning and management (Sevaly Sen.2001. "Involving stakeholders in aquaculture policy-making, planning and management". In: RP Subasinghe, et al Technical Proceedings of the Conference on Aquaculture in the Third Millennium). Stakeholder involvement has arisen out of a new general development model that seeks a different role for the state, which is based on pluralistic structures, political legitimacy and consensus. It is based on the assumption that greater information and broader experiences make it easier to develop and implement realistic policies and plans, new initiatives can be embedded into existing legitimate local institutions, there is less opposition and greater political support, local capacities are developed, and political interference is minimized.

Enabling the small and poor farmers and aquatic users to have a voice in policy and planning mitigates the inadvertent effect of policies and programmes of marginalizing the poor and weak. This has been a keystone of the STREAM Initiative (established in 2001as a NACA primary programme element by a multi-agency collaboration that includes FAO, DFID, NACA and VSO, an international NGO). A growing body of lessons includes effective ways to organize and strengthen organizations or groups of poor people so that they become partners to government, development agencies and civil society in identifying potentials and developing solutions to improve aquaculture and aquatic resources management.

Well defined rights. Finally, while the above refers to a stakeholder role of the State, it also highlights a fundamental role of governance, which is to ensure that basic rights of individuals and the welfare of the public take precedence over that of interest groups. Defining basic rules to impartially arbitrate among potentially conflicting interests may prevent many of the conflicts from arising in the first place. (Denis Bailly and Rolf Willmann. "Promoting Sustainable Aquaculture through Economic and other Incentives." In: RP Subasinghe, et al Technical Proceedings of the Conference on Aquaculture in the Third Millennium. NACA Bangkok and FAO Rome).

Legislation on integrated coastal area management, defining access rights and limitations to various types of activities, and recognizing basic individual rights such as access to shore or water with specific properties would help private and public promoters of aquaculture development plan their activities with more security and more informed basis for decisions. Well-defined individual or collective rights act as incentive where those who have rights, either on the side of the aquaculture promoter or on the part of another interested party, can use them for persuasion or can claim them in front of jurisdiction capable of enforcement.

Focus on the Farmer. Development plans invariably stress that the farmer is both the reason for and the key player in rural development. At the risk of putting theory before evidence, but also to see how the elements of the work program are supporting the farmers, let us consider what a farmer's basic goals could be. These are:

- Higher yield
- Lower costs
- Better economic returns
- Less risk

In addition, s/he must satisfy the basic demand of the consumer for a product that is safe, at a price that is affordable, and supplied in enough quantities at a time that they are needed in the form and state that are wanted. On top of these, society requires that s/he produces without polluting the surroundings, without exploiting farm workers, if any, and as much as possible without tampering with other living things in the wild. Other conditions are in the horizon that include keeping the fish in comfort.

To achieve his four objectives in the light of market access requirements, the entire range of practical concerns of a farmer would now include:

- reducing the risk of losing a crop from pest and disease and other reasons
- reducing the risk of losing money from ill-informed choices of what to farm, how to farm and how and when to sell, in what form and at what volume
- assurance of a reliable supply of preferably hatchery-bred viable and healthy seed
- information on other ways of farming that offer the prospect of raising a better crop, and potentially earning more money from it
- knowledge in producing and selling fish that is wholesome and safe to eat, and leaves the surroundings clean
- opportunities to work with other farmers and other workers to better comply with safety requirements on his fish and the manner in which they are farmed
- options for him and fellow farmers in the development of better ways of managing their farms, and harvesting and marketing their products
- opportunity to work with others in identifying his production problems and the ability to look for or work out solutions for them
- skills to do all the above, and further opportunities to improve those skills
- collective ability to deal with suppliers of farm inputs and buyers of their product
- skills and tools to determine what is the best option for him and his family to earn a living
- opportunity to express his views in policy and development planning

Satisfying these would keep the farmer in business.

Staying in business. Society's interest in keeping the farmer in business is to continuously enjoy the supply of his produce. Reciprocally, it is in the farmer's interest to satisfy what society requires. In this light, helping the farmer stay in the farming business is a social responsibility.

But apprehension has been expressed, at the Aquaculture Trade and Market Access

Workshop (Manila 2003), that the increasing number and stringency of market requirements could drive the poor, small farmers – unable to comply with all these requirements -- out of farming. And studies have shown that difficult access to capital and the high capital requirements for certain technologies and farming systems either make it difficult for the poor to enter or could eventually marginalize the poor farmers (Ahmed, M. et.al. 1994).

These two factors – high capital needed to adopt technologies and high cost of compliance with market requirements -- raise the specter in Asia (where more than 80% of fish farmers are small) of hundreds of thousands of displaced and unemployed farmers, or farmers turned laborers in what used to be their farms now consolidated by some corporate giant.

Sustainability and making a profit. Farming can only be sustainable if the farmer wants to keep on farming. There is no plausible reason in a democratic environment for any farmer to want to keep on farming other than to benefit from it. Making a profit is nothing to make excuses about. To paraphrase management guru Peter Drucker, a farmer who succeeds in business, who earns a profit to pay for production costs, for his family's living, and for their future security is a responsible farmer. It is the one who fails to make a profit and fails in faming (or makes profit by taking short cuts whose costs society ends up paying for) who is not.

Empowerment and reward. In this regard, a sustainable aquaculture program should emphasize and strengthen the system of support that enables the farmer to play a stronger and active role in the social and economic processes that impact on his livelihood. This simply means empowering him, and assuring that for staying in business, he is justifiably rewarded.

From the rural development arena to the global market place

Competitiveness. Between satisfying the farmer's objectives and meeting the demands of the consumer and the rest of society stands an economic mechanism called the market. Its basic function is to make compatible the goals of the producer on one hand, and the needs of the consumer and requirements of society, on the other. Globalization however has raised the question as to whether the market mechanism alone can enable this compatibility, without distorting its mechanism to favor the farmer, as with a subsidy. As market distorting gratuities are discouraged, the acceptable way to go is for farmers to have a better capacity to comply. This underlines the importance of farmers being organized to attain economy of scale and acquire a stronger power to transact with suppliers and buyers.

Limited resources. Another reality facing farmers is having to do more with less. At the FAO workshop in Iran in September 2005 to review aquaculture development in Asia, one of the trends identified by the meeting was the continuing intensification of aquaculture. This is a short simple statement that embodies a complex train of events and linked factors. What it simply indicates is that farmers and the sector, to reach their basic goals of producing and earning more will now have to do with a lot less: less land, less freshwater, less or inferior biological resources, probably less financial resources. This too needs technical and economic efficiency and attaining economy of scale.

> These are some hard evidence of the advantages of being organized and adopting better management practices from NACA-assisted projects in India and Vietnam and a analysis of the implementation of Good Aquaculture Practices and Code of Conduct on Shrimp aquaculture in Thailand.

To sum up, for farmers, and users and gatherers of aquatic resources, being organized into a formal association or a self-help group is to collectively achieve a strong capacity to enter and stay in aquaculture, effectively demand and absorb institutional services and technical assistance, cope with natural hazards and economic risks, address barriers to property and financial access, and acquire and effectively use capital and operating assets (ADB, 2005).

Aquaculture development in the Philippines

Over the last two decades from the 1980s, aquaculture in the Philippines surpassed several major historical changes in policies brought about by major legislations dictated by both the local pressures from all stakeholders and supported by regional and international agreements/resolutions and covenants. The last decade of the 19^{th} century saw a major paradigm shifts towards conservation and management versus expansion and exploitation and sustainability over expanded production (Lopez, 2004). It was also in the 1980s when decentralization of national policies were devolved to local governments (LGUs) when Republic Act 7140 was enacted and came into force followed by Republic Act 8435, otherwise known as Agriculture and Fisheries Modernization Act of 1997 (AFMA) calling for maximized and sustained utilization of production areas towards local industrialization.

Major shifts in management direction in fisheries and aquaculture of the country was only realized in 1998 when the new Fisheries Code was adapted, of which socioeconomic impact were only felt in the millennium years from 2000 onward. These developments and new trends in management policies resulted from the convergent external and internal pressures out of regional agreements amongst the Asian states known to be the worlds major aquaculture producers all over the world (Millennium Agreements) supported and guided over the international FAO guidelines on the Code of Conduct for Responsible Fisheries (FAO-CCRF). The local scenario on the other hand saw a restrictive implementations of all if not both the Local Government Code of 1991, strengthened by the AFMA Code of 1997 and superseded by enforcements of projects under the Fisheries Code of 1998.

Total fishery production increased at an average annual rate of 2.5% between 1990 and 2002. There have been modest increases in commercial capture fisheries (2.5% per year increase over the period 1990-2002). However, most of this increase was brought about by very large increases in aquaculture production (more than 6% annual production increase over this period). The Philippines now contributes only a little over 1% of global farmed fish production compared to 5% previously. The global position of Philippines in aquaculture production has fallen from 4th place in 1985 to 12th place today.

In 2002, the total aquaculture production was 1,338,178 mt valued at US $ 2,264,880,000 (Bureau of Agricultural Statistics, 2002). In 2002, milkfish from brackishwater pond, pen and cage had average yields of 0.71 mt/ha, 56.19 mt/ha and 171.37 mt/ha, respectively. Shrimp from brackishwater pond had average yield of 0.46 mt/ha. Tilapia from freshwater pond and freshwater cage had average yields of 3.37 mt/ha and 18.34 mt/ha, respectively. Carp from freshwater fish pen, fish cage and fishpond had average yields of 5.44 mt/ha, 2.52 mt/ha and 1.72 mt/ha. Seaweeds from open coastal waters had average yield of 42.05 mt/ha.

Contribution to the Economy

Currently, around 18% of the food fish supply comes from aquaculture. Milkfish and tilapia represent the bulk of aquaculture production. Their combined production in 2002 of 364,289 mt represents 8-9% of total animal meat consumption. From 1998 to 2002, milkfish and tilapia production registered an annual average growth of 11.7% as compared to only 2.6% for capture fisheries. The prospects for further increasing aquaculture production are therefore enormous. In the last 5 years, abundant production from aquaculture has made farmed fish increasingly more affordable compared to wild-caught fish. Over a 10-year period, milkfish and tilapia prices increased by an average of 3.4% and 1.7% respectively, as compared to 7.3% for the small pelagic roundscad (Cruz, 2004).

Although the Bureau of Fisheries and Aquatic Resources has been using 258,480 as the employment figure for aquaculture since 1987, the industry estimates employment generation higher than that figure. In the seaweed industry alone, the Seaweed Industry Association of the Philippines claims that in 2002 there were 1,017,925 individuals engaged in seaweed farming (Monzales, 2003).

In 2002, SIAP reported an export earning of US$ 138,438,853 from seaweeds. Seaweed farming does not require high investment and yet the return of investment is high. The yield from a one-hectare seaweed farm can be as much as 48 mt (wet weight) in two months (Guerrero, 2003). Aside from seaweed farming, oyster and mussel farming can also be a source of livelihood for coastal communities. Though it may not be the main source, it can contribute significantly to household income and food. Women and children can also participate (Gallardo, 2001). A productivity of 5,000 kg/ha in 6-7 months for oysters is reported. Using nylon nets, a hectare of mussel farm in Manila Bay can yield 180 mt in four months (Guerrero, 2003).

Aquaculture indeed can contribute significantly to food security, employment and foreign exchange generation.

Human Resources and Employment

There is no recent comprehensive census on the human resources in the aquaculture industry today. However, the few studies on some farming systems may give us a picture of the human resources in the industry. In 2002 Census of Fisheries of the National Statistics Office, the Philippines has a total of 226,195 aquaculture operators, breakdown as follows:

1. Fishpond operation – 126,894
2. Seaweed farming – 73,549
3. Fish pen operation – 5,325
4. Oyster farming – 3,041
5. Mussel farming – 2,422
6. Others – 14,964

Aquaculture industry includes various grow-out and hatchery systems which require skilled labor and technical personnel. It has important linkages with the various sectors that supply the inputs: fry/fingerling production/gathering and trade, fertilizer and chemical supply, supply of construction materials and feed ingredients, and feed manufacture, transport and storage. Many people work in the allied sectors: post-harvest processing, transport and storage, marketing and financing. Add to these the highly trained manpower involved in research, development and extension in support of the industry.

According to a 1995 assessment of the milkfish industry (Dureza, 1995), most traditional milkfish farmers are not aware of proper milkfish farming practices. However, progressive, educated and well-read milkfish farmers are willing to explore new technology which will enhance their production and profitability. These are the ones who engage in semi-intensive and intensive milkfish culture systems. Some of them even engage in milkfish hatchery. In milkfish breeding and hatchery technologies, most technicians do not have the necessary skills and knowledge required in the carrying out of such activities. Milkfish processing also requires skills and techniques for the processing of value-added products. Most personnel involved in the said sector do not have adequate knowledge for such activity.

Based on a 1996 socioeconomic profile of tilapia grow-out pond operators, the average age of farmers is 47 years. On the average, small farm (below 4.43 ha) operators are younger (44 years old) than large farm (4.43 ha and above) operators (51 years old), with a high percentage of the former being in the 30-40 age bracket and the latter in the > 50 age bracket. The average number of completed years of education of small and large farm operators in 10 and 11 years of schooling, respectively, with an overall average of 11 years. About 41% of the large operators and 47% of the small operators have completed a college degree. The average household size is six members per household.

Tilapia grow-out pond operation in the Philippines is very lucrative. The high profitability of tilapia farming can partially be attributed to the attainment of a high level of technical efficiency in farming operations. The mean level of technical efficiency is 83%, with large growers having a higher efficiency (88%) than small growers (79%). The high technical efficiency of tilapia farmers is associated with their high level of education (Dey *et al*., 2000b).

Based on a 2001 socioeconomic profile of shrimp (*P. monodon*) brackishwater pond operators in Pampanga (where 40% of shrimp come from), a large majority (84%) of them consider fish farming as their primary professional activity and the educational level is relatively low. Two thirds of the operators had only received a primary education, and only 12% had attended college (Irz and McKenzie, 2002).

There is no available sex disaggregated data on employment in the aquaculture sector. Women, however, are very much part of aquaculture production and post harvest activities.

Summary
As aquaculture and fisheries in the Philippines continue to expand, environmental and social issues are emerging which the sector has to face. Most notable among these are the increasing fish kills in cage culture and the degradation of municipal fishing grounds. In marine cage/pen farming, the worst disaster in Bolinao, Pangasinan on February 2002 was the first major fish kill episode in coastal waters in the Philippines where thousands of kilos of milkfish died. Losses to operators and coastal fishers were estimated to be in the order of US $ 10,000 (San Diego-McGlone, 2003). While seaweed, oyster and mussel farming are widely recognized as "environment-friendly", unsustainable aquaculture practices can also cause some serious ecological and socio-economic problems. The problems associated with the fishpen operations in Laguna Lake and fishcage operations in Sampaloc Lake were just some of the prominent examples in the past (Santiago, 2001).

The government, industry and civil society are gradually responding to these challenges. They are currently working together to formulate a national framework for sustainable fishing and aquaculture in the country. There are relevant policies on environmental issues in the Philippines. However, although some rules and regulations are already in place, there is still much to be desired in their implementation. Pursuant to the Fisheries Code of 1998, a Code of Practice in Aquaculture was formulated, but this has yet to be revised to make it more enforceable. The Fisheries Code requires that the government formulate incentives and disincentives such as effluent charges, user fees and negotiable permits to encourage compliance with environmental standards and promote sustainable management practices. Aquaculture facilities should only be constructed within established zones and they should not obstruct navigation and the migration path of migratory fishes.

The creation of FARMCs, on the other hand, as provided for by RA 7160 and RA 8550, aims to safeguard the common cause of local fisherfolk. They were empowered to chart directions toward poverty alleviation and a sound environment. In many instances, however, it is observed that they have very little role and contribution in the decision making of the LGU. This may be due to the lack of knowledge by the LGU and by fisherfolk themselves about the rules and responsibilities of the FARMCs. There are cases when members think that their organization is established to avail of loans. Thus, the Department of Agriculture must issue guidelines on the mechanics of FARMC organizing and conduct public awareness and education on the purpose of their organization, as well as the responsibilities, functions, and authority of members which must be duly recognized by the concerned LGUs. There are calls for the abolition of double taxation (RA 4850 or RA 7160) imposed by the LGUs and LLDA. There are cases where LGUs overpower national laws and policies by creating their own interpretation of rules and regulations in fisheries.

Certain key and historical trends will play a dominant role in molding fisheries management within the next decade. First is the devolution of management responsibilities to local levels. If the national government cannot respond to various demands and requirements to support capacity building for fisheries management, local governments will need alternative sources of guidance such as NGOs and the private sector to keep up with the perennial, long-term and undying issues on social upliftment and the environment in fisheries.

Secondly, national fisheries management will have to refocus and concentrate energies on specific and defined fisheries production sectors that are less geographically bound to municipal jurisdictions. It must also expand and turn its management functions towards addressing the rural poor sector of the industry, providing appropriate technology for the poor, and developing the rural fisheries community by providing basic services. The emerging roles of national fisheries management institutions are likely to be less concerned with the actual "field" management functions and implementation responsibilities, and will eventually be turned increasingly toward technical and financial support and broad policy guidance.

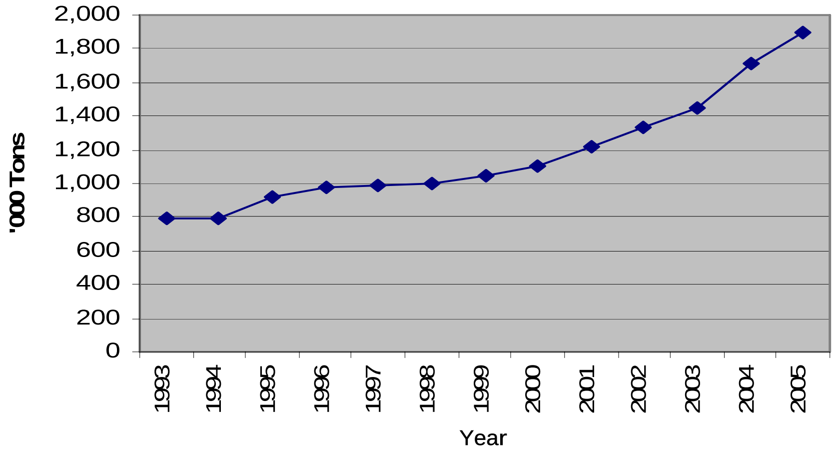
Thirdly, fisheries policy formulation will become an increasingly complex task, as the inherent tensions between local and national concerns and priorities will likely become the source of prolonged discussions and disputes at the policy making level. The process of devolution and decentralization will continue to present interesting and unique challenges, and in fisheries management, the primary concern will be finding the right balance between the various international, regional, national and local management bodies in their areas of concern to properly address poverty alleviation and environmental concerns.

Barut et al (2003) said that unlike typical industries that start low on the growth curve, aquaculture began with a "bang". For the first five years, aquaculture posted double-digit growth, i.e. 15% average for the first four years. In 1980, aquaculture accounted for almost 25% of total capture fishery production at 300,000 metric ton (t), a yield that had doubled by 1990. By 1996, total aquaculture production had already eclipsed production from both the large scale and small scale fishery sectors.

Barut et al (2003) also wrote that aquaculture production has been included in official statistics since the mid-1970s. The volume of aquaculture production has been rising ever since, except for 1997 when output slightly declined. Indeed, aquaculture has offset the declines in the municipal catches since 1983 such that total fish production has increased. Since 1984, fish production from aquaculture has registered volumes close to the output of the commercial sub-sector. Aquaculture output overtook commercial fishery production in 1994, and began to exceed municipal output in 1996. A closer look at the aquaculture statistics however, indicates that at least two-thirds of the sector's output comes from seaweed production.

In sum, the coming decades will be occupied with an attempt to strike a new balance between institutional forces and resolve tensions created by a historical movement towards decentralized fishery management. How government, NGOs, the fishing and aquaculture sector, other stakeholders, and the general public will respond to these changes and challenges will define their future roles in the newly emerging system of fisheries management in the country. The growth of Philippine aquaculture is a continuous trend to reach its 2 million metric tons mark in 2006 (Figure 5). But in the coming years, it may not be sustained unless new markets are developed, market competitiveness and farming risks are reduced. In this age of international trade and competition, there is therefore a need for the Philippine aquaculture industry to plan and implement a development and management program that is global in perspective.

Figure 1: Growth of Aquaculture in the Philippines
(From Lopez et al., 2005; BFAR, 2006)



Aquaculture in the Philippines: Socio-economics, poverty and gender

Farmers in the Asia-Pacific region contribute over 80 percent of the world's Aquaculture production, with China alone producing 50 percent of global production (Edwards and Demaine, 1997). The over riding fact is that, a majority of these farmers, operators, caretakers or labourers engaged in Aquaculture are poor. The poor are often characterized by low risk bearing ability, lack of rights to access and use the resources and weak entitlements to convert the resources into outcomes where they have access. Lack of coordination between sectors, unclear public/private sector responsibilities, insecure tenure and user rights, inadequate support from government, weak enforcement, rent seeking, lack of information sharing and little involvement of primary stakeholders, all contribute to the marginalization of the poor in one way or the other (Haylor and Bland, 2001).

Despite such problems and the engagement of a large number of poor households, there has been little research priority to explore the possibilities of Aquaculture to improve livelihoods of the poor. If Aquaculture is to play an even greater role in the alleviation of poverty, it is necessary that the actual and potential contribution of Aquaculture to poor and women be fully documented (Tacon, 2001). Recent shifts in development thinking do indicate some hope and a growing emphasis on poverty alleviation through Aquaculture (as indicated in the Bangkok Declaration of the Conference on Aquaculture in the Third Millennium, 2000). The regional governments need to go a step beyond declarations and fully implement the recommendations to address the specific problems of small-scale Aquaculture, especially initiatives that contribute directly or indirectly towards alleviation of poverty and improve participation of women. The initiatives by the Network of Aquaculture Centres in Asia-Pacific (NACA), FAO and other regional organizations is a major step to actively involve regional governments and increase awareness within the aquatic resource sector of the need to address poverty and the role of women more strategically (FAO and NACA 2002).

Gender and Aquaculture sector in Philippines

The majority of the farms were owned by men and women were mostly used as labourers in the study areas. In general, women were paid less and also burdened with household work. The involvement of women was mostly observed in family enterprises and in some specific jobs, for e.g., fish processing industry and hatcheries which were considered as female jobs. Women's labour was seen as a significant contribution in poor households which did not have the capacity to hire labour from outside. This is also supported by other studies in Asia that indicate womens' crucial role in Aquaculture production. For example in parts of Vietnam and Cambodia, higher yields were obtained from fish ponds managed mainly by women (Nandeesha, 1994). In Thailand and China, they often took the main responsibility of farm and Aquaculture production because of male migration to cities. IWomen's role was especially prominent when the cages or ponds were located close to their homesteads in the study area. Traditionally, women have been involved in different stages of small-scale Aquaculture and are active caretakers of fish in homestead ponds, hatcheries, cages or even in rice fields (FAO, 1987). The study showed that women were involved in Aquaculture mainly because it provided them with better income earning opportunities than other sectors (32%), or their families owned the farms where they had to share work or due to lack of other employment options. Women were involved in various stages of Aquaculture in Philippines and their role is growing significantly in certain areas like fish processing industry (Table 3).

Table 1. Role of women in general in Aquaculture in Philippines

Pond preparation	Women share work with men in small Aquaculture farms owned by households.
Seed collection and hatcheries	This is an important area where women are preferred to work, especially in hatcheries.
Feeding and guarding	In most household owned farms women share the responsibility of feeding, cleaning and guarding.
Accounting and book-keeping	Women are being hired by commercial farms to carry out accounting and book-keeping.
Seafood processing industry	Women dominate in the seafood processing industry in Philippiens, besides they are also involved in seaweed processing in homesteads, planting and harvesting of saweeds
Marketing of fish	Women dominate in marketing of fish in most rural areas in Philippines and also taking over urban markets
Development works, governance, research etc.	Increasingly more women are taking up Aquaculture as a means of livelihood and profession

Despite their positive contribution, women faced some constraints in Philippines, but the situation was more encouraging for their participation. The following factors were discussed during the field survey:

1. **Skills and training**: Lack of skills was viewed as one of the main constraints for entry of women into Aquaculture. In Pampanga, all the female respondents expressed

lack of skills as the main constraint, as there were not many training programs targeting women. Male-female contact socially is not a problem in Philippines unlike in countries like Indonesia, Malaysia and Bangladesh. Whereas, several studies show that female extension workers are often best for reaching women (Bueno, 1997). Zaman (1998) from his study in Bangladesh shows that some of the training programmes designed were not women friendly. However the study agrees that training programmes in Aquaculture should be designed to facilitate participation of women (Zaman, 1998; Nandeesha, 1994). They should be conducted close to villages or homesteads, made simple with the use of more visual aids for the benefit of women who are not literate and organized during the day when women are free from household chores.

2. **Physical and social mobility**: In some communities women are restricted to move away from homesteads for work. This is closely linked to religion, class or caste to which the household belongs. Such *socio-cultural restrictions* limit women's contribution to household income and narrow down options for employment and income sources. In southern India, women's involvement is limited to hatcheries in the backyards and not preferred to work grow out ponds (Shaleesha and Stanley, 2000). However, in Philippines this is not seen as a constraint and women do not have any restrictions to move around to seek jobs. Only 14% of the women respondents in Zambales saw physical or social reasons as a limiting factor to be involved in Aquaculture. A third of the women respondents in Pampanga viewed household duties as a limiting factor.
3. **Other factors**. The other limiting factors included credit facilities and ownership of farms. It was observed in some farms that the farm licenses were in the name of women, but they were actually operated and managed by males. In general, there was less discrimination of women in Aquaculture in Philippines and was not seen as a problematic issue.

Benefits of women's participation in Aquaculture

On the contrary, women's participation is changing with the mounting pressure on land and water resources, environmental degradation, out-migration of male family members and increasing rural poverty. Integrating gender in Aquaculture according to respondents***:***

- benefited women through an increase in household income and improvement in nutrition (practical needs/efficiency goal);
- helped women gain control over their own livelihoods and improved their status both within the household and the community (strategic needs/empowerment).
- Improved access to income and livelihood options
- Increased fish availability for family consumption, an important source of animal protein for poor rural households
- Higher household income due to added human capital inputs in Aquaculture
- Increased participation in various decision-making processes within the family.

To ensure better involvement of women in Aquaculture development as well as improve the economic condition of women, the following aspects are to be considered:

- A better understanding of the existing gender relations in the community and the household must be gained by institutions/organisations working for the development of Aquaculture. Participatory technology development may offer more scope to incorporate women's experiences.

- Successful cases of women's involvement in Aquaculture should be emphasised. Aquaculture training and extension efforts should be improved by taking a more holistic approach that encompasses women's time use, household responsibilities, literacy levels, as well as all aspects of their daily chores.
- Development of indicators to ensure that the involvement of women is monitored on a regular basis so that their activities or participation in Aquaculture can be re-focused regularly.
- Even though women were the ones who did the retail marketing of fish in Philippines, their information on market was very limited. A mechanism is necessary to expose women to more extensive market information and to link them to a wider market network.

Opportunities and constraints in aquaculture

In recent years, small-scale Aquaculture has been introduced in many parts of the Asia and has made important contributions to income generation and employment of the rural poor. Since Aquaculture requires only modest investments in physical and human capital, it is assumed that it has greater potential to raise the income of the poor compared with other agricultural activities. According to Edwards (1999) “Aquaculture contributes to the alleviation of rural poverty directly through small-scale household farming of aquatic organisms for domestic consumption and/or income; or indirectly through employment of the poor as service providers to Aquaculture or as workers on aquatic farms of wealthier farmers; or indirectly by providing low-cost fish for poor rural and urban consumers.”

Opportunities

Overall, respondents felt that Aquaculture provided them with options for employment and income generation. Aquaculture provided opportunities to different age and social groups:

For the whole family including women and children.

Aquaculture has the potential to increase the household income in areas where it is difficult to find other sources of employment and thus support the current consumption. Availability of family labour in very poor households complemented the needs of Aquaculture during various phases of production, as per the survey. The general trend was that the poorer the households the larger the participation of the family members in various on-farm activities in Aquaculture. This was more conspicuous for households where Aquaculture was the only source or the main source of income. Such households were more concerned about basic inputs and services in order to set up cages or ponds and run the farms.

To the poor households

A number of the activities in different phases of Aquaculture require labour all throughout the year that suit the poor who were dependant on daily wage labour. The agricultural labour and landless households considered Aquaculture as an opportunity to earn extra income during lean periods. Aquaculture provides additional labour and higher wages compared to agriculture in many areas in the Asia-Pacific region (Hambrey et. al.

2001). The study also had similar observations. Competition from agriculture increases the bargaining power of landless and the poor who might demand more wages. In practise, it may not be easy for the landless to bargain, as large farm owners can hire labour from outside rather than from local villages as observed in many farms in Philippines. The study showed that, some of the respondents were not locals and migrated into the area to take up aquaculture. Interventions from local municipalities in such situations helps to regulate large farm owners to hire certain agreed minimum number (quota) of workers from local areas on the farms. Such a condition could be laid out in the licence agreement as part of the conditions.

Table 2. Importance of different benefits that could result from Aquaculture to various end user groups

User groups	As a source of employment	Income	Food Security	Poverty Alleviation	Needs
Landless poor (cage operators, caretakers, labourers)	Very Important	Very Important	Important	Very important	High priority (policy, financial, technical)
Women (labourers, processing, marketing)	Important	Important/ supplementary	Important in household diet	Important	Priority (policy support, training)
Small farmers (owners, operators)	Supplementary	Important	Supplementary	Variable	Priority (policy, licences)
Rural youth (technicians, cage operators, caretakers	Variable	Variable/ Important	Variable	Variable	Priority (training, financial)

***By sale of fish in the market and post harvesting/processing especially for women*.**
Activities including, harvesting, sale of fish in the local markets, sorting and cleaning, processing fish etc, all need some semi-skilled labour which are usually taken up by women in the Asia-Pacific region. Men did not compete with women in such activities due to lower wages and also socio-cultural reasons as observed in the study area. With the increase in number of fish farms and production, there seems to be a growing need for semi-skilled women work force in the area. The demand was high during the harvest periods and in fish processing sector. The increasing demand for women in Aquaculture as wage labourers is likely to enhance the bargaining power of women in the household and the in the market.

In processing units, transportation, packing, operation and maintenance of large farms etc. for youth
Youth have certain skills that suit the specific requirements of Aquaculture sector, for example, transportation of fish, packing, operation and maintenance of farms in large fish farms where certain activities are mechanized. There is a need for skilled work force which suits the participation of youth in fish farming. In Philippines, it is a good opportunity for youth to tap the employment potential and for government to customize

training programs in order to encourage easy absorption of the youth in Aquaculture sector. Fish farms at schools increase awareness, early exposure and training. In the study are, some initiatives were reported to set up hatcheries in a few schools the study area. Such measures could also help to educate children at school by including Aquaculture in the school curriculum.

Constraints

In some situations, the main constraints for the poor to enter and sustain themselves in Aquaculture sector are social, economic and institutional factors, which restrict their access to resources, rather than the availability of resources (Tacon and Barg, 2001), whereas, in others, the key constraints may include, limited access to appropriate Aquaculture technologies and inadequate resources. In the five areas surveyed, nearly a half of the respondents complained that they did not receive any kind of help such as credit, seed, training etc. or other services from the government. Some of the major constraints according to respondents that affect Aquaculture production were disturbances from severe weather conditions (47%), diseases (25%) and bad water quality (20%) and lack of proper feed. Surprisingly, factors such as credit or access to land and water were not seen as constraints by respondents.

The most pressing constraints affecting production according to respondents were in the following order:

1. *Risks due to natural calamities*
2. *Threats from disease outbreaks*
3. *Deteriorating water quality*
4. *Inputs: access to feed and markets*
5. *Effective support services (technical and institutional support)*

If Aquaculture is properly planned there are considerable opportunities for poor people's entry (Friend and Funge-Smith, 2002). From experiences and lessons derived from various development projects implemented by governments and civil society organizations in several developing countries (Bangladesh, Cambodia, India, Laos, Nepal, Philippines, Thailand and Viet Nam), the FAO and NACA (2002) recommended measures for appropriate targeting of poor people, targeting the landless, creating opportunities for the poorer people, targeting the women, strategies for collective action, caution in providing subsidies and gratuities and adopting livelihood approaches. The assistance needs to recognize specific and prevalent features of poverty among the intended beneficiaries, including the means of overcoming key barriers for entry into Aquaculture and adoption of technologies, and to mitigate risks to which the poor are particularly vulnerable. The ADB (2004) studies of small-scale freshwater Aquaculture in Bangladesh yielded strategies for targeting the small and poor households which focused mostly on; secure access and use rights to land and water, financial and human capital assistance, training, and back up plans to face risks (floods, theft, diseases), which are quite common.

If Aquaculture is to play a greater role in the alleviation of poverty, it is recommended to:

- Develop a farm insurance scheme to protect the poor against natural calamities and diseases. A number of poor respondents sustain their livelihood on a monthly or seasonal basis. If the farm or fish cage or pen is damaged in a typhoon or bad weather, they find it difficult to recover and absorb the losses without external financial support. Shrimp farmers expressed were more concerned with disease outbreaks.

- Implement measures to improve water quality. Respondents realize the impact of bad water quality on production. Improving water quality is not the priority for government or private agencies. This requires an integrated effort, co-operation between sectors, farmers' participation, to monitor water quality, check excessive use of feed and chemicals on farms.
- Improve market information and facilities to market the product, especially for poor farmers operating fish farms in rural areas.
- Invest in building the institutional capacity, training of poor and women, and increasing the knowledge base concerning sustainable Aquaculture practices to manage the sector. This is in line with Tacon and Barg (2001) findings from their studies of Aquaculture potential for reducing poverty.
- Secure rights to land and water (special provisions to landless and households below poverty line

Small-scale Aquaculture may be one of the few options for poverty alleviation of poor households in coastal communities, which are among the most impoverished (Philips, 2002). Poor fishers culture molluscs and seaweeds in the Philippines. These require minimum inputs which are suitable for poor households. Most commonly practised systems by the poor are extensive and in cases where they get some financial support they switch over to semi-intensive system. Due to lack of access to capital and inputs the poor often tend to go for extensive system of cultivation, which reduces the productivity, quality etc, and gives lower price in the market. This vicious cycle needs to be broken, if the strategy is to promote the entry of the poor into commercial production and help them to accumulate capital.

Aquaculture policy initiatives

As a part of the study, a round table meeting of some key stakeholders (including representatives from BFAR, NGOs, Research sector) in Aquaculture sector was conducted in Manila in December 2006. During this meeting important issues were identified that would help in better management of Aquaculture and the improvement of water bodies in Philippines. The group suggested an ecosystem based approach as an option to address the current problems within Aquaculture in Philippines. This requires close co-operation between relevant government agencies and other stakeholders to manage identified watersheds within their limits. The Local Government Units (LGUs), the Department of Nature and Environmental Resources (DNER) and the Bureau of Fisheries and Aquatic Resources (BFAR) local agencies were identified as the key actors in Aquaculture. Co-ordination and funding was seen as the basis for an ecosystem based approach. Strengthening capacity at the local level, especially of LGUs and other bodies who have the legal and administrative authority was considered useful by several stakeholders. If the ecosystem based approach is opted, it would need the identification of ecosystems or water bodies as the units of planning. Within each ecosystem, the LGUs need to be identified and among them champion Local Government Units LGUs to be listed that can serve as an example for others to follow. Existing models like the Laguna Lake Development Authority (LLDA), the existing coastal resource management plans and the Philippines eco- governance projects were seen as important starting points to look at future management plans for identified water bodies. The study suggests the following measures to be taken in order to ensure that the poor, women and youth are included in any future development programs.

At the national level:

- Certain national policies like RA 8850 (the Fisheries Code)) and RA 8435 (Agricultural and Fisheries Modernization Act), mention "poverty alleviation" and "social equity" as one of the objectives.
- In addition, there is a need to increase emphasis on Aquaculture for poor in national social and economic development plans and policies, with the view to enhance institutional and financial support for the sector. Initiatives are already being taken in this direction, but not adequate to address immediate constraints faced by the poor. [1]
- Allocation of national budgets for training of the poor and women in Aquaculture is a necessary priority.
- Integration of relevant sectors to bring services closer to the farmers and make it easy for the entry of poor into Aquaculture. The challenge is to ensure that the National Fisheries and Aquatic Management council treat poverty agenda with priority.
- To set up a separate fund under the corporate social responsibility head with mandatory contributions from large farms. This fund can support the poor who need credit to operate small farms.

At the regional level:

- Promotion of regional cooperation and customizing legal frameworks for effective cooperation.
- Using the existing plans (BFAR Fisheries management plans, Mariculture highways, The DNER Coastal Resource Management Plans, etc) and plan for future Aquaculture development defining clearly the role of marginal communities.
- Pilot projects to be developed and extended to the district and village level with the active participation of BFAR.
- Improved cooperation in Aquaculture management, which should be oriented to strategic and cross-sectoral matters, such as capacity-building of the poor, co-ordination of relevant sectors, etc.
- Exchange of experiences among researchers and managers on the formulation and enforcement of measures proposed in national policies.
- Closer cooperation among national and regional governmental organizations and international and local NGOs in the promotion of participation of poor.
- The water bodies should be divided into coherent management units, which should be the basis for planning of Aquaculture development, and integrated with other sectoral development plans.

[1] The Aquaculture subsector has been identified in the Government's current MTPDP (2004–2010) as a sector whose increased growth will create jobs and ensure food security in support of the country's drive toward economic development. But it does not focus on the involvement of the poor, rather it emphasizes on the intensification and increasing production intensity, diversifying existing commodities and fishery farms, or expanding fisheries production in inland waters.

At the local level

- To motivate and strengthen LGUs to co-operate with other relevant agencies dealing with Aquaculture development programs. The Law (RA 8550) recognizes BFAR as a line agency and also provides BFAR some legitimacy to interact with other relevant agencies dealing with Aquaculture. This could be the legal basis for interaction at the local level.
- To provide authority and improve capacity of community organizations or village councils to monitor the farms to make sure that regulation are enforced. To ensure the participation of farmers in planning and implementation.
- To strengthen the capacity of organizations in planning, monitoring, and data bases etc. at the local level. It can help to maintain simple databases at the local level for the benefit of the poor and agencies dealing with poverty reduction programs.
- To organize/strengthen fish farmers associations at the local level (based on experience from Japan). The associations can serve as a platform for representation of the poor and their problems. The law (RA 8550) encourages participation of local communities in Aquatic resource management through Fisheries and Aquatic Resources Management Council (FARMCs). Priority should be given to the poor while issuing permits, rights and licenses for Aquaculture.

Recommendations

Aquaculture in Philippines is expanding rapidly and also becoming an important source of income and employment for the rural poor, women and youth. The study also shows that Aquaculture has the potential to increase the household income in rural areas where it is difficult to find other sources of employment and thus support the current consumption and meet unexpected cash needs. Since Aquaculture requires only modest investments in physical and human capital and it has greater potential to raise the income of the poor compared with other agricultural activities. It is essential that the rural poor get support in the form of training services, access to credit, quality seed material and market access. In line with the present development strategy of the Philippines Government which focuses on the country's rural poor, Aquaculture can become a potential engine for rural economic growth and poverty reduction provided the strategy is put into practice with the active involvement of the marginal groups for whom the strategy has been developed.

The study suggests that rather than creating new agencies, it is necessary first to look at the policies and institutions that already exist in Philippines, and that can facilitate the entry of poor, women and youth into Aquaculture. What is needed is an integrated institutional framework where the relevant polices, formal departments (LGUs, BFAR and DENR local agencies) and informal institutions to be pulled together to manage Aquaculture development programs in order to vulnerable groups. A number of measures can be initiated at the local level, for example**,** improving the cage designs using locally available materials, issuing licenses only to farmers who operate the farm themselves and prioritizing the poor, developing local co-operative insurance schemes to include poor, legitimizing community networks, increasing training programs, improving communication channels, strengthening fishers organizations etc. Security of tenure is an important issue and farmers are concerned about the rights to access and use common waters. The contexts of the poor are diverse and need to be addressed in a holistic and systems approach in future Aquaculture development programs.

Environmental impact from aquaculture

Aquaculture, like many other human activities, produces wastes which, if not managed properly, may negatively affect the environment. In intensive aquaculture, a considerable amount of organic wastes are produced in the form of particulate and/ or soluble substances (mainly the uneaten food, faeces and excreta) which increase biochemical oxygen demand, nitrates and phosphates in receiving waters. This may not necessarily be a problem as natural breakdown processes or dilution in the receiving waters can assimilate this, provided that natural waters are not overloaded, and the increased fertility of oligotrophic waters may even bring positive effects on the local ecosystem, enriching food availability for wild species.

The risk of negative impacts of aquaculture wastes are greatest in enclosed waters with poor water exchange rates, where excessive development of intensive aquaculture can lead to eutrophication and other ecosystem changes (e.g. algal blooms and low dissolved oxygen levels). This is typically site specific and occurs in slow moving rivers, lakes and shallow bays, when the nutrient loading is far higher than the carrying capacity of the ecosystem, usually as a result of over-crowding or poor water exchange.

There are several types of impacts, ranging from the strictly physical, chemical, biological effects on the environment as well as secondary effects (such as algal blooms, near, mid and far field effects on benthos, biodiversity and sensitive habitats.

In general, the environmental interactions posed by intensive marine shellfish culture are fewer than for fin fish culture owing to the fact that shellfish are net extractive of nutrients. However, they do concentrate organic material and deposit wastes as faeces and pseudofaeces causing enrichment of the local benthos (Chamberlain *et al*., 2001) and, if cultured in sufficiently high density, in some areas can clear the water to such an extent that they reduce productivity (Smaal *et al.*, 2001). Regulation on shellfish farming is, however, less well developed than for marine finfish farming owing to its lower perceived environmental risk.

Wastes from fish farming are usually considered in 3 overlapping categories:

1. **Soluble wastes,** being the products of fish excretion and including reactive nitrogen species such as ammonia
2. **Solid wastes**, being mainly uneaten feed material and faeces
3. **Chemical wastes**, being medicines - such as antibiotics and anti-parasitcs, disinfectants, and antifoulants – such as tin or copper compounds formulated into coatings or paints.

Soluble wastes

Soluble compounds, such as ammonia and urea, constitute a large part of the wastes released by fish farms. Like fecal matter, these are natural products produced by wild fish, and unlike fecal matter which accumulates in the immediate vicinity of the pens, they can be flushed by movement of the water and thus tend to approach an equilibrium level where the rate of release into the water column is balanced by flushing (Silvert, 1992).

Soluble nutrients from aquaculture may constitute a risk of eutrophication. The EU definition of eutrophication is:

"the enrichment of water by nutrients especially compounds of nitrogen and phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms and the quality of the water concerned".

The undesirable consequences of eutrophication include(Black *et al.*, 2002):

- increased abundance of micro-algae, perhaps sufficient to discolour the sea and be recognised as a bloom or "Red Tide";
- foaming of seawater;
- killing of free-living or farmed fish, or sea-bed animals;
- poisoning of shellfish;
- changes in marine food chains;
- removal of oxygen from deep water and sediments as a consequence of the sinking and decay of blooming algae .

Absolute standards for what constitutes eutrophication are not available. What constitutes a harmful disturbance to the ecosystem will vary according to the normal seasonal cycle which may be very different in temperate, sub-tropical and tropical regions. Thus to assess the acceptable level of phytoplankton biomass will require some knowledge of annual nutrient cycles and the primary production response for different environments and such measurements have often not been made. An alternative is to look for a deleterious ecosystem response such as the hypoxia caused by enhanced carbon inputs to deeper waters and sediments. Hypoxia may constitute a threat not only to the ecosystem but to the farmed fish themselves.

Solid wastes

The major solid wastes from fish farming are from uneaten feed and faecal material. The quantity of both these components will vary by species, food conversion ratio, food digestibility and the skill of the operator in matching feed availability to demand.

Waste Feed. A significant amount of feed does not get consumed by farmed fish and goes into the environment, which can have significant impacts. Some of the feed is in the form of dust that is too small to be ingested by the fish, some feed gets lost through over feeding of the fish, or if the feed pellets are the wrong size for the fish. Excess pellets fall through the pen and can be found on the bottom. These may be consumed by wild fish, consumed by benthic organisms or breakdown into nutrients by benthic assimilation. Unconsumed feed can have several effects both in the water column and on the bottom.

Fecal Matter. Fish feces come in many different forms, but constitute a major and unavoidable form of nutrient enrichment affecting the environment. Modern fish feeds are constituted in such a way as to minimize the loss of nutrients, which are expensive additives, by providing them in forms that can be easily assimilated by the fish (largely protein). The nutrients that are not assimilated are excreted mainly as soluble wastes such as urea and ammonia, so the fecal matter consists mostly of carbon and inert material.

Benthic effects. The initial effect of nutrient enrichment is almost always an increase in benthic productivity, since there is more food to feed the benthic community. This situation can persist for a long time if the degree of enrichment is low, but the amount of deposition under fish farms is usually so high that benthic scavengers cannot process all of it, and some begins to decompose through bacterial processes. This leads to reduced oxygen levels and increases in sulphide concentrations, which are too stressful for many bottom dwellers and therefore many species are driven out and the species diversity falls. At extreme levels, only a few species can persist, notably polychætes of the genus *Capitella* known as indicator species. If the carbon loading is excessive then the capitellids die out and eventually we find just bacterial mats; the seabed becomes azooic and soon after totally anoxic.

Benthic macrofaunal communities in sediments receiving normal detrital inputs derived from planktonic production in the overlying water column are species rich, have a relatively low total abundance/species richness ratio and include a wide range of higher taxa, body sizes and functional types, i.e. they are highly diverse communities (Pearson, 1992). The total productivity of the system is dependent on the availability of food - organic matter, and its quality. Animals have evolved to maximise the utilisation of the available resource by virtue of a wide range of feeding modes and some species can vary their mode of feeding depending on environmental factors. Benthic types include filter feeders that gather detrital material from the water column above the sediment, surface deposit feeders that feed on material deposited on the sediment surface, sub-surface deposit feeders that consume buried organic material by burrowing, and carnivores that prey on other macrofauna. Microbes degrade organic material and are themselves consumed by macrofauna, mediating the transfer of nutrients up the food chain.

Chemical wastes

Several classes of chemicals are used in fish farming. Three of the most important are antibiotics, antiparasitics and antifoulants. Since the advent of effective fish vaccines for several important bacterial diseases, the use of antibiotics in salmon culture has declined since the early 1990s (Alderman, 2002), but less is known about the use of antibiotics in other species, particularly those in the developing world (Graslund and Bengtsson, 2001; Holmstrom *et al.*, 2003; Tacon *et al.*, 1995). The main concerns relating to antibiotic use relate to the possibility of the development of bacterial resistance that can be transferred to human pathogens reducing the efficacy of antibiotics in human medicine (Cabello, 2004; Cabello, 2006). Prophylactic use of antibiotics is a particular concern, as is adequate testing of aquaculture products for antibacterial residues. Where residues persist, low levels of antibiotic intake can stimulate resistance in human pathogens but another concern is that some of the antibiotics used in aquaculture may not be approved for human medicine and carry a health risk. For example, nitrofurans (e.g. furazolidone) are a group of antimicrobials which possess either carcinogenic or mutagenic properties whose use is banned in many countries but still permitted in some. In general, limits have not been set for the concentrations of antibiotics permitted in the environment.

Other impacts

Physical Structures

The nets of the cages, pens and associated moorings changes the environment by preventing causing friction to the water currents and changing the current patterns. The UPMSI has demonstrated that friction from the nets can alter the residence time of water in a bay.

Oxygen Depletion

Oxygen is utilized in the vicinity of fish cages by

- the consumption of oxygen by the fish
- the consumption of oxygen by the release of organic compounds that decompose in the water column by chemical processes that use oxygen (Biological Oxygen Demand, BOD).
- The consumption of oxygen by the primary production (algae) and secondary production (zooplankton) that are utilizing the additional nutrients released by aquaculture.

Turbidity

One of the effects of aquaculture is to make water more turbid because of the release of particulate matter. In clear water environments like lakes, and in isolated coastal embayments, the effect may be significant. The effect of increased turbidity is lower light penetration, which can reduce primary production by phytoplankton and by benthic macrophytes, and possibly could reduce the feeding efficiency of visual predators.

Disease Transmission

There are impacts from the release of disease organisms and the pharmaceuticals used to treat them into the water column, the transmission of disease to other farms and to wild stocks, and the effects of antibiotics and other treatments on natural communities.

Genetic Mixing

Most farmed species, especially those of finfish, are genetically different from the native species, and there is concern about genetic contamination from the release of farmed species into the wild. Domestic fish are bred for traits that are not always optimal for survival in the wild, so if some escape into the wild. For example, if a storm or predator attack damages a pen, the viability of wild populations may be threatened by interbreeding.

Biodiversity

Aquaculture can affect local biodiversity in many ways. The use of wildcaught fry is still common for some particular marine species. Repeated fishing for the juveniles of certain species can drastically alter species composition by preventing some of them from bring recruited into the reproductive population.

The movement of broodstock and fry within a country or between countries may significantly alter the genetic characteristics of local stocks of the same species due to inevitable escapes and/or stock enhancement practices. Likewise the escape of alien species such as salmon and tilapia can have deleterious effects on biodiversity.

Organic loading from cage or pen aquaculture also causes a decrease in benthos flora and fauna biodiversity.

Impacts and their Effects
Scale Issues
One of the critical issues in understanding aquaculture impacts is identifying the scale on which they appear. Some impacts appear only in the immediate vicinity of the operation, while others are more widely distributed, and although they may appear smaller, the large area that they affect makes them important. Silvert (1992) identified three major time and space scales for the impacts of finfish farms:

- ***Localised*** This is a very small scale in both space and time, illustrated by depletion of oxygen in and near the pens at slack tide.
- ***Near field***, such as the deposition of carbon and other wastes on the seabed in the vicinity of a fish farm.
- ***Far field***, usually due to the release of soluble nutrients and disease organisms into the water column.

Nutrient Budgets of Fish
One of the key components of estimating the degree of environmental impact that fish farms have is by constructing models that can be used to predict the quantities of different effluents that are released into the environment.

Primary vs. Secondary Effects
The primary effect are the nutrients are released into the water column. The secondary effects of the nutrient release are more important with nitrification leading to enhanced primary productivity, and in particular, harmful algal blooms.

Sensitive habitats
This impact is can be a problem particularly in sensitive habitats. There can be the loss or modification of habitat in places where aquafarmers clear mangroves for ponds and where they install cages or pens above seagrass beds and close to coral reefs. Other environmental effects include the disturbance in wild fish spawning or nursery grounds, salinisation of soil and water, and coastal pollution.

Sensitive habitats such as mangrove are affected by aquaculture. Untreated pond effluents and fish cages can also potentially impact on coral reefs and sea grass communities, the latter has been well documented, here organic wastes from improperly located fish cages can rain down and smother such sensitive ecosystems. Freshwater marshes and wetlands that are often home or feeding grounds of birds are potential areas which might be improperly used for aquaculture without strict government controls. The awareness of the importance of conserving critical and fragile habitats has been growing. This has evidently reduced the deleterious use of critical habitats for aquaculture and led to the development of appropriate policies and regulatory measures in many producing countries, worldwide particularly in those were an environmental impact assessment is mandatory since fragile habitats are or should be clearly identified.

Recommendations on mitigation of impact
Mitigation of aquaculture impacts such as effluents and wastes from inland or coastal facilities can take a variety of forms. It is necessary to determinate what impacts are acceptable i.e.whether the impact is reversible or can the ecosystem recover. Impacts involving permanent damage clearly have to be considered more carefully than ones that can be reversed by a year or two of remedial action.

Recovery
Little is known about the rates of recovery of aquaculture sites, and most of what is known has been inferred from a small number of studies of abandoned sites. Oxygen dynamics play a major role in site recovery, since without adequate oxygen flux some of these processes cannot occur. The success of sites can depend strongly on their location, it is not clear that we can always predict successful locations.

Improved feed management
Improved feed management in terms of feeding strategy to reduce food conversion rates is one of the most effective ways to reduce the impacts of aquaculture. Innovations in automated feeding technology and feed form/composition have significantly reduced feed inputs and effluent loads per unit of production, whilst maintaining productivity. In salmon farming over the past decade, feed conversion ratio has been steadily decreasing, from 1.5 to near 1.1:1. Such reduction implies less organic matter and nutrients discharged to the environment. However, other types of aquaculture (sea bream and sea bass in the Mediterranean Sea) still need to improve their feed conversion ratios and strong regional efforts are being made to address this task.

Use of extractive aquaculture to reduce nutrient loadings
Low trophic level aquaculture also provides opportunities for improving the aquatic environment. The extensive low input mollusc or seaweed systems remove nutrients from the culture environment). Effective integration of combinations of fed aquaculture and such “extractive” aquaculture practices can result in net increase of productivity and could mitigate against nutrient build up in the environment. Mixed culture of fish, molluscs and seaweeds practiced in the coastal bays of China is a good example. However the techniques require further development and improvement. Economics of such integrated systems also require careful examination. If densely located, even extractive aquaculture systems can cause negative impacts on the environment, especially on sediments, as a result of faecal and pseudofaecal accumulation.

The scientific basis of marine fish farm regulation
Planners must ensure that aquaculture developments meet aesthetic, social and economic criteria, and that there is harmonisation between new developments and local infrastructure capacity or other resource use e.g. tourism. Planners and regulators have duties to ensure that developments do not adversely affect the environment.

The objectives of regulation can be separated into three areas:
1. protection of legitimate users of the environment, such as tourists or fishermen, such that resources are fairly distributed.

2. protection of the environment for its biological structure including protection of important/rare habitats and species
3. protection of ecosystem functions such as the recycling of nutrients and the maintenance of oxygen levels

The first of these is the subject of the evolving “discipline” of Integrated Coastal Zone Management (ICZM) which has 8 broad principles (Defra, 2006). It is worth presenting these here in full:

a. **A broad holistic approach.** The objective of a holistic approach is to forego piecemeal management and decision making in favour of a more strategic approach which looks at the ‘bigger picture’, including cumulative causes and effects. This means considering the conservation value of natural systems alongside the human activities which take place on land and coastal waters. Taking a holistic approach will also involve looking at the problems and issues on the coast in the widest possible context, including looking at the marine and terrestrial components of the coastal zone and considering how different issues conflict or interact together.

b. **Taking a long term perspective.** Successful coastal management must consider the needs of present and future generations. Therefore, administrative structures and policies required to manage the environmental, social and economic impacts now, must also be adaptable to take account of, and acknowledge, uncertainties in the future.

c. **Adaptive management.** The coastline has been subject to constant physical and economic changes over the years, and management of such a dynamic environment requires measures which are able to adapt and evolve accordingly. Successful management should reflect this principle by working towards solutions which can be monitored effectively.

d. **Specific solutions and flexible measures.** Coastal management measures for each stretch of coast must reflect and accommodate the many variations in the topography, biodiversity and local decision-making structures. Integrated management should therefore be rooted in a thorough understanding of the specific characteristics of an area i.e. its local specificity.

e. **Working with natural processes**. The natural processes of coastal systems are continual, so it becomes necessary in some instances to adopt a different approach which works with natural processes rather than against them. By recognising the physical impacts and the limits imposed by natural processes, decisions regarding the human impact on the coastal zone are made in a more responsible manner and are more likely to respond to environmental change.

f. **Participatory planning**. In the past stakeholders may not have had sufficient opportunity to contribute towards the development and implementation of coastal management measures or programmes. Participatory planning incorporates the views of all of the relevant stakeholders (including maritime interests, recreational users, and fishing communities) into the planning process. It can also help to promote a real sense of shared responsibility and coastal stewardship by reducing conflict as real issues, information and activities which affect the coast can be aired more openly.

g. **Support and involvement of all relevant administrative bodies**. Administrative policies, programmes and plans (land use, spatial, energy, tourism and regional development for example) set the context for the management of coastal areas and their natural and historical resources. Addressing the problems faced by … coastal zones will therefore require the support and involvement of all relevant administrative bodies at all levels of government to ensure cooperation, coordination and that commons goals are achieved. It is therefore essential to engage key bodies from the start so that decisions are consistent and firmly based on local circumstances.

h. **Use of a combination of instruments**. Managing the different activities which take place on the coast requires the use of a number of different policies, laws and voluntary agreements. While each of these approaches is important, achieving the right combination is key to resolving conflicts, as these instruments should work together to achieve coherent objectives for the planning and sustainable management of coastal areas."

Recommendations

The regulation of aquaculture in developed countries has developed considerably over the past decade. This has been driven by the need to improve the scientific basis for management of this very high economic value sector. Regulators must base their decisions of good science in order to protect the environment and but at the same time allowing development with its economic benefits. This has particularly been the case for the major salmon growing countries, although Chile perhaps has still to catch up in a regulatory sense with its rapidly expanding industry. In the developing world, where aquaculture products are primarily for export, market pressures are increasingly brought to bear to ensure food safety, for example concerning residues, and there is also a growing awareness of environmental issues, particularly relating to habitat destruction related to shrimp farming. In the Philippines, regulation of the very large number of small scale fish farms where the market is local represents a significant regulatory challenge, but the potential environmental costs make rational regulation essential for the future of this industry. In this paper we have outlined some of the approaches being taken by aquaculture regulators in other countries. It is highly likely that some of these approaches will be relevant and adaptable to the Philippine industry.

Aquaculture environmental impact on sensitive habitats.

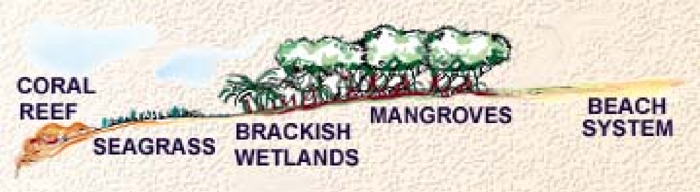
Aquaculture has grown rapidly in the last 20 years. Total aquaculture production in 2003 was 54.8 million metric tons, valued at $67.3 billion in U.S. dollars. More than 90% of this output comes from Asia.

However development also comes with impact. This impact is can be a problem particularly in sensitive habitats. There can be the loss or modification of habitat in places where aquafarmers clear mangroves for ponds and where they install cages or pens above seagrass beds and close to coral reefs. Other environmental effects include the disturbance in wild fish spawning or nursery grounds, salinisation of soil and water, and coastal pollution.

Sensitive habitats such as mangrove are affected by aquaculture. Untreated pond effluents and fish cages can also potentially impact on coral reefs and sea grass communities, the latter has been well documented, here organic wastes from improperly located fish cages can rain down and smother such sensitive ecosystems. Freshwater marshes and wetlands that are often home or feeding grounds of birds are potential areas which might be improperly used for aquaculture without strict government controls. The awareness of the importance of conserving critical and fragile habitats has been growing. This has evidently reduced the deleterious use of critical habitats for aquaculture and led to the development of appropriate policies and regulatory measures in many producing countries, worldwide particularly in those were an environmental impact assessment is mandatory since fragile habitats are or should be clearly identified (GESAMP, 2001).

In order for aquaculture to be sustainable the aquaculture industry must acknowledge its interdependence with the ecosystem which it shares. Ecologically damaging practices need to be replaced with ecologically sound ones.

Coastal Habitats affected by Aquaculture



The Philippine coastal zone is typical of tropical coasts, with five major resource units occurring along its shallow coastlines: coral reefs, mangrove ecosystems, beach systems, estuaries and lagoons, and seagrass beds. It is important to note, however, that ‘coastal resource management’ cannot be limited to the coastal zone, because there are tight linkages between upland and coastal ecosystems and what occurs in one ecosystem inevitably affects the other ecosystems.

Coastal wetlands. The world has lost half its coastal wetlands, including mangrove swamps and salt marshes. Over the past century mangrove forests have been decimated - 25 million hectares are estimated to have been destroyed or grossly degraded. In the Philippines, for instance, the mangrove area has been decimated by development, dropping by 90 per cent - from one million hectares in 1960 to around 100,000 in 1998.

Mangroves. The issue of clearing mangroves for fish and shrimp ponds has largely abated over the years for many reasons. Foremost is the greater awareness on the importance of mangroves that has led many governments to impose either stricter regulations over their use or outright ban on further clearing although implementation may still be uneven among countries. Secondly, it has become increasingly clear that technically the mangrove is not the best area for semi-intensive or intensive aquaculture and new farms are seeking areas behind the mangrove intertidal areas. Additionally, many countries are now attempting to implement the RAMSAR Resolution VIII.32 on “Conservation, integrated management, and sustainable use of mangrove ecosystems and their resources” (RAMSAR, 2002), which effectively protects fragile mangrove ecosystems worldwide. Finally, the attention given to mangroves and aquaculture had largely ignored the impacts of other uses such as agriculture, with various studies now showing that aquaculture globally accounts for less than 10 percent of the loss of this important coastal habitat.

Using mangroves for aquaculture is a historical practice. In Southeast Asia, particularly Indonesia and the Philippines where the culture of milkfish has a long tradition, the mangrove area was considered an ideal site for brackishwater fish ponds because the ground elevation of such areas is low enough to be flooded naturally during high tide. Such attitude on mangroves was common throughout the world up to the 1970s, since “mangroves were generally considered as waste lands with little intrinsic value and their destruction was encouraged by government and planners” (Spalding, Blasco and Field, 1997). It was only during the 1980s at the height of widespread interest on shrimp farming that concern heightened over the destruction of mangroves. This appears to coincide with the development of large shrimp farms using mangrove areas in the western hemisphere, particularly in Latin America. So although most of the mangrove forests in Asia were originally cleared for fish and merely converted to shrimps much later, the destruction of mangrove forests is often still attributed largely to shrimp farming.

In most of Asia, not only has the further clearance of remaining mangrove areas for aquaculture been banned, but also many countries have embarked on replanting and restoration. Besides these, various attempts have been made to develop aquaculture in ways that do not cause damaged to mangroves.

Mangroves provide a rich habitat for over 2,000 species of fish, shellfish, invertebrates and plants. Some 80 species of salt tolerant trees currently occupy about 182,000 square kilometres of intertidal, lagoonal and riverine flatlands throughout the world.

In 1920, the Philippine mangrove forest area was estimated to be around 450,000 hectares. Largely as a result of conversion to fishponds and saltbeds, the clear-cutting of trees for firewood and other domestic uses, and reclamation for industrial or other development purposes, this area has shrunk to less than 150,000 hectares, of which 22% are in Palawan, 32% in Mindanao, and 23% in Eastern Visayas and Bohol. From 1980 to 1991, mangrove areas were depleted at a rate of about 3,700 hectares per year, mostly due to conversion to fishponds. Today, old-growth mangrove areas are said to be no more than 20,000 hectares, about two-thirds of which are in Palawan and the remainder in Zamboanga del Sur.

Already, the culture of seaweeds and fish in cages in subtidal bays and rivers is compatible with adjoining mangroves and suitable for family-level operations.

But there remains a need for mangrove-friendly aquaculture technology in intertidal forests, in which mangrove trees spend high tides with their roots submerged and low tides with their roots exposed. There are mangrove friendly aquaculture systems such as the rearing of mud crabs inside intertidal pen enclosures and the use of mangroves on pond walls which is undertaken in the Philippines. Several studies have shown that mangrove estuaries can process nutrients, such as those from fertilizers, in aquaculture pond effluents at least over short spatial and temporal scales. That opens up the possibilities of integrating intensive aquaculture with natural or constructed mangrove wetlands in a way that could be sustainable through careful management and planning.

Seagrass beds. Seagrass beds, the underwater meadows of the ocean, have fared little better. Though no overall quantitative estimates of damage are available, these diverse ecosystems appear in retreat near virtually all inhabited coastal areas.

In the Philippines there are 16 known species of seagrasses, the highest number in the Indo-Pacific region. These species are valued mainly for their role as fish nursery areas and as foraging grounds for food fish, dugong, turtles and wading birds. The depletion of seagrass beds is known to result in high water turbidity and lower production of seagrasses and their associated fauna. Like the other coastal ecosystems, seagrass ecosystems in the Philippines are under threat from aquaculture as well as other natural and man-made forces -- typhoons, tidal waves, and volcanic activity as well as mining, aquaculture, deforestation and blast fishing.

Sedimentation from fish cages smother the seagrass beds with particulate matter with high impact directly beneath the cages reducing in impact away from the cages. In Europe the impact can still be measured up to 400 meters from the cages (MEDVEG).

Coral reefs. Coral reefs are also being destroyed. Of the world's 600,000 square kilometres of reefs found in tropical and semi-tropical seas, It is estimated that 70 per cent of them - some 400,000 square kilometres - could be lost within 40 years.

Coral reefs have high biological diversity, supporting more than one million species. They also have other benefits such as buffering waves and protecting shorelines from erosion; they help transfer nutrients from the land to the open ocean; they provide feeding, breeding and nursery areas for many commercially important species of fish and shellfish; and they offer potential new medicines.

In 1997 Reef Check charted the health of 300 reefs in 30 countries. According to the survey, less than one-third of all reefs had healthy, living coral cover, while two-thirds were seriously degraded. The Caribbean had the lowest rate of living coral, an average of just 22 per cent. Southeast Asia was second, with only 30 per cent of its coral reefs in good to excellent condition; coral reefs in good to excellent condition must have 50 per cent or more of their area in living coral.

Another study by WRI confirmed these findings, observing that the world's most degraded reefs are in Southeast Asia and the Caribbean. In Southeast Asia, for example, one of the epicenters of coral biodiversity, more than 80 per cent of all reefs are at risk. In 2001 the Worldwatch Institute reported that over the decade of the 1990s, the percentage of the world's coral reefs suffering from severe damage increased from 10 per cent of the total to nearly 30 per cent.

The root causes of the deterioration of coral reefs have historically been attributed to direct human impacts, such as over fishing and destructive fishing practices, chronic forms of pollution, including untreated sewage, and sedimentation and physical alteration associated with coastal development. In addition upstream deforestation and agricultural practices in the watershed lead to sedimentation and nutrient run-off downstream, suffocating reefs and stimulating the growth of algae, which can alter the community structure of reefs in over-fished conditions.

The Philippines lies in the Indo-West Pacific Region, reputedly the world's highest biodiversity marine area, and is part of what is known as the "coral triangle," the center of the most diverse habitat in the marine tropics. Reports say the country's coral reefs host about 400 species of corals, 971 species of benthic algae, and a third of the 2,300 fish species known to inhabit Philippine waters. There are 27,000 sq km of coral reef areas in the Philippines, with 60% of them occurring in Palawan.

But Philippine coral reefs are under severe pressure from various human activities, not only from dynamite, cyanide, and other illegal fishing, but also from legitimate activities such as aquaculture and tourism. Aquaculture also affects reefs by sedimentation and eutrophication. The degradation is both fast and widespread.

Beach systems. Most small Philippine islands have coral sand beaches, i.e., beaches formed by coral reef growth and erosion. Forming an integral part of the reef communities, these beaches depend on healthy coral reefs for continued supplies of sand, at the same time supporting crustaceans, mollusks and some worms. Undisturbed beaches also serve as nesting places for sea turtles. Unregulated and unplanned development of beaches for tourism and the quarrying of sand for construction and other purposes are two of the most common threats to beaches in the Philippines. Aquaculture can also contribute to the destruction of these beach systems due to the landing jetties constructed for loading and unloading fish and feed, the use of the beaches for cleaning of nets and housing for the aquaculture workers

Brackish wetlands. This ecosystem is usually found behind the mangrove formation and is characterized by the predominance of *Nipa fruticans* (nipa palm). In some places in the Philippines, it is regarded as part of the mangrove ecosystem. Pollution and conversion to other uses (such as reclamation for housing, fishpond development and dumping of garbage) have resulted in decreasing fishery productivity and loss of wildlife and aesthetic value.

Many of these brackish wetlands have been converted into fish and shrimp ponds and are leased long term using the Fishpond Lease agreements. This destroys the native vegetation specialised to these wetland areas and affects the water exchange and salinity of the areas.

Biodiversity. In the Philippines, the greatest marine biodiversity can be found in the mixed coastal fauna of the coral reefs, mangroves and seagrass beds. These habitats host well over

5,000 species of plants and animals, including, according to one estimate, 1,400 species of fish, 1,400 species of crustaceans, more than 900 species of seaweeds, and as an untold number of unknown species. More than 17% of the better known fish are endemic to the Philippines, and there are more than 90 genera and at least 400 species of coral known to thrive in Philippine tropical waters.

This biodiversity is under threat also by aquaculture development.

- Destruction of important habitats for diversity (mangroves, corals)
- Fish escapes competing with native species (Tawili in Taal lake).
- Genetically improved species breeding with local strains

The importance of biodiversity, which includes the diversity of genes, species and ecosystems, has recently been acknowledged by the entry into force of the Convention on Biological Diversity in 1993, by the acceptance of the FAO Code of Conduct for Responsible Fisheries in 1995, and by the expansion, also in 1995, of the FAO Commission on Plant Genetic Resources to include all genetic resources for food and agriculture.

Although genetic improvement of common carp probably started several thousand years ago, the application of genetic principles to most aquaculture species is a relatively recent phenomenon. Thus, the majority of farm-raised aquatic animals and plants are very similar to their wild forms. Genetic improvement programmes are beginning to be applied to more and more aquatic species, but when compared to the levels of domestication in livestock and crops, the aquatic sector is still far behind. The number of farmed taxa for which data are reported to FAO has increased for all major groups since 1984: 34% for fishes, 29% for crustaceans, and 31% for molluscs (Garibaldi, 1996). As domestication extends to more and more species, so will the application of genetic improvement technologies.

A small percentage of aquaculture production now comes from genetically improved species (Gjedrem, 1997). (This refers to directed genetic improvement and not simply to the domestication process). Therefore, there is tremendous scope to increase productivity by applying techniques of genetic improvement, such as selective breeding, chromosome manipulation, hybridization, production of mono-sex groups, and gene transfer.

Genetic improvement programmes have been successful at increasing production; for example Atlantic salmon in Norway, tilapia in the Philippines, catfish in the southern USA and Thailand, and oysters in North America (Dunham, 1995; Gjedrem, 1997). There is increasing interest in the creation of selective breeding programmes for marine shrimp, tilapia, common carp, and rohu in Asia and Africa (Gupta and Acosta, 1996). Previous work focused on salmonids and inland species, but genetic principles are being applied to more marine species.

Another technique receiving current attention is the transfer of genes between species, or the addition of copies of a species' own gene to improve production. Transgenic common carp, catfish, coho salmon and tilapia have been produced and are being tested for commercial use. These transgenic fish demonstrate increased growth and have the potential to increase aquaculture production substantially especially in the potential to reduce the fish meal and fish oil requirement for marine fish..

The Convention on Biological Diversity has recently designated aquaculture, especially coastal aquaculture, and agrobiodiversity, which includes biological diversity and genetic resources used in or of potential use to aquaculture, as priority areas for action. These international mechanisms acknowledge the value of genetic diversity to both natural ecosystems and aquaculture production systems. Nearly all genetics technologies and breeding programmes rely on genetic diversity as the raw material for improving farmed species. Technical guidelines have been produced to help implement the section of the FAO Code of Conduct for Responsible Fisheries that deals with aquaculture and the use and protection of aquatic biological diversity.

The Ecosystem based approach to aquaculture management

In recent years, world aquaculture has become a dynamically developing sector of the food industry, and many countries have striven to take advantage of their new opportunities by encouraging the aquaculture development in response to growing international demand for fish and fishery products. It has become clear, however, that many aquatic resources used for aquaculture can not sustain an often uncontrolled increase of exploitation.

The ecosystem approach is a management principle. As such it builds on the recognition that the nature of the natural world is integrated and that we must take a holistic approach to environmental management. The science to support ecosystem approach to management must also be integrated and holistic. A core element of this science is ecology with focus on the properties and dynamics of ecosystems (Fenchel 1987). Many scientists and managers have recognised the need for an ecosystem approach for fisheries (Likens 1992), although it is only during the last 5 -10 years that a broad awareness of the need for such an approach has grown in aquaculture.

The increased awareness and formalisation of the ecosystem approach have emerged as a result of international environmental agreements within the framework of the United Nations. A fundamental description of the basis of an “ecosystem approach” was first formalised in the Stockholm Declaration in 1972 (Turrell 2004). The most authoritative account of the ecosystem approach is probably that found in Decision V/6 from the meeting of the Conference of the Parties to the UN Convention on Biological Diversity in Nairobi, Kenya, in 2000. This decision has an annex with a description, principles and operational guidance for application of the ecosystem approach (www.biodiv.org/decisions/default.asp).

Ecological integrity is a state of the ecosystem in which ecological diversity and resilience is present, allowing the ecosystem to sustain itself and the inhabitants dependent on it. Integrity of the ecosystem cannot be achieved, however, when irresponsible actions impair the beneficial uses of resources. Scientific inquiry, public policy development and co-management programs are essential for achieving and maintaining ecological integrity.

An ecosystem approach entails an integrated, multi-resource emphasis and broad, precautionary strategies that anticipate and prevent environmental damage. This approach respects and affirms the interconnectedness of ecological processes and requires people to understand and conduct themselves as an integrated part of the ecosystem rather than as an entity separate from it.

The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of the ecosystem approach will help to reach a balance of the three main objectives

- conservation
- sustainable use
- fair and equitable sharing of the benefits arising out of the utilization of the natural resources.

Ecosystem based environmental management and relevance to the Philippines

Agriculture and fisheries in the Philippines directly account for about a fifth of the total economy and directly and indirectly (which considers the backward and forward linkages, or the cluster universe) three fifths of the economy. More importantly, it directly employs about 10 million people, nearly 40% of the labour force. The Philippines produced 1,450,000 tonnes from aquaculture (2003) and it employs over 1 million people. Aquaculture production is still rising rapidly.

Aquaculture tends to develop in “hot spots” initially with pen culture in Laguna and recently with milkfish cage and pen culture in Dagupan and Bolinao and tilapia cage culture in Taal Lake. This rapid increase in production has put pressure on the aquatic ecosystems and incidences of fish kills have been observed.

In general, the management of fisheries and aquaculture should be undertaken with an ecosystem approach based on their scientifically calculated safe carrying capacity and implemented in a coordinated way by the concerned LGUs, through appropriate regulations for lake management.

Regulations covering aquaculture management

In the Philippines, the planning, management, monitoring and control of fisheries and aquaculture have been devolved from the National Government to Local Government Units (LGUs). In the case of lakes, there are three different regulations, namely:

1. the National Integrated Protected Areas System Act or RA 7586 of 1992 which provides for the establishment and management of national integrated areas system defining its scope and coverage. The Act includes the Protected Area Management Board (PAMB) which is responsible for the general administration of the area;
2. the Local Government Code or RA 7160 of 1991 which provides for the empowerment of the LGUs; and
3. the Fisheries Code of RA 8550 of 1998 which aims for the rehabilitation of fisheries and other aquatic resources through enforcement of laws and regulations.

Agencies governing aquaculture development
At the national level, the two principal agencies with coastal management responsibilities which apply to aquaculture are the Department of Environment and Natural Resources (DENR) and the Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR). These two agencies have retained authority over some land and water uses, management activities and specific geographic areas. There is some overlap of responsibilities between the two agencies.

While national government has devolved significant authority to the local level, national government agencies have maintained significant institutional presence especially at the regional, provincial, and in the case of one agency, municipal level (Lowrey 2005). DA-BFAR and DENR have offices and staff at regional (multiple provinces) and provincial levels. The DENR has staff responsible for covering jurisdictional responsibilities in multiple municipalities. The Department of Interior and Local Government (DILG) is the primary national government agency responsible for overseeing, monitoring, and evaluating LGUs and the devolution process. Every municipality has one member of staff assigned from DILG. In spite of the broad representation of national government agency staff at provincial and municipal levels, coordination between national and local government is weak and major capacity gaps exist.

While LGUs are generally well versed in the provisions of the LGC, they are less knowledgeable about special laws, such as the Fisheries Code and environmental laws that are primarily under the jurisdiction of national government agencies. The primary implementing agency for the 1998 Fisheries Code is the DA-BFAR; however, many of the provisions in the law relate specifically to LGUs. Implementing Rules and Regulations and Administrative Orders are issued describing specific implementation requirements.

Unfortunately, the overlap in responsibilities, laws and regulations has led to confusion as to the roles of BFAR, DENR, DILG and LGUs in terms of planning, monitoring and control of aquaculture and fisheries, and has resulted in uncoordinated, uneven and often, unsustainable development of aquaculture.

There is therefore a need to resolve interagency roles and improve linkages between DILG, BFAR, DENR and encourage cooperation between the main agencies involved with aquaculture development, management and control. The NAFC and NFARMC as interagency Councils could be used for resolving conflict, overlap between agencies and to encourage cooperation between the agencies. There may be a need to draft joint BFAR/DILG Administrative orders or ordinances for monitoring and control of aquaculture development.

There are a number of initiatives to coordinate planning and management of aquatic ecosystems among key national agencies. The Protected Area Management Boards of national protected areas are usually comprised of representatives of these different government bodies and private sector stakeholders. The joint memorandum order on the implementation of the Fisheries Code between DENR and DA-BFAR is a start at the national level. The Philippine Fisheries Code of 1998 provided for the creation of Fisheries and

Aquatic Management Councils (FARMCs) to act as consultative bodies of the LGUs in determining priorities on fishing activities of municipal fishermen and aquaculture development. They also assist LGUs in the preparation of the Municipal Fishery Development Plans, recommend fishery and aquaculture ordinances and assist in the enforcement of laws. The DA-BFAR, LGU and Coastal Resource management Plan (CRMP) have worked together in establishing and strengthening the capacity of FARMCs to fulfill their role in Coastal Resource Management.

Identification of ecosystems and aquaculture zones

Aquatic ecosystems have already been identified within the Clean Water Act prepared by DENR. Aquaculture zones have been identified by the Conservation International Priority Areas, Fisheries Resource Management Project (BFAR). These two resources should be used for identifying the aquatic ecosystems that are of significant importance for aquaculture.

The identified areas should then be checked to ascertain if these aquatic ecosystems have significant aquaculture production and ranked in terms of scale of resource use (low, intermediate, high).

Carrying capacity of ecosystems

There is presently little known about the sustainable aquaculture carrying capacities of water bodies in the Philippines. However, there is a need to base aquaculture development on the sustainable carrying capacity of the resource and to develop quality standards for aquaculture that can act as a measure of compliance. Carrying capacity can be calculated by using box models such as the Environmental State Variable (or Vector) Model Concept. These models can estimate the "State" or category, such as trophic state (eutrophic), or if the nutrient concentration in the water will be above a set quality standard. Models can represent some or all of these variables by dynamic equations.

State variables for assimilative capacity models include:

- concentrations of drivers such as nutrients;
- environmental factors such as temperature;
- and environmental quality variables (EQVs) defined by the regulators, such as dissolved oxygen concentrations.

Some variables may belong to several categories.

The simplest models average values of each state variable over a substantial homogeneous boxed volume that, ideally, corresponds to a defined water body. More universal models such as European Regional Seas Ecosystem Model (ERSEM) deal with a large number of linked volumes that may represent whole sea areas.

Models such as these, need to be tested and validated in different types of water body in the Philippines so that carrying capacities of the identified ecosystems suitable for aquaculture can be calculated. In addition, there is a need to review the water quality standards in waters where aquaculture is carried out and maximum limits set so that these areas are not overly impacted by aquaculture.

Coordinated planning and zoning of aquaculture
There are two major aquaculture zoning plans developed, one by BFAR (Coastal Resource Management Plan) and the other by DENR (Coastal Development Plans). In order for coordinated planning and zoning of aquaculture development, these two plans need to be reviewed and harmonised. The criteria used for zoning aquaculture areas in these plans also need to be reviewed to ensure that they were based on relevant scientific criteria.

Coordinated co-management of ecosystems by surrounding LGUs
The Fisheries Ordinances issued by BFAR are implemented by the coastal LGUs. In many cases, the LGUs surrounding an aquatic ecosystem act independently with varying levels of implementation of the ordinances and management of aquaculture. There is a need for a framework that encourages these LGUs to work together in a coordinated manner. However there is need for a ecosystem- wide development plan for aquaculture and a need to motivate LGUs to plan and manage aquaculture in each ecosystem responsibly and sustainably.

In protected freshwater ecosystems there are the PAMBs that bring LGUs in the catchment area together for unified planning and management of that aquatic ecosystem. In marine and brackishwater areas there are Integrated Fisheries and Aquatic Management Councils (IFARMCs) which have been created in areas such as bays, gulfs, lakes and rivers and dams which are bounded by two or more municipalities/cities. IFARMCs could potentially undertake the same role as PAMBs but this needs to be prioritised and implemented within the IFARMCs.

Recommendations
The ecosystem based co-management should be applied to aquaculture planning and development in the Philippines a number of steps must be taken.

Aquatic ecosystems and ecosystems with aquaculture or potential aquaculture should be identified using the Clean Water Act as a basis. This data should be entered in a GIS database for easy data storage and analysis.

An estimate of the safe and sustainable aquaculture carrying capacity of the identified ecosystems should be made based on best available science. Within each ecosystem an assessment should be made on the industries that have greatest impacts on the ecosystem. Within each ecosystem, an integrated development plan should be made (taking aquaculture into consideration) and prioritise commercial activities in the aquatic ecosystem.

A framework of planning and management should be developed at Central, Municipal and Local Government level using PAMBs and IFARMCs as the basis. Develop a management plan that is within the capabilities and funding of LGUs that will have to implement it. Find ways to encourage LGUs to implement the management plan and enforce aquaculture regulations.

The Central Government must support the LGUs by formulating enlightened policy and sensible regulations as well as undertaking or assisting with the collection of baseline environmental data on the ecosystem, estimation of the safe and sustainable aquaculture carrying capacities and monitoring environmental impacts of aquaculture.

Ecosystem based management of aquaculture (Case study)

A report on Ecosystem Based Management Concept Analysis of Case Study Areas was completed. The analysis of Ecosystem Based Management Concept Analysis was made for 3 Case Study Areas. The paper is in its final stage of completion and inputs from the recent visit to Pangasinan and to Lake Taal will be incorporated in the said paper.

There three case study areas analysed for the success and failures of the LGUs and/or projects to address impacts on aquaculture. The study areas included:

- Ø Lingayen Gulf's ABBA area (Anda, Bolinao, Bani and Alaminos) with assistance from the SAGIP Lingayen Gulf Project, and
- Ø Taal Lake ecosystem with assistance from BFAR and NGOs. The two case study areas represents brackishwater, marine and freshwater areas and represents so various approaches to cooperative management framework.

So far, with the recent fish kills in Bolinao last June 2007, BFAR has to step in to address the never ending management of the Gulf brought about by some political interests and difficulties in the area. The creation of the technical working group that is concurrently drafting the Memorandum of Agreement among the municipalities of Lingayen Gulf that well spell out the framework and unified regulations that they will respected and enforce hopefully will address the management flaws of the Gulf.

Codes of Conduct

A review of a cross-section of codes of conduct and practices was made and the issues covered analysed so that it would be possible to compare the scope of the Philippine Codes of conduct for Aquaculture (Fisheries Administrative Order 214) with the other codes.

The following codes were analysed;

- FAO's Code of Conduct for Responsible Fisheries
- GAA's Best Aquaculture Practice
- SEAFDEC's Regional Guidelines for Responsible Aquaculture in Asia
- FEAP's Code of Conduct for European Aquaculture
- Bangkok Declaration and Strategy for Aquaculture Development, 2000
- Best Management Practices Manual for Black Tiger Shrimp Hatcheries in Vietnam
- Code of Good Environmental Practices for well-managed salmonid farms in Chile

FAO's *Code of Conduct for Responsible Fisheries*

The FAO Code of Conduct for Responsible Fisheries provides general guidance, in the form of suggestions or observations intended to assist those interested in identifying their own criteria and options for actions, as well as partners for collaboration, in support of sustainable aquaculture development.

Codes of Practice for Aquaculture in the Philippines (FAO 214)
This Code of Practice outlines principles and guidelines for environmentally-sound design and operation for sustainable development of aquaculture industry. It lists down general guidelines for site selection and evaluation, farm design and construction, water usage, water discharge, effluent management, use of drugs, chemicals, potential toxic fertilizers and pesticides, stock selection, introduction of exotic species and GMOs, feed management, fish health management, aquaculture data management and incentive schemes to encourage compliance.

The codes analysed consisted of the following categories:

Codes of conduct at different scales:

- International: FAO's Code of Conduct for Responsible Fisheries
  GAA's Best Aquaculture Practice

- Regional: SEAFDEC's Regional Guidelines for Responsible Aquaculture in Asia
  FEAP's Code of Conduct for European Aquaculture

- National: Codes of Practice for Aquaculture in the Philippines

Codes of conduct in conceptual basis:

- Bangkok Declaration and Strategy for Aquaculture Development, 2000

Codes of conduct as guiding principles:

- FAO's Code of Conduct for Responsible Fisheries
- Bangkok Declaration and Strategy for Aquaculture Development (2000)
- SEAFDEC's Regional Guidelines for Responsible Aquaculture in Asia

Codes of conduct as guidelines for planning and management:

- SEAFDEC's Regional Guidelines for Responsible Aquaculture in Asia

Codes of conduct/best practice at the farm/operation level

- Best Management Practices Manual for Black Tiger Shrimp Hatcheries in Vietnam
- Code of Good Environmental Practices for well-managed salmonid farms in Chile

Development of a code of Conduct for the Philippines
Philippines FAO gives some guidelines at the Policy and Institutional level as well as at the operational level.

In terms of environmental and biodiversity impacts, all have some guidelines but the strongest come from Chile. Addressed by Phil FAO but need to be strengthened.

Need for separating

- Conceptual and underlying principles
- International and Regional cooperation

- Code of Conduct for Policy and Institutions at national level
    - Legislation and regulation
    - Aquaculture planning and management (zoning and licensing)
    - Aquaculture monitoring (production and environmental impact)
    - Aquaculture capacity building (training and extension services)
    - Food safety (Chemical use, post harvest)
- Code of Conduct for main issues
    - Environmental impact (Benthos, eutrophication, algal blooms)
    - Sensitive habitats (mangroves, wetlands, seagrasses, corals, etc)
    - Biodiversity (sensitive species, wild fisheries)
    - Fish welfare (fish health, handling, killing and live fish transport)
    - Socio-economic issues
- Code of Practice at farm level
- Code of best practice at culture system level
    - Cage culture
    - Pen culture
    - Pond culture
    - Mollusc culture
    - Seaweed culture

Codes of conduct and best practice should be working documents with continual review and improvement based on feedback from their implementation.

The Phillippines FAO should be reviewed and update in the light of codes of conduct developed from other countries and available scientific information on aquaculture impacts.

The existing codes of conduct are good as far as they go, but each of them has flaws. In general, transparency requires that codes be vetted by all stakeholders before they are finalized. Some codes such as the GAA and Thai codes give some, if inadequate, consideration to social issues, but most others do not. Few of the codes were developed with the involvement of other stakeholders, which is essential if the codes are to be taken up by the industry and implemented. In addition, a economic impact assessment should be made to asses the financial impact for the farmer to implement the guidelines and benefits from complying.

In spite of the many problems and limitations associated with the voluntary adoption of codes of conduct and their implementation in a meaningful way, codes of conduct for aquaculture should be encouraged. They will not be perfect, and they cannot be expected to solve all of the environmental and social problems that can arise from the operation of aquaculture facilities. However, codes of conduct can enhance the environmental awareness of producers and should result in more responsible management. In many countries, it will be years before aquaculture will be effectively and efficiently regulated by environmental and social legislation. In the absence of effective regulation, codes appear to offer one of the best possibilities for improving the environmental and social performance of aquaculture.

Better practice guidelines for small-scale fish cage and pen operators

BPGs were prepared for cage and pen operators with emphasis on mitigating environmental impact. These BPGs cover both cages and pens in marine, brackish and freshwaters. The guidelines cover the culture practice from the purchase of fry or fingerlings until the point of sale.

This BMG is separated in to sections which follow the culture process as follows;

1. Planning and siting
2. Farm design and construction
3. Broodstock and hatchery management
4. Production management
    - Ø Feed and feed management
    - Ø Fish health and welfare
    - Ø Quality and food safety
5. Harvest and post harvest management
6. Monitoring and evaluation
7. Record keeping
8. Socio aspects (staff training, health and safety)
9. Environmental mitigation

Better Practice Guidelines aim to give farmers sensible and practical guidelines to follow in the planning, management and operation of their farms. These guidelines are based on lessons learned from local and international practice or scientific research. Better Practice Guidelines are useful to improve our ways of working (knowledge, skills, capacity and practices).

We no not yet know the best way to produce fish but we can improve the way we do it based on lessons learned, knowledge and research. By describing and sharing this, we hope to provide guidelines toward “better-practice”.

These guidelines are being developed as good practice guidelines that if followed, would encourage responsible and sustainable production. They incorporate many of the DA-BAFPS BAPS but are focused on particular culture systems and mitigating aquaculture impact on the environment.

It is hoped that these guidelines will be taken up by producer organisations, mariculture parks, aquaculture parks, clusters of farmers and large farmers. It would be difficult for a farmer to implement all guidelines immediately but it is hoped that the farmers will start to implement some immediately and gradually implement the others as time goes by.

Within each section there are crosscutting issues that need to be addressed

- Ø Legal and regulatory
- Ø Genetics and biodiversity
- Ø Biosecurity
- Ø Sustainable operation
- Ø Environment

Care has been taken to ensure that these BPGs do not adversely affect the poorer small-scale farmers.

Better Management Practice for Local Government Units

This report attempts to prepare better management guidelines for Local Government Units for planning, zoning and siting aquaculture development as well as management, monitoring and control of aquaculture with emphasis on mitigating environmental impact. These BMPs cover both cages and pens in marine, brackish and freshwaters. Other BMPs need to be developed for different culture systems such as for hatcheries and nurseries, freshwater, brackish and marine ponds, seaweed culture, etc.

Zoning
Aquaculture should be zoned so that it is not in conflict with other users of the coastline and that it is located in a suitable area with sufficient depth and currents.

Environmental considerations
With increasing aquaculture production, there is a need to consider the environmental consequences in the planning and licensing of aquaculture. The goal should be sustainable production within aquaculture carrying capacity.

Sustainable production
With increasing production, there are increasing impacts to the environment. The environment is able to assimilate certain impacts such as organic sedimentation or dissolved nutrients but if the impact is greater than the assimilative capacity, then there is a build up impact and eventually will pass a threshold where there are consequences such as fish kills.

Carrying capacity
An assessment of carrying capacity of zones allocated to aquaculture should be developed and validated for aquaculture in the different aquatic environments (fresh, brackish, marine) for the Philippines. This estimation needs to take into consideration the inputs by aquaculture and by other human activities. The planning and management of aquaculture should adhere to a production below the estimated carrying capacity.

Ecosystem management approach
Planning of aquaculture development should take the aquatic ecosystems approach where aquaculture is planned for the aquatic ecosystem as a whole rather than for individual zones within an ecosystem.

Co-management
Although the management of aquaculture is undertaken by individual bordering LGUs, they should consider co-management of the whole ecosystem with other LGUs that border the same ecosystem.

Review of Philippine aquaculture legislation and regulations

The problems with existing Philippine structure (legislation, regulations and enforcement) were analysed in Deliverable 6 “Review of the capabilities for enforcing environmental laws and regulations”.

The creation of BFAR in the mid ‘70s brought forth significant development in the country’s fisheries and aquaculture legislations leading to the future policy directions of the industry in decades that follows. The Fisheries Decree of 1975 (PD 704) outlined the conduct of studies on fish and fishery/aquatic products, establishment of fish hatcheries, nurseries and demonstration fishponds, conduct of experiments and demonstrations on the culture, gathering and processing of fishery products, issuance of licenses, leases or permits to exploit, occupy, produce, culture or engage in other fishery activities, promote the production of fish meal to maximize the utilization of fish and fishery products to complement the development of animal industry, issuance of Fishpond Lease Agreements (FLAs) and permits to operate fishpens and set aside public lands to be subdivided into family-size fishponds for leasing to qualified applicants.

The fisheries decree existed for almost two decades until the subsequent promulgations of three major related laws of the land that has brought forth changes in the development of the fisheries and aquaculture industry of the country. These are the enactments of the Local Government Code in 1990 (RA 7160), followed by the Agriculture and Fisheries Modernization Act (AFMA) of 1998 and subsequently after three months later, the Fisheries Code of 1998. These three major laws made substantial changes in the fisheries legislation history over the past decades in setting policy directions and management reforms in the aquaculture industry from resource exploitation to sustainable production.

The existing regulations were reviewed and commented on. These included;

The Fisheries Code of 1998, its implications to AFMA and RA 7160

The most significant milestone of the decade was the promulgation and approval of Republic Act No. 8550, the Philippine Fisheries Code of 1998.   This landmark legislation provides the policy, legal and institutional framework for the sustainable use of the fisheries resources with its long term goal to ensure the attainment of the following objectives in the fishery sector

The Comprehensive Agrarian Reform Law (1987)

When the Comprehensive Agrarian Reform Program (CARP) was passed as a law, fish ponds were also included. The implementation of such a law should have led towards a more equitable distribution of aquaculture resources. However, with a very strong lobby from the fishpond sector, and to the consternation of the grassroots sector, fishponds were recently granted exemption from the land reform.

The NIPAs Act (1992)

The National Integrated Protected Areas System (NIPAS) Act of 1992 (RA 7586) intends to protect areas with natural biological or physical diversities of the environment, particularly those with unique biological features to sustain human life and development as well as plant and animal life. These includes all areas or lands declared as parks, sanctuaries, refuges, reserves, landmarks, protected landscapes and seascapes, virgin forests and watersheds existing as of 1992 and such other areas as may be declared under the NIPAS law.

DA-DENR Joint Memorandum Order No. 1 (2000)
This joint DA-DENR Memorandum Order of May 2002 is purportedly to define and identify areas of cooperation to harmoniously implement laws and regulations covered under RA 8550 and such other promulgated national environmental laws that may have in conflict to fisheries and aquaculture.

Water Code of 1976 (PD 1067) – prescribes the conservation of fish and wildlife which should be coordinated properly with other features of water resources development programs thru the National Water Resources Council (NWRC) which did never exists.

Philippine Mining Act of 1995 (RA 7942)- of which general provisions to exploit the mineral resources has greatly affected the adjacent inland and marine waters due to unregulated mine tailings, irresponsible disposal of contaminated waste to marine environment affecting the seaweeds beds and most of the inland lake fisheries.

Philippine Sanitation Code of 1976 (PD 865, Sec. 32,f) - stipulates that shellfish, particularly oysters shall be planted and grown only in areas approved by the Secretary of health or his duly authorized representatives (local health authority) and in places licensed by the BFAR. It further stipulates that oysters offered for sale if not originating from approved areas, shall be confiscated and destroyed bythe local health authority. The IRR of the same code was approved on 29 Dec. 1995 with amendment to include a “Shellfish Sanitation Code” which could serve as a basis or reference in promulgating and passing a local ordinance in the concerned municipality.

Clean Water Act of 2006- the most recently enacted law encompassing the Water Code, Pollution and Mining Acts and the utilization of water resources prescribing particular provisions of water use in inland bodies for irrigation and aquaculture.

The development of the Joint Administrative Order (JAO)

The project prepared the Joint Administrative Order (JAO) between the Departments of Environment and Natural Resources, Agriculture and Interior and Local Government identifying the areas of collaboration and cooperation among the three departments in the planning, management and control of mitigating impacts from aquaculture is in its second stage of consultation among the agencies involved including the League of Municipalities of the Philippines and National Fisheries Aquatic Resources Management Council. The issue on Fishpond Lease Agreements (FLA) is a challenging item that needs a lot of consultations and dialogues among the agencies concern. Issue such as disposal of used cages, pens and other fishing paraphernalia was addressed in the JAO as well as introduction of exotic and invasive alien species. Third consultation is tentative scheduled mid September. Considering that there is again changes in the top level of the Department of Environment and Natural Resources, considerable delays is expected to happen. The series of consultations is expected to go even beyond the life of project. But this will be a good start to get the major three (3) agencies discussed and dialogue on its major concerns of addressing impacts from aquaculture.

The JAO will encourage cooperation and improve linkages among agencies involved in aquaculture development, management and control. This will also assist LGUs in the preparation of their Municipal Fishery Ordinances that will include the aquaculture component. The JAO also will give FARMCs more participation in the local level especially in the enforcements of fishery laws.

The Making of the Joint Administrative Order among Departments of Agriculture, Environments and Natural Resources, and Interior and Local Governments on the planning, management and control of aquaculture development to mitigate impacts on the environment.

Process in the development of JAO:

- First inter agency meeting was held on July 4, 2007 at Visitors Center, PAWB attended by representatives from DENR, DILG, LMP, UPMSI, BFAR offices, NFARMC, Akvaplan-niva, etc.
- Issues included in the JAO on mitigating impacts from aquaculture development were solicited, identified and prioritized by the inter-agency group.
- First draft was presented to the 2nd inter agency meeting on August 8, 2007 held at BFAR Conference Room.
- Comments were integrated and drafts were circulated again among the inter agency members as well as succeeding consultations were conducted, individually and collectively.
- Final draft was transmitted to the agencies concerned on December 4, 2007 for final comments and subsequent comments were finally integrated in the final copy.

Salient features of the JAO:

1. Adoption of the Code of Practice for Aquaculture that spells out the proper management of feeds in the bodies of water, stocking density, carrying capacity of the lakes and other bodies of water, water quality standard, exotic species and the like;
2. Proper disposal of used fishery structures, paraphernalia, conduct of environmental impact assessment as well as monitoring, creation of inter agency group for FLA areas, as well as creation of joint quick response team for management aquatic pollution such as fish kills, management of fishery structures in protected areas, environmental impact assessment.
3. Defines and identifies areas of collaboration, common provisions and roles and responsibilities of each agency.

Plans on how JAO will be disseminated, utilized and the initiatives continued:

1. conduct of regional briefing for the 3 agencies with assistance from technical working group.
2. printing of the signed JAO and distribution to the regional offices of the 3 agencies.
3. involvement of the private sector in the process.

4. issuance of corresponding memoranda and circulars to the respective regional offices for the adoption and implementation of the JAO.
5. monitoring of the JAO implementation by the 3 agencies with pilot areas identified.
6. capability building on JAO, Guidebook and Better Management Practices.
7. the need to come up with a comprehensive resource management initiatives by the LGUs.
8. identification of issues, concerns and gaps that were not addressed by the JAO and the guidebook on aquaculture management

Guidebook for LGUs

The project prepared the guidebook to help local governments and the communities whom they govern, address the negative environmental problems associated with aquaculture. Fish kills, red tide, eutrophication, and other forms of aquatic pollution are among the negative impacts of aquaculture which should be managed, avoided, and mitigated by local government units. Aside from its impacts on human health and the environment, widespread environmental disasters associated with aquaculture imply losses in revenues both for the entrepreneur and the LGU, which are incurred not only in the short term, but which will have long-lasting effects. It also implies loss of food resources for the domestic market and quite possibly, a default on agreements for exportation of products.

Mitigating the negative impacts of aquaculture is one of the many responsibilities of local governments. Aquaculture, whether land-based or water-based, is practiced within an LGU territory and is subject to local planning, regulation, policy formulation, taxation, and revenue generation. Thus, LGUs, being subsidiaries of national government, have the duty to share in national government's goals and aspirations. One of these goals is to "share with the national government the responsibility in the management and maintenance of ecological balance within their territorial jurisdiction" subject to the provisions of the LGC and national policies.

As a corporate entity, the LGU must perform its function to the approval of its shareholders, in this case the general citizenry, the private sector, and small fishers and farmers who are engaged in aquaculture. In cases where the environmental impact of certain activities, extend beyond municipal boundaries, the LGC and other national policies also provide for LGUs to group together to jointly address the problem. Aquaculture is a fast-growing source of food and raw material supply for industry and the Philippines occupies a significant role in the world market. Nevertheless, negative consequences of growth are as significant and should not be ignored.

In summary, this guidebook will help LGUs and other local level partners and stakeholders to:

- appreciate the potential of aquaculture to contribute to national goals of food security, income generation, and employment;
- recognize the threats posed to the environment as a result of bad farm practices and lackluster governance;

- Ø appreciate and understand the national policies governing aquaculture and environmental management and use these as an arsenal for better governance; and
- Ø recognize the role of national agencies vis-à-vis their own.

National policies governing aquaculture management are discussed together with a clarification of mandates of LGUs vis-a-vis national agencies to clarify scope of action, and finally a 15-point agenda for LGUs is suggested to encourage responsible and sustainable aquaculture development in the Philippines.

The 15 point agenda

Existing policy framework for aquaculture management allows LGUs to implement the following:

1. Enact ordinances in support of national standards on good aquaculture practice by adopting FAO 214 and implementing the EIS system. LGUs must share with national government the maintenance of ecological balance.
2. Institute a licensing/permitting system consistent with measures of resource rent, resource value, opportunity cost, and cost recovery criteria.
3. Institute a farm identification system that will allow farm inspectors or farm workers themselves to report occurrences and circumstances needing immediate attention.
4. Protect and rehabilitate damaged ecosystems
5. Work with national agencies to monitor performance of feed suppliers
6. Coordinate with national agencies to constantly provide farmers simple advice on feed management
7. Help the farmers manage their farms better.
8. Allow the environment to "rest" – FALLOW and continue monitoring until recovery is attained!
9. Work within the Environmental Carrying Capacity
10. Monitor farm conditions, recognize signs of impending disasters and react immediately!
11. Recognize impending disasters and react immediately
12. Organize fishfarmer communities
13. Invest in collecting information for decision making. Establish a registry of aquaculture farms and establish procedures thereof per FAO 218.
14. Incorporate aquaculture activities in local plans such as the coastal development plan or municipal development plan as provided by the Local Government Code and AFMA
15. Promote cooperative management schemes through joint management of a shared environment

Encouraging inter-agency cooperation

The objectives of the inter-agency meetings were to investigate ways to resolve inter-agency roles and improve linkages between the main agencies namely Department of the Interior and Local Government (DILG), Bureau of Fisheries and Aquatic Resources (BFAR) and Department of Environment and Natural Resources (DENR) for environmental management of aquaculture development in the Philippines. A number of meetings have already taken place.

The objectives of the meeting were to investigate ways to;

- Encourage cooperation between the main agencies involved with aquaculture development, monitoring, management and control
- maximize NAFC and NFARMC as inter-agency Councils for resolving conflict, identify overlaps between agencies and encourage cooperation
- Prepare a white paper outlining socio-economic importance of aquaculture development and the risks to environment from uncontrolled development
- Prepare a draft joint BFAR/DENR/DILG Administrative order or ordinances for planning, monitoring and control of aquaculture development on a ecosystem/water resource basis by surrounding LGUs.

The jurisdiction and activities of the three agencies were reviewed and clarified.
The culmination of this work was the preparation of the Joint administrative order.

Environmental Impact Assessment in the Philippines

The project undertook a review of the Environmental Impact Assessment regulation for aquaculture in the Philippines. This review was incorporated into a review undertaken by NACA and other authors (Project Authors in bold, see details below).

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EIA and monitoring in aquaculture: Review of Environmental Impact Assessment and Monitoring in Aquaculture in the Asia-Pacific Region by Network of Aquaculture Centres in Asia-Pacific (NACA) December 2007

This review was prepared as part of the FAO Project "EIA and monitoring in aquaculture". The purpose of the review was to provide a compilation, review and synthesis of existing EIA and environmental monitoring procedures and practices in aquaculture in the Asia-Pacific region, the largest aquaculture producing region in the world. This review, as in other regions, gave special consideration to four areas related to EIA and monitoring in aquaculture including: (1) the requirements; (2) the practice, (3) the effectiveness and (4) suggestions for improvements. Australia, China, India, Indonesia, Japan, Malaysia, Philippines, Thailand and Vietnam were covered in some depth, and a brief overview is provided of EIA and monitoring in several other countries in the region that are in various stages of adoption and implementation of environmental impact assessment, monitoring and other environmental management measures for aquaculture. The review synthesis provided an overview of the current status of EIA and monitoring in the countries around the Asia-Pacific region and provided a number of recommendations for future improvements in the environmental management of aquaculture.

Water Quality Criteria and Standards for Freshwater and Marine Aquaculture

A review was made of the water quality standards and criteria being used in Australia, Brunei, Hongkong, India, Kenya, Malaysia, New Zealand, Norway, South Australia, USA, and UK. The parameters being looked into are, physical (pH, alkalinity, DO), biological (TSS, P, nitrate, nitrate, unionized and ionized ammonia), heavy metals (Hg, Pb, Cd, Ni), selected pesticides, and coliform. These informations were compared to the parameters and values presently being applied in the Philippines. The findings of this paper were used as basis in making the recommendations on water quality guidelines for the Philippines. This guideline is envisioned to be utilized by the regulators as well as the aquaculture operators.

The Philippines have existing regulations regarding water quality management. One of these is the Department Administrative Order 1990-34 which was extensively discussed in this paper. Generally, the these laws and regulations are comparable with other countries that are considered to be well-advanced in managing their aquaculture industry. However, there are some standards and/or criteria that needed to be updated and amended.

In addition to the review of regulations, this paper also includes the outputs from the series of consultations and meetings with the different sectors. This paper was first presented to the Environmental Management Bureau of the Department of Environment and Natural Resources, the agency mandated to regulate and monitor the water quality throughout the country. Afterwhich, it was presented to different stakeholders such as aquaculture operators/owners, local government units, central and regional BFAR offices, academe, aquafeed miller companies, SEAFDEC, DA-BAFPS, and NGOs.

The following are some of the major recommendations that came up during the consultations and meetings:

1. Consider the "sum of impacts" from all sources. The present guideline only monitors the effluents from the different sources. However, the over-all condition of the water body are not well-presented since the totality or sum of the effluents from all sources are not considered. Since, the impacts on the habitat and organisms of these discharges increases in magnitude exponentially, thus, adding 1 + 1 will not give you an accurate picture.
2. Provide provisions that will protect the aquaculture industry from effluents from outside sources.
3. Inclusion of sediment quality as one of the indicators of the health of the water body. Sediment condition is a more reliable parameter compared to water quality since it is more stable than water conditions. Water samples varies spatially and temporally, thus will not give out conclusive state of the water body. Further, sediments can provide information on a long-term scale.
4. Strengthen information dissemination and tap the religious sector as a medium to promote and strengthen awareness.

The following are the recommendations which were already included under the proposed Water Quality Guidelines and General Effluent Standards of 2008 of the EMB-DENR:

1. Inclusion of standards for un-ionized ammonia and nickel
2. Amending the TSS standard from percentage increase into an exact value
3. Considerations on the assimilative capacity of the water body
4. Reclassification of water body for aquaculture purposes

To conclude, the amending of water quality guideline is already a seen as a good move by the Philippine government towards sustainably managing the aquaculture industry. However, efforts should still be continued as aquaculture industry is not one of the priority sector at the moment.

Improvement of Aquaculture Feeds

Recommendations were prepared for the Improvement of Aquaculture Feeds for Better Profitability and Reduced Impact on the Environment. Aquaculture feed accounts for about 60% - 80% of operation cost in intensive aquaculture, and about 30%-60% in semi-intensive system. However, only 40% of these feed inputs are being utilized by the fish. With poor digestibility and stability, it will further decrease. Consequently, all these uneaten feeds will pollute the water. Within the aquaculture industry, good water quality is inevitable in order to maximize production and profit. Therefore, poor feed quality is not beneficial, economically and ecologically.

This paper reviews the impacts of feed wastage and the use of poor feed quality on the environment and economics of aquaculture production. It looked into the roles of different sectors, i.e. national agencies, fish farmers, operators, caretakers, local government units, and feed manufacturers in addressing these issues. Lastly, this paper also presents the output of the consultations with these sectors.

Akvaplan-Niva, in cooperation with BFAR initiated a series of consultation meetings with the major players of aquaculture industry. These meetings aim to inform these groups of the impacts of aquaculture in the environment, specifically of feed wastage.

Each sector was met on separate occasions, discussing their concerns and steps/ways of minimizing environmental impacts thereby ensuring the sustainability of the industry. Recommendations were also made at this time. These discussions are important to deal the concerns of each sector.

The culminating meeting was held, gathering all the different sector. During this time, the output of the consultative meetings per sector as well as the recommendations formulated were presented and discussed.

Below is the summary of the output during the culminating meeting:
<u>Regulators Sector:</u>
- creation of standards for feed stability and digestibility
- develop Better/Good Management Practices

<u>Feed Millers Sector:</u>

- improve pellet stability by adding binders to feeds and/or through extrusion
- improve feed digestibility
- develop "Best Practice for Feed Millers"

Local Government Units Sector:

- regular feed quality through feed accreditation
- regulate the number of cages and stocking density by using carrying-capacity of the water body as a basis
- levy resource fees for water quality monitoring purposes

Producer Association Sector:

- feed accreditation

Farmer Sector:

- exercise good feeding practices
- stop overfeeding
- buy feeds that have low feed conversion ratio

The project work on the improvement of feed quality has lead to the inclusion of physical standards on grinding size, water stability, pellet stability being included in the new feed quality standards.

GIS database for planning aquaculture development

The development of a GIS database for aquaculture as a management tool for BFAR and LGUs in planning and management, monitoring, control and surveillance, policy formulation, and zoning of responsible and sustainable coastal aquaculture development in the Philippines. The GIS database for aquaculture shows management interventions, ecosystem management areas, resource profiles, hotspots, cold spots, production areas, exploitation rates and suitable areas for aquaculture. The geospatial data will provide key inputs to the LGU's Comprehensive Land Use Plan (CLUP), Coastal Resource Management (CRM) plan and sustainable aquaculture development plan in the context of mitigating environmental impacts of aquaculture.

GIS Database for PHllMl NAQ covers:

Resource Profiles

- Mangrove
- Coral reef
- Sea grass

Management Interventions

- Marine Protected Areas (MPAs)
- Fish Sanctuary I Fishery Reserve

Ecosystem management

- IFARMC areas
- BFAR-initiated FARMC area

Production
- National aquaculture production/exploitation
- Regional aquaculture production/exploitation

Coastal Aquaculture Structures
- Fishponds
- Fish cages
- Fish pens
- Mariculture parks

The GIS work collected, verified and processed spatial data necessary to aid planning of aquaculture development. It undertook geo-corrections, spatial data encoding, map data analysis, report generation and documentation covering thematic data for pilot project site (SABBAC) and regional study areas. The thematic data layer for pilot study area included data from FRMP, EMMA, FAO SAR, Sagip Lingayen; including data from IFAD namely, aquaculture production, pond, water boundaries. National data scope was disaggregated on a per region classification, covered mangrove, coastline, lakes, 18 FRMP bays, 58 NFARMC ecosystems, aquaculture production, mariculture parks, seaweed culture, coral reefs, MPAS, NIPAS, PAMB, dams, river systems.

BFAR needs real mapping [Remote Sensing methodology] to calculate the value and amount of the various component resources for aggregation, analysis and data presentation. RS methods [using satellite image] should be conducted to provide multi-temporal [multi-date] analysis and will assist in the definition of resources declined or accepted or which resources declined or increased in amount per value, provided that the Bureau has the baseline data to compare the latest dataset.

The use of GIS for BFAR is for the planning, management, monitoring and control of responsible and sustainable aquaculture Development in the Philippines.

This can be demonstrated at the National and local levels

	National/Regional	Local
Planning	**Unsuitable areas –** sensitive habitats, MPAS, hotspots **Resource use –** Hotspots, coldspots, rivers, lakes, coastline **Ecosystems –** aquatic ecosystems **Aquaculture Zones** **Mariculture highway**	**Unsuitable areas –** sensitive habitats, MPAS, **Resource use –** rivers, lakes, coastline **Ecosystems –** aquatic ecosystems
Management	**Mariculture Parks**	**Mariculture Parks**

	Catalogue ponds – brackish and fresh **Catalogue** cages and pens	**Catalogue ponds –** brackish and fresh **Catalogue** cages and pens
Monitoring	Production statistics	Production statistics Illegal ponds
Control		Linking ponds identified by Satellite images to FLAs and licences
Data management	Data collection by BFAR Regional offices sent to FIMC National database at FIMC	Data collection by LGUs sent to FIMC
Dissemination/availability (Knowledge is only useful when shared)	Web based availability	Access to FIMC database from LGU

GIS outputs and exploitation

Planning and Development

Key information from the baseline will assist in identifying potential impact of aquaculture on key resources such as mangrove areas, coral cover and sea grass; including conservation and protected areas. Comprehensive GIS-based mapping should be utilized in the development of coastal aquaculture development zones with sustainable if not minimal impact to sensitive ecosystems. Geospatial data will also assist in the development and implementation of site suitability analysis, zoning, CLUP and coastal resource management plan.

Policy Formulation

The increasing aquaculture activities has brought about serious impacts to the environment such as organic loading in which its progressive accumulation occasionally breach the threshold capacity resulting to fish kills, elevated production of harmful algal blooms and possibly phytoplankton composition shifts. The construction of fisheries coastal aquaculture structures near tourism zones, protected areas, and other sensitive habitats through the use of mapping and remote sensing has raised legitimate concerns that without proper constraints and policies may cause short and long-term impacts on the environment.

Monitoring and Control

Overlaying time-series of production data and exploitation rates along with the other thematic layers such as resource profiles, ecosystem management zones, interventions, aquaculture structures and protected areas usually render useful information to LGUs for better decision-making and fine-tuning of aquaculture-related initiatives. The wealth of information articulated in dynamic geospatial data representation may readily be compared with the latest field data sets for analysis and cross-referencing with existing management policies.

Information, Education and Communication
The results of mapping coastal aquaculture will produce information that should be packaged into useful contents to deliberately address target audiences and stakeholders in mitigating environmental impacts of aquaculture.

Data Management
Regular data collection at the Regional and LGU levels should become an integral part of building a national GIS database for aquaculture. The participation of LGUs in periodically profiling resources, interventions, ecosystems, aquaculture structures and other initiatives is deemed important in building the knowledge base for sustainable coastal aquaculture.

GIS data will be disseminated, utilized and the initiative continued
The GIS data derived from PHILMINAQ Project will further be validated and cross-referenced with data sets from other national government agencies, NGOs, academic and research institutions to increase confidence levels on the data holdings. The fine-tuning efforts on the results will address data gaps and critical variances derived from different data sources.

Majority of the GIS data sets with no outstanding issues or contentions will readily be distributed to all stakeholders and potential target audiences using diverse channels that include print and online publications such as the BFAR national and regional newsletters, 16 BFAR web sites, 10 center web sites and project-related publications. The results will be presented to BFAR management conference and consultative meetings among DA attached Bureaus and DENR, multi-sectoral councils (e.g. IFARMCs, RDCs, MSN), on-going multi-lateral projects, people’s organization, aquaculture congress among others.

Processed GIS data will be utilized as key inputs in planning and development at the national, regional, and LGU levels. The GIS data will be used for the formulation of Comprehensive Land-Use Plan (CLUP), mangrove management plan, coastal resource management, participatory coastal resource assessment, mariculture zone development, formulation of municipal fisheries ordinances (MFOs), monitoring MPAs, Monitoring Control and Surveillance (MCS), red-tide monitoring and law enforcement.

In order to continue the initiative, a series of GIS activities will be regularly conducted to monitor the hotspots, aquaculture resources, coastal aquaculture structures. On the other hand, most of the data providers will be revisited to acquire the latest data on the state of critical resources, aquaculture practices, MPAs and production statistics.

Monitoring of aquaculture impacts

The objective was to develop three types of survey for monitoring the impact of aquaculture. These range from low cost through intermediate to fully scientific surveys and differ in terms of cost, complexity and accuracy but all give a good indication of the level of aquaculture impact.

Use of surveys

- Check level of impact
- Check extent of impact
- Check if
  - production over carrying capacity,
  - too many licenses issued
- Check if impact
  - getting worse,
  - staying the same,
  - getting better

Categories of surveys

Category 1. low cost simple survey that can be undertaken by local Government or larger farmer

Category 2. Medium level survey that requires some dedicated equipment that can be undertaken by Government regional offices, Protected Area Management, IFARMCs, Aquaculture parks and other aquaculture management organisations

Category 3. Comprehensive survey (baseline survey) to be undertaken by Government research Institutes or similar, scientists for EIA, baseline survey or detailed impact studies.

A field manual of methodology for the 3 categories of monitoring survey were prepared by APN and SAMS and details can be found in Deliverable 12a, 12b and 12c.

Use of Modelling for zoning and estimating carrying capacity

Description of the Hydrodynamic model

The hydrodynamic model used for the SABBAC area residence time estimation is a 2-dimensional vertically-integrated barotropic tide model. The model grid is 75mx75m and the bottom bathymetry was digitized from topographic maps and navigational charts. (Figure 1). The model is driven by tidal oscillations of sea level at the three open boundaries. This was obtained from deployments of pressure gauges at the open boundaries for 15 days where tide height was measured on an hourly basis. The model was allowed a spinup time of 1 day and then allowed to run for 30 days. Hourly sea surface heights and currents were stored and were used to drive the residence time model.

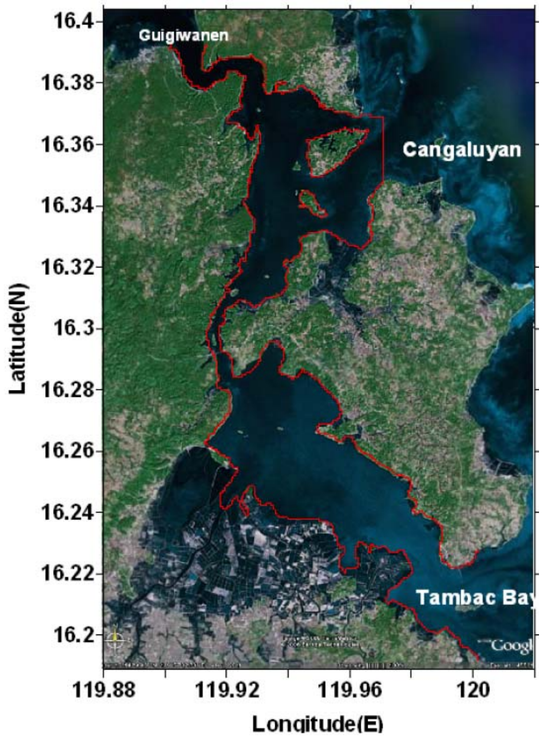


Figure 1. Domain of hydrodynamic model in SABBAC area.

The effect of the fish cages and pens on the flow field was simulated by assuming that the obstruction of the structures was similar to increasing the frictional drag within the grid cell where the cages orpens are located. Measurements of flow reduction within cages were done on the field yielded average reduction of 43% and 59% for cages and pens, respectively.

Numerical experiments with the model show that this reduction is equivalent to a frictional drag (C_D) of 0.0078 for cages and 0.026 for pens. These elevated frictional drag values was only used in cells where cages and pens are found.

Methodology for determining residence times

The velocities generated by the hydrodynamic model were used to simulate the transport of passive particles which form the basis for estimating residence time. Passive particles were initially placed at the center of each model grid. The location of each particle over time was then calculated using the equation of Tartinville et al. (1997) modified for 2D model:

$$r(t+\Delta t) = r(t) + \Delta t\{u + (6\,k_h/\Delta t)^{1/2} d_h\}$$

where, r is the location of the particle, t is the time of particle of r, Δt is increment time, d_h is a randomly generated dimensionless number, k_h is the eddy diffusivity of grid size, and u is the advective velocities provided by hydrodynamic model. These particles can move freely between grid cells and once a particle exits any of the three open boundaries, it is completely removed in the calculation and never returns. The time from its release to its exit through the open boundaries is the residence time. In a tidally dominated flow, the residence of a particle released close to the open boundaries will vary greatly with the phase of the tide The simulation time is 30days, hence the resulting residence time is averaged to compensate for the stochastic estimation of the position and location of the particles in Lagrangian method. Figure 2 shows the difference between the residence time estimate with and without fish farms.

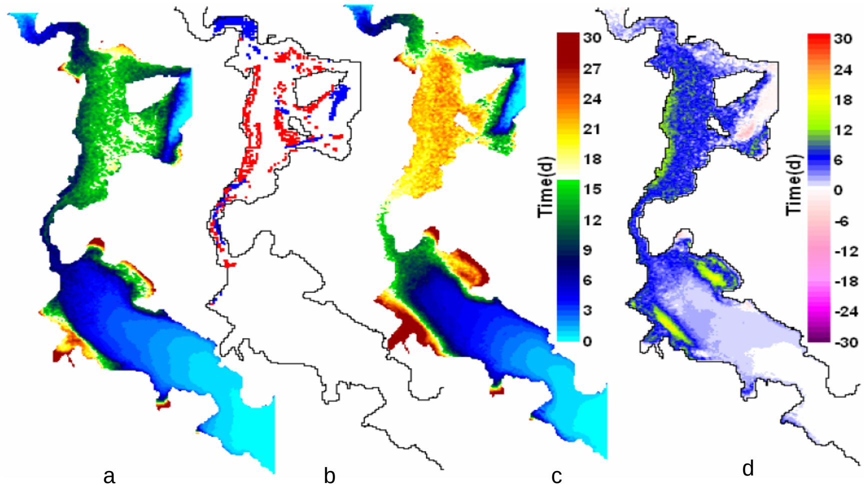


Figure 2. Predicted residence times without structures (a), with structures (b and c) and change in residence time due to structures (d).

The models described above may not necessarily apply for different areas. Other methods of residence times may be used.

Methodology for determining average current speeds

Water currents influence the fate of dissolved and suspended waste (excess feeds and fecal material) from mariculture cages and pens. Stronger currents can advect mariculture waste material further away from the source allowing for a higher rate of dilution and dispersion. Weak currents can lead to local accumulation of waste particularly on the seabed. The currents must therefore be one of the important criteria in selecting sites for mariculture cages or pens. Most areas being developed for mariculture are sheltered from the open sea. Thus, most of the time, the flow is dominated by the tides. In this note, we describe different ways to measure currents and how to calculate average tidal currents for the purpose of site selection.

Measuring currents

Currents can be measured in a variety of ways ranging from electronic measuring devices to simple surface drogues or drifters. Electronic instruments to measure currents allow continuous measurement over a period of time but can be prohibitively expensive for some mariculture cage or pen operators or even for local government authorities. Surface drogues are relatively inexpensive but require manpower over the period of measurement. Both methods can be used to estimate the average current in a particular area and comparison using hypothetical data will be used.

Averaging of currents

Current variations in the coastal areas are dominated by the tides. The strongest components of the tide contribute to the fortnightly variations known as the spring and neap cycle (see

Figure 3). The average current used to characterize a particular area should take into account the current variations at this time scale. One way is to simply average the speed over a 15 day period. If a hydrodynamic model is available, the spatial variation of the average current speeds can be represented as in the map shown in Figure 4.

Calculating the average speed is straightforward if a continuous 15-day time series of the currents is available either from direct measurements or from a hydrodynamic model. However, if none is available, one should be able to estimate the average speed by conducting direct measurements of currents continuously for 24 hours at selected days during a spring-neap cycle. The timing of the spring and neap tides can be determined from the Tide Tables published by NAMRIA (see example in Figure 5). For example, measuring hourly velocities for 24 hours during spring tide and again during neap tide will yield average values which differ only by about 8% compared to averaging currents measured hourly for 15 days (Figure 6). This suggests that in the absence of continuous current measuring instruments, it is possible to represent the average currents over a spring neap cycle using 24-hour measurements of currents conducted for only two days, once during the spring tide and again during the neap tide.

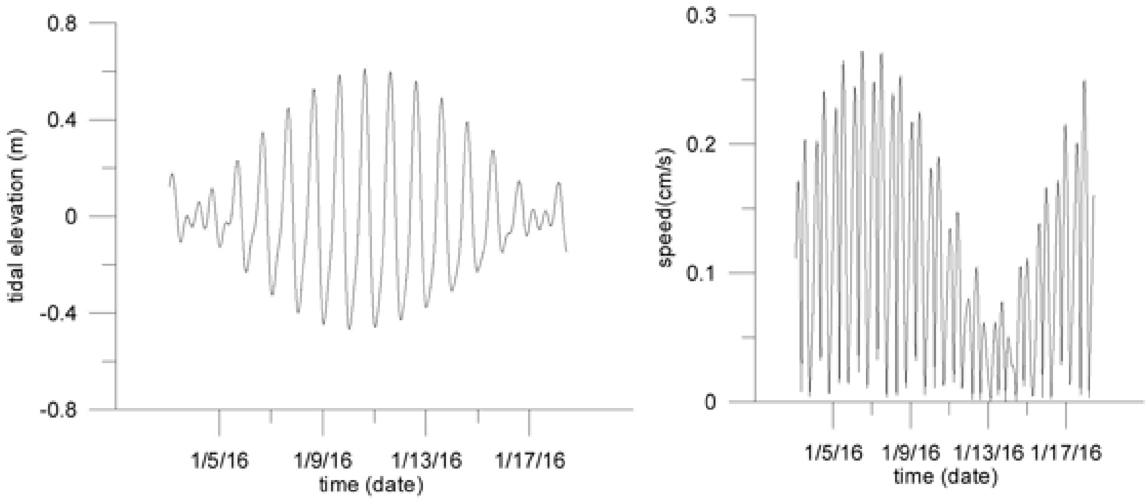


Figure 3. *Example of sea level and current variations over a spring neap cycle.*

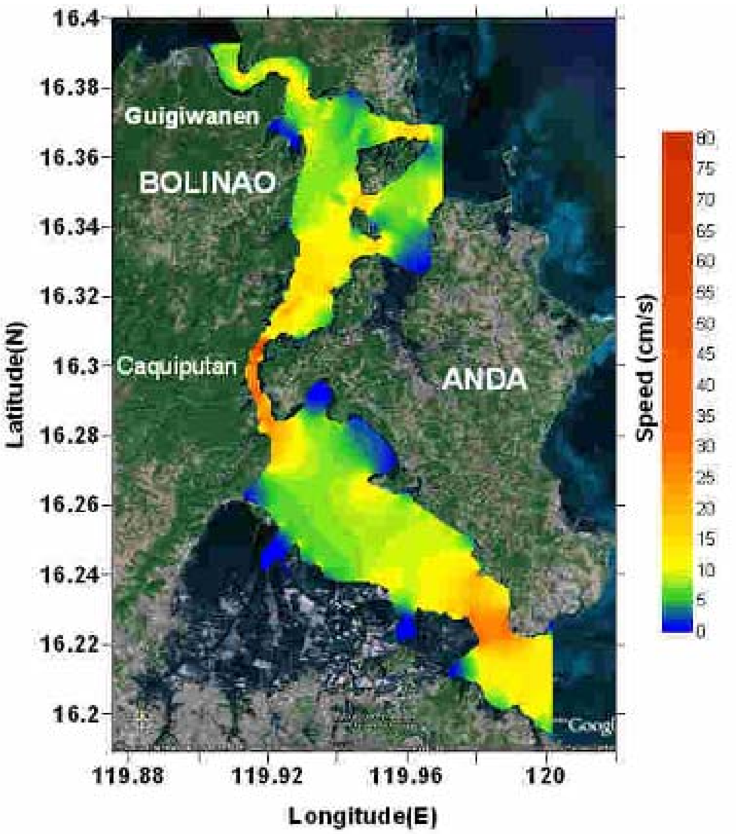


Figure 4. *Average speed over the model domain in the SABBAC area calculated from a hydrodynamic model.*

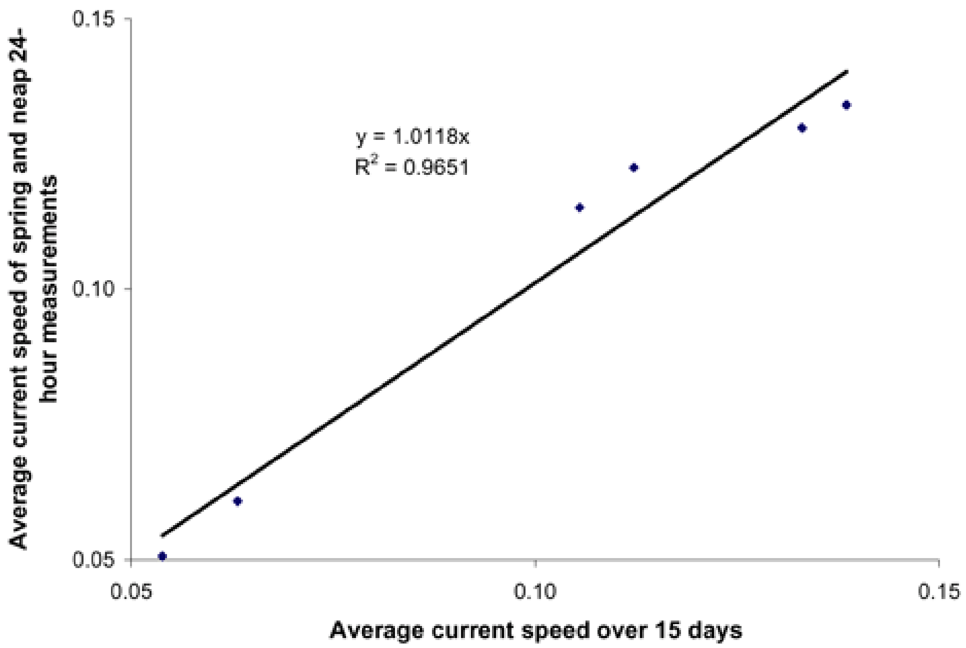


Figure 5. *Correlation between average current measured using a 15-day hourly time series against the average obtained from 24-hour measurements during spring and neap.*

Other ancillary parameters can also be derived from the current measurements or hydrodynamic model data. For instance, the Scottish Environmental Protection Agency (SEPA) requires mariculture operators to provide:

- Mean, maximum, minimum current speeds;
- Ranked percentage of mean current speeds;
- Percentage < 3 cm s-1 (to define whether a site is quiescent or not);
- Percentage > 9 cm s-1 (as this current speed is important for resuspension in the Scottish models);
- A graph of speed percentiles; and
- The length of time this analysis has been undertaken.

Methodology for selecting optimal aquaculture zones

It is difficult to prescribe a standard methodology for mariculture site selection because different sites have their own set of characteristics and one approach that works for one site may not work for another. The amount of available information needed for making an informed decision also varies between sites. For the example shown here, the SABBAC area has been the site of several research projects over the past few decades and relatively more information is known about the site compared to other coastal areas in the Philippines. Nevertheless, an attempt is made here to develop a methodology for selection of mariculture zones based solely on hydrodynamics.

Residence time.

Residence time for an area proposed for mariculture should not be more than 14 days to ensure that the water can be flushed within a spring-neap cycle. This can be estimated using residence time and hydrodynamic models. An example is shown in Figure 10. It is necessary to repeat the residence time calculations every time the configuration (location and numbers) of the cages change.

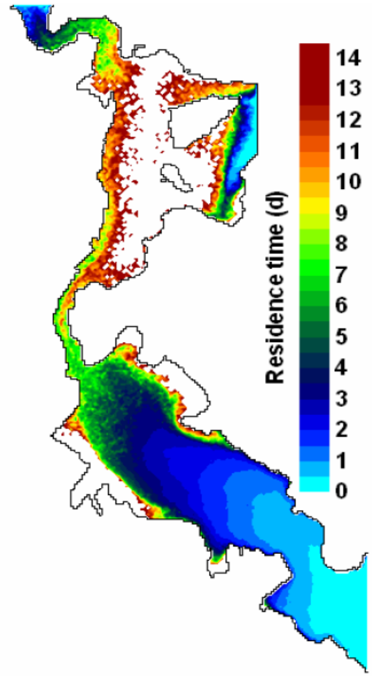


Figure 6. Example of residence time map showing only areas with residence times < 14 days.

Current speeds

Mariculture areas often have muddy substrates which require only small current speeds for resuspension of sediments. Dudley et al (2000) estimates a minimum speed of 0.3ms-1 for resuspension to occur in pens (Figure 11). Cromey et al (2002) suggests even a lower value of $0.095ms^{-1}$ for resuspension velocities in mariculture areas. Removal of waste from small embayments is also enhanced if threshold velocity for resuspension is surpassed (Panchang et al, 1997). Allowing for resuspension in a tidally dominated area will tend to redistribute deposited sediments over a much large footprint but will reduce sediment flux rates.

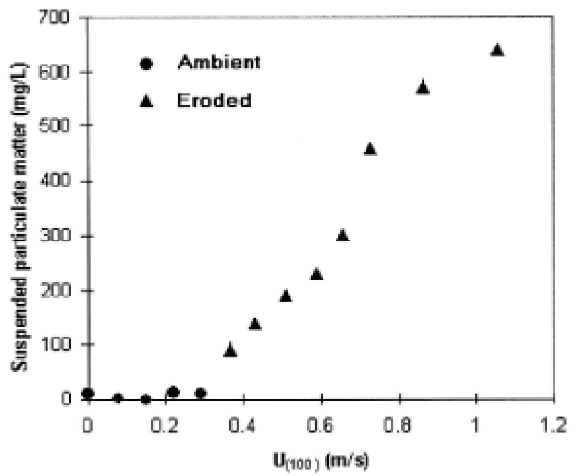


Figure 7. Sediment resuspension as a function of current speeds.

Critical entrances for navigation and water exchange

Provide enough space for navigation especially in narrow passages and keep critical passages free to allow unobstructed flow of water. These passages are typically the entry or exit points of exchange with the open sea. Minimum space for navigation should allow two-way traffic of the widest boats (typically large boats with outriggers).

In addition, critical passages should be free of fish farms to allow unobstructed flow of water. These passages are typically the entry or exit points of exchange with the open sea. Hydrodynamic modeling and residence time calculations suggest that in the SABBAC area, the most critical passages are the Guiguiwanen Channel and the Caquiputan Strait (Figure 12).

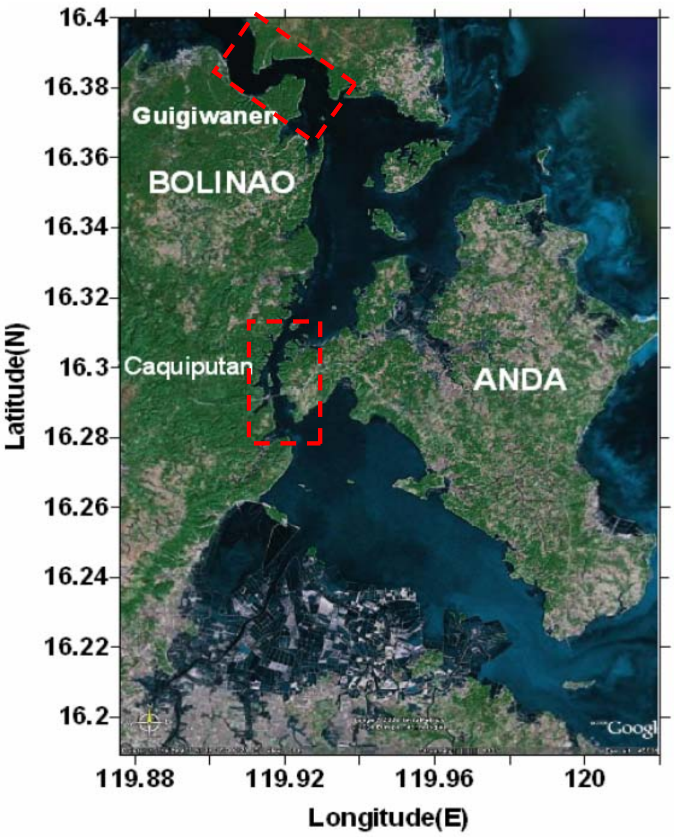


Figure 8. Important passages for navigation and flushing in the SABBAC area.

Current speed and depth
For a tidally-dominated circulation, it is important to note that the magnitude of the flow also depends on the depth. For instance, flow from relatively deep water must speed up to conserve volume once it flows along shallow bathymetry. The availability of current speeds and bathymetry in an area can provide useful information in mapping potential mariculture zones. Depth and current speed can be used as one the criteria and a classification scheme may be adopted. An example is shown below

- Strong currents in deepwater – ideal for cages;
- Weak currents in shallow water – ideal for shellfish culture and not for cage or pen structures
- Strong currents in shallow water – in most instances, shallow areas with strong currents are important passages for water exchange and should be kept free of any structures. Depending on area, may also be suitable for pen culture if it does not interfere with the flushing of the embayment;
- Weak currents in deep water – areas where there is a high tendency for waste material from mariculture to accumulate. It is best that these areas are kept free of pollution sources.

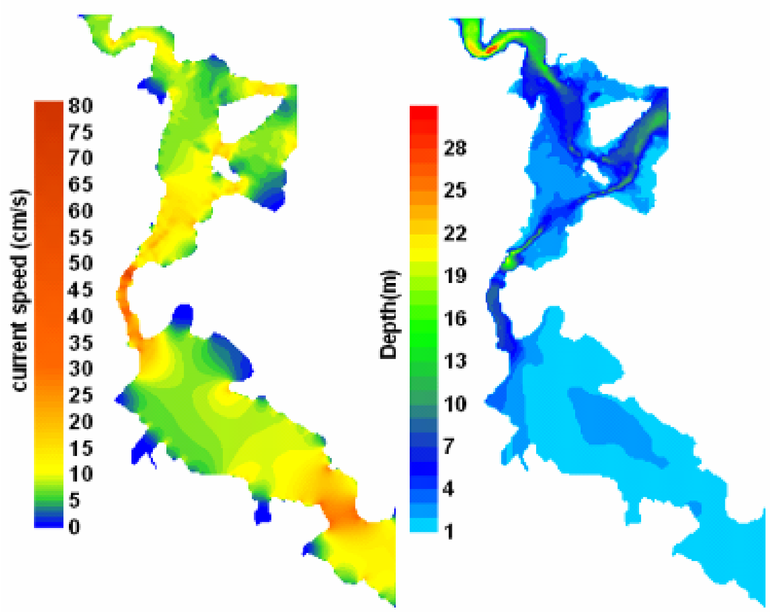


Figure 9.Average current speed (left) and bottom depth (right).

The integration of these variables and finding the optimum combination that is deemed to give the best solution is best done using the tools available in a Geographic Information System (GIS) system.

Siting of aquaculture zones from sensitive habitats.
Results of a study by Pusceddu et al. (2007) indicate that "quantitative and qualitative changes in the organic loads of the sediments that arise from intensive aquaculture are dependent upon the ecological context and are not predictable only on the basis of fish-farm attributes and hydrodynamic regimes. Therefore, the siting of fish farms should only be allowed after a case-by-case assessment of the ecological context of the region, especially in terms of the organic matter load and its biochemical composition."

Mangroves, seagrass beds, and coral reefs are sensitive habitats in coastal areas that can be affected by aquaculture. The environmental impacts on these habitats include habitat loss and/ or modification and release of wastes. Habitat loss happens when mangroves areas are cleared for the development of fish pens, shrimp ponds, salt beds, and reclamation for industrial or other development. Habitat loss also occurs when fish pens and cages are installed above seagrass beds and near coral reefs.

Current fish farming practices result in large amounts of feed wasted that end up in the marine environment (e.g., FCR or feed conversion ratio >2.5). Wasted feed partly dissolve in the water column with the undissolved part end up in the sediments. Hence, the level of nutrients in the water column and sedimentation of particulate material are increased. Moreover, the sediments also become enriched with organic matter (Holmer et al., 2003). Work done on the impact of salmon farming indicated that sedimentation can extend up to 1.2 km from the farm site (Milweski, 2000). In the case of Bolinao, Pangasinan, water quality conditions have become eutrophic over a 10-year period of unregulated fish farming that resulted in a massive fish kill in 2002, when the number of fish pens and cages more than doubled the allowable limit (San Diego-McGlone et al., 2008). The fish kill coincided with the first reported Philippine bloom of a dinoflagellate *Prorocentrum minimum* (Azanza et al., 2005).

The effect of wasted feed on seagrass habitats comes from sedimentation that smother the seagrass beds with particulate matter (http://ec.europa.eu/research/agriculture/projects/qlrt_2000_02456_en.htm). This type of impact has been measured up to 400 m from the fish cages. The large input of organic matter led to high sulfate reduction rates that contributed to sediment anoxia and sulfide toxicity (Holmer et al., 2003). Aquaculture wastes also led to stress on individual plants, as evidenced by the decrease in shoot biomass and seagrass cover closer to the fish cages (Ruiz et al., 2006), changes in physiology as an adaptive response to anoxia, and death, to demonstrate its intolerance to highly reducing sediments (Pérez et al., 2007).

Sedimentation and eutrophication also affect coral reefs. According to Villanueva (2005), there is diminished larval output, growth, survivorship of scleractinian corals after exposure to fish farm effluents.

Given the above environmental impacts, aquaculture activities should be sited far from sensitive habitats. Any prescribed distance from these habitats should be based on flushing, residence time, density of fish farming structures, and allowable levels of water quality parameters.

Aquazones for Bolinao north channel

The modelling activity utilised hydrodynamic model flow fields provided by Dr Villanoy and E Magadong. For the 6 zones, a spacing of 20 m between cages in the same row and 120 m between and cage rows was recommended to prevent severe impact underneath the cages. The exception was zone 4, which had large circular cages so a spacing between cage centres of 30 m was recommended. Also, the spacing between cage rows was adequate to allow impact to be minimised on areas between cage rows, thus allowing remediation of sediments between rows. In addition to spacing recommendations, two scenarios were presented for each zone, one for a high (inefficient) Food Conversion Ratio - the current situation - and one for an improved situation with a lower (more efficient) FCR. These scenarios with a lower FCR showed how the environmental impact could be minimised by using better quality feed. This better quality feed used in the model did not break up so easily and also had better digestibility. This meant that the model could be used to show that careful use of better quality feed so that less is wasted, resulted in a reduction in impact at the zones.

The detailed report for modelling of the 6 SABBAC zones with TROPOMOD is given below.

Depositional Modelling

A particle tracking model used for predicting output, movement and deposition of particulate waste material (with resuspension) and associated benthic impact of fish farms. Simulated particles exiting the fish cage are displaced by currents and random walk eddy dispersion and deposit on the seabed. This data is used to predict impact on the sediments.

Used for:

- Regulating discharges of medicines
- Determining the maximum biomass for a site
- Assisting selection of sites
- Preparation of EIAs

PHILMINAQ project modelling approach with TROPOMOD

Modelling of the SABBAC zones has the following objectives:

- to test scenarios which encourage careful feeding, so waste feed and nutrient input to the environment is minimised; farmers will also save money
- to encourage use of better quality feed, where better digestibility of feed means less feed is needed; better quality feed also breaks up less, so more goes to growth

The modelling approach also aims to:

- maintain enough spacing between cage rows so that remediation of sediments can take place – impact should be low between rows in each zone
- maintain enough space between cage rows to prevent reduction of currents by high aggregation of cages – although not predicted by TROPOMOD, this effect is known to exist and has been shown by MSI models
- prevent overlap of zones by predicting the extent of the zones and recommending minimum spacing between zones

The TROPOMOD model was therefore set up to evaluate the following:

- How severe is the impact – what is the maximum impact underneath cages?
- How far to the boundary of the impact?
- How can husbandry practices be optimised to use the zone most productively?

Bathymetry and current flows

TROPOMOD was set up using flat bathymetry from the MSI model (Figure 14, Table 3).

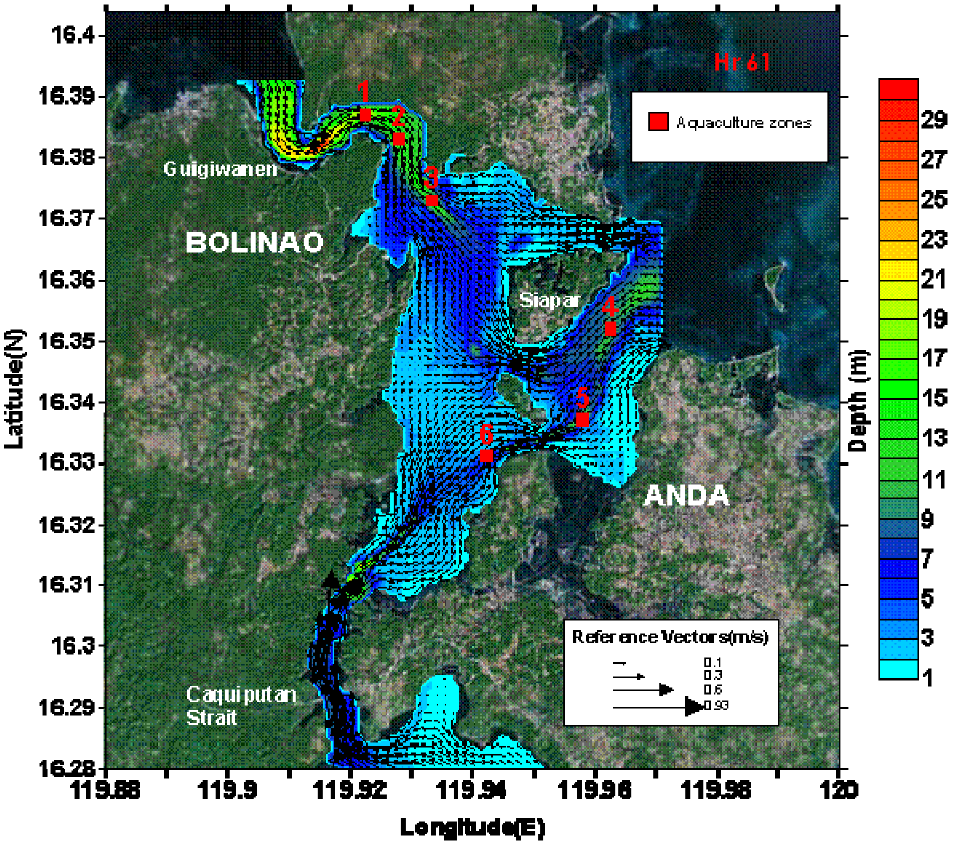


Figure 14. Bathymetry and flow fields from the MSI model of SABBAC zones 1 to 6.

Flow fields of current speed and direction were calculated from model tidal constituents to give a time series of depth-averaged current speed and direction for 1 month for each zone (Figure 15). Summary statistics were compared for each zone and zone 6 in the south of the area had the highest maximum speed, with zones 1 and 2 in the north having the next highest maximum and average current speeds (Table 3). The lowest current speeds were predicted by the MSI model in zones 4 and 5 to the east and south of Siapar. However, zone 4 is exposed to waves from the sea to the east, and the effect of waves on dispersion is not predicted by TROPOMOD. TROPOMOD is therefore likely to underestimate the dispersion and so will underestimate the assimilative capacity of zone 4.

Table 3. Zone depth and mean and maximum current speeds for a 30 day time series taken from the MSI hydrodynamic model of the area.

Zone	Depth (m)	Mean speed (cm/s)	Max speed (cm/s)
1	20	10.8	28.6
2	14	11.5	30.6
3	13	8.9	23.7
4	10	7.9	24.8
5	10	6.0	18.8
6	5	14.2	43.0

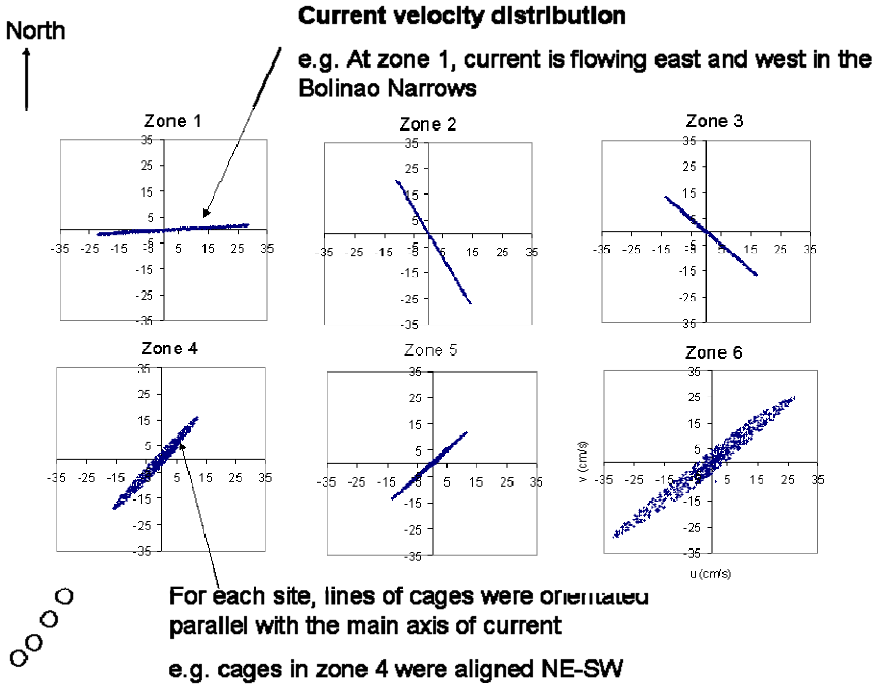


Figure 15. Hydrodynamic model data (x-axis easting cm s^{-1}, y-axis northing cm s^{-1}) used in TROPOMOD modelling of SABBAC zones 1 to 6.

Zone size and cage size

Each zone had a size of 600 m by 200 m (12 ha). In all zones except zone 4, square cages of 12m * 12m with net depth of 8 m were used. Zone 4 is an exposed site and so had larger circular cages of 20 m diameter and 8 m deep in the model. Assuming stocking density was the same between square and circular cages, this resulted in the larger circular cages in zone 4 containing 2.2 times more biomass than square cages.

FCR and settling rates of feed and faecal particles

Two different scenarios were undertaken for each zone with Feed Conversion Ratio (FCR) of 2.8:1 and 2.0:1. The high FCR means 2.8 units of food for every 1 unit of biomass produced and represents the FCR measured at Bolinao by the EMMA project. This high FCR is caused by high feed losses through careless feeding of poor quality feed. This poor quality feed also breaks up quickly as shown by experiments undertaken during the May 2007 training course. Feed settling experiments during the training course measured settling velocity of pellets as 8.9 cm/s for intact pellets. However, with poor quality feed such as the feed in use in Bolinao and Sual, intact pellets quickly broke up to finer particles, resulting in a high loss of nutrient to the environment. For the FCR 2.8:1 scenario, poor feed quality was represented in TROPOMOD by defining feed particles of three different sizes: 5% of particles remaining intact and the remaining particles were smaller particles settling at a slower rate. A scenario using FCR of 2.0:1 was undertaken to represent more careful feeding practices with better quality feed. In this scenario, pellets were assumed to have a higher concentration of binder and so remained intact with a settling velocity of 8.9 cm s^{-1} (Table 4).

UP-MSI measured an average faecal settling rate of 0.84 cm s^{-1} for milkfish. This rate is consistent with the value for Sea Bream and Sea Bass faeces, measured by Magill et al. (2006) of 0.48 and 0.70 cm s^{-1} respectively. Magill et al. (2006) showed the importance of determining faecal particle size in addition to settling velocity, as high numbers of fine particles bias the numerical mean towards slow settling particles, but these particles only represent a small proportion of the faecal mass. Similar video based experiments undertaken by Magill et al. (2006) were undertaken in the PHILMINAQ project but videos were accidentally lost. Thus, the 0.84 cm s^{-1} value used in the modelling is a good first measurement of Milkfish faeces, as no other data existed previously.

Table 4. Zone and cage size and settling velocity data.

Model input data	Value
Zone size	600 m by 200 m (12 ha)
Cage size	12m*12m*8m – square - (all zones except zone 4) 20 m diameter circular – zone 4
Feed settling rate for different scenarios:	
Scenario A - FCR 2.8 – pellet break up (estimated)	8.9 cm/s (5%), 4.5 cm/s (65%), 1.6 cm/s (30 %)
Scenario B - FCR 2.0 – intact pellets (measured)	8.9 cm/s (100%)
Faeces settling rate – measured by PHILMINAQ for Milkfish	0.84 (cm/s)

Feed ration and modelling the different sized fish in cages in a zone

At any time of the year, an aquaculture zone will have cages with different sized Milkfish as farmers stock with small fish at different times of the year. Although modelling the zone with fish at maximum size would give a worse case scenario, this would be unrealistic. Therefore to simulate a more normal situation where fish were at different stages of the growing cycle, several different size fish and feeding rates were used in the same scenario. For all zones except zone 4, eight different types of cages were modelled, where each cage contained one size of fish as shown in Table 5 (data source – EMMA project). For zone 4 which contained large circular cages, the fish numbers, biomass and feed ration were 2.18 times higher than for square cages. For all zones, 1 in every 8 cages is empty.

Table 5. Feed ration used in the model for different cages in all zones except zone 4, where feed ration was 2.2 times higher in the larger circular cages at this site – data source EMMA project.

Fish weight (g)	Fish numbers per cage	Cage biomass (kg)	Feed rate (% day^{-1})	Feed ration (kg $cage^{-1}$ day^{-1})
0	0	0	0	0
20	27247	545	8.5	46
41	26873	1091	8.9	97
91	26498	2406	7.1	171
162	26124	4224	5.1	214
247	25749	6358	4.4	278

386	25375	9799	3.3	323
433	25000	10825	1.8	193

As there is no order to the location of cages with different sized fish in the aquaculture zone, each cage in the model grid was assigned a biomass and feed ration from Table 5 randomly. This ensured that a mixture of fish sizes and feed rations were in use in the modelled zone, as would be the case for an operational zone.

In scenario A, a FCR of 2.8:1, feed wastage of 27 % and a digestibility of 49 % was used. This scenario used three different settling rates for pellets to simulate pellet break up (Table 3). Scenario B used a much lower feed wastage with improved digestibility and only one settling rate for feed pellets.

Table 6. Mass balanced model used for determining feed wasted and faecal outputs. In each of the scenarios, the amount of consumed feed allocated to growth and maintenance is the same (FCR data from EMMA project). TROPOMOD settings are also shown.

Scenario	**A**	**B**
Description	High feed wastage, poor feed quality with low digestibility	Low feed wastage, better feeding quality with improved digestibility
FCR	2.8	2.0
Pellets fed (kg wet wt)	322.6	230.4
Pellets fed (kg dry wt)	**293.5**	**209.7**
Pellet water content (%)	9	9
Total feed lost to environment (kg dry wt)	**77.8**	**21.6**
Feed consumed (kg dry wt)	215.7	188.0
Maintenance (kg dry wt)	26.2	26.2
Growth (kg dry wt)	78.6	78.6
Total (kg dry wt)	104.8	104.8
Faecal output (kg dry wt)	**108.8**	**83.2**
Faecal output (g faeces/kg food)	372.3	396.0
Mass budget (kg dry wt)	**291.4**	**209.7**
TROPOMOD settings		
Pellet digestibility (%)	49	56
Pellet water content (%)	9	9
Feed wasted (%)	27	10

Definitions of environmental impact

Using model validation data sets from MERAMOD and DEPOMOD, the threshold of 75 g m^{-2} d^{-1} was used as the definition for SEVERE impact (Figure 16). From the Bolinao sediment trap data sets, stations which had 114.0 g m^{-2} d^{-1} (0 m) and 148.7 g m^{-2} d^{-1} (25 m) were devoid of fauna. For model predictions of above 15 g m^{-2} d^{-1}, impact has been detected with MERAMOD and DEPOMOD validation data sets. Also, recent data sets from shellfish farms in Canada show that 15 g m^{-2} d^{-1} was a useful threshold, above which moderate impact was measured (Weise et al., In review).

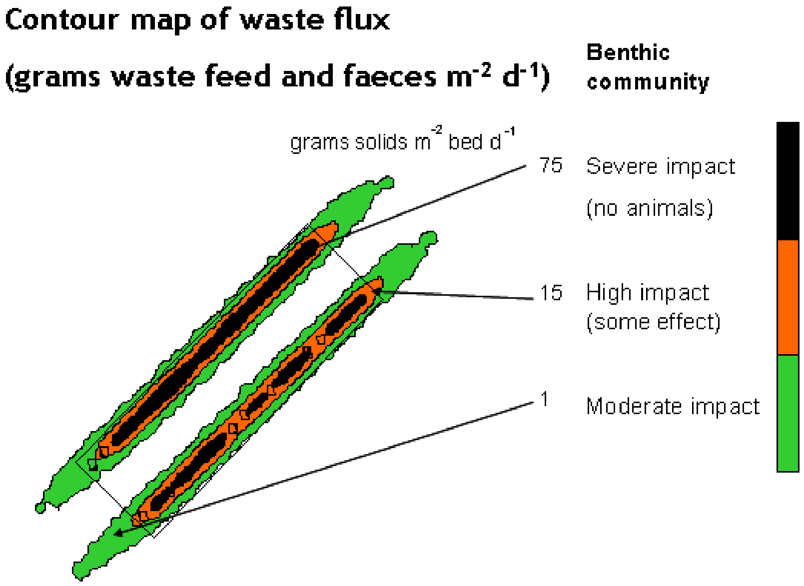


Figure 16. Definition of Severe, High and Moderate impact for the SABBAC zone modelling. There are two rows of cages shown and different colours represent different amounts of waste flux (grams waste feed and faeces depositing on the bed per m^2 per day)

Using TROPOMOD predictions, the zones were divided up into different sub-zones of impact from LOW to SEVERE (Table 7). The percentage area with HIGH or SEVERE impact was predicted with TROPOMOD, as well as the distance to the boundary of moderate impact. This distance to the boundary was used to determine whether adjacent zones would overlap. The extent of the area of SEVERE impact was also evaluated for each zone.

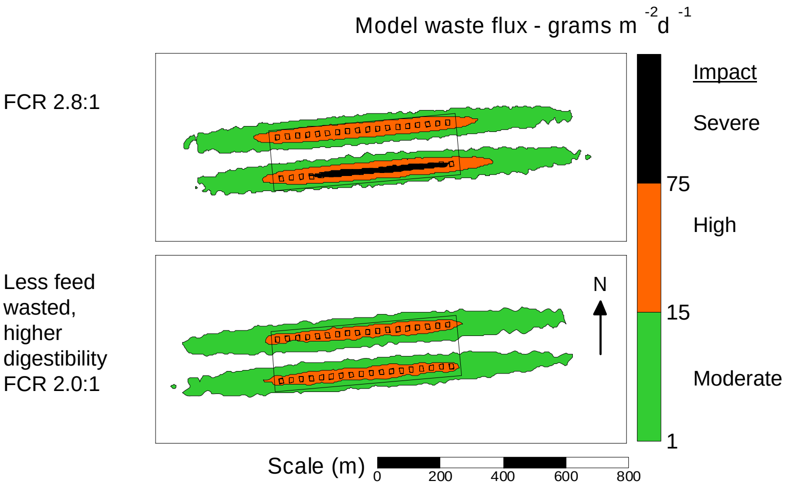
Table 7. Definition of impact areas with the TROPOMOD model using predicted flux as an indicator if impact.

Definitions	Zone colour	Predicted flux (g m^{-2} d^{-1})
Impact areas:		
Low/None		<1
Moderate		1 – 15
High		15 – 75
Severe		75 +
% of zone area HIGH and SEVERE impact		>15
Is more than 1 % of zone SEVERE impact? Yes or No?		> 75
Distance to boundary of zone of effect - 1 g m^{-2} d^{-1} contour		1

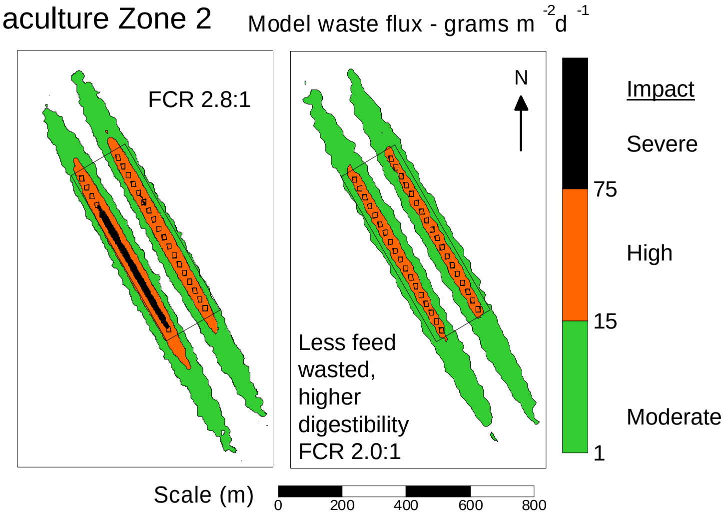
Results

The model results are shown in the next series of figures. The percentage of area with HIGH impact was greater than 50 % for zones 1 to 4 for the current high FCR situation. The model showed that by reducing feed wastage and feeding less, the area of the zone impacted was reduced to around 35 % in most zones. In most zones also, the area of the zone classed as SEVERE impact was reduced to less than 1% when a FCR of 2.0:1 was used,

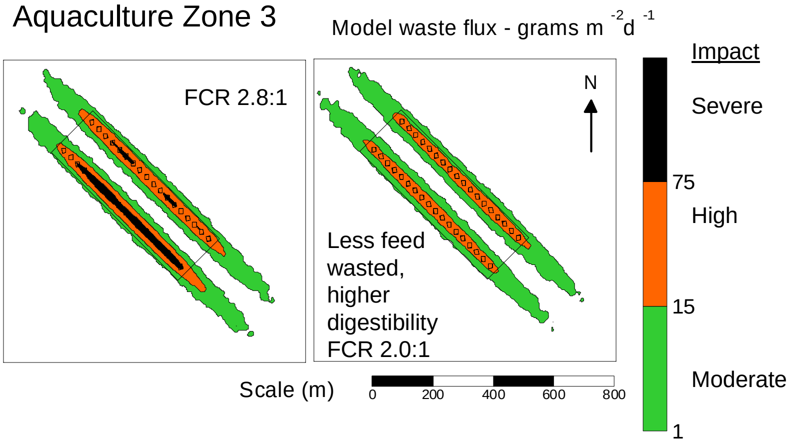
Aquaculture Zone 1 – Bolinao Narrows



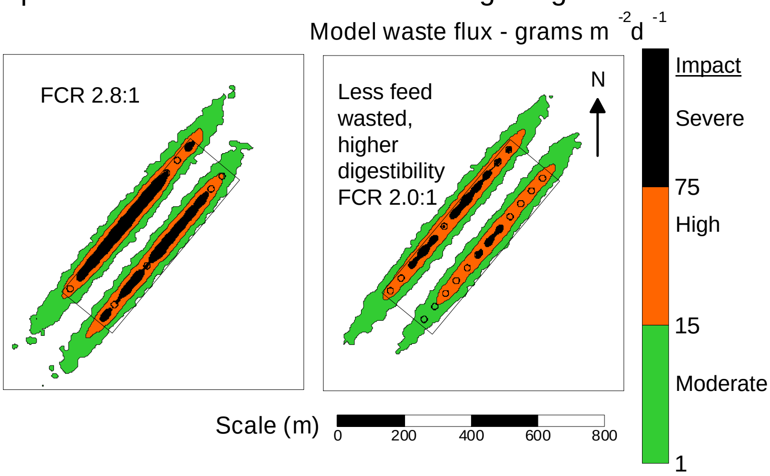
Aquaculture Zone 2

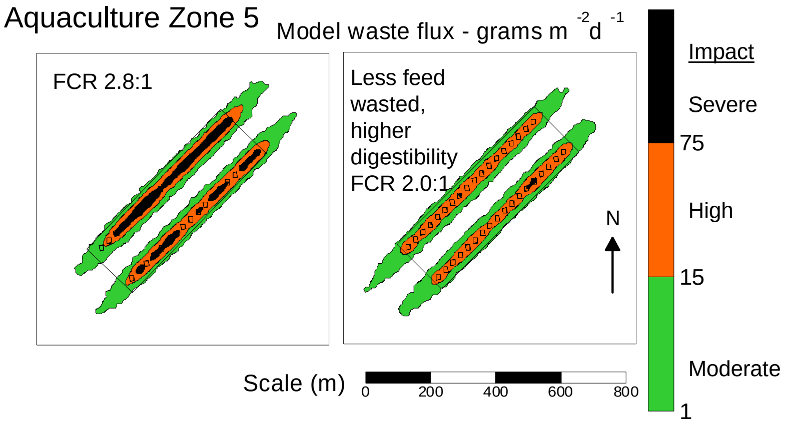


Aquaculture Zone 3



Aquaculture Zone 4 – 2 rows of 12 large cages





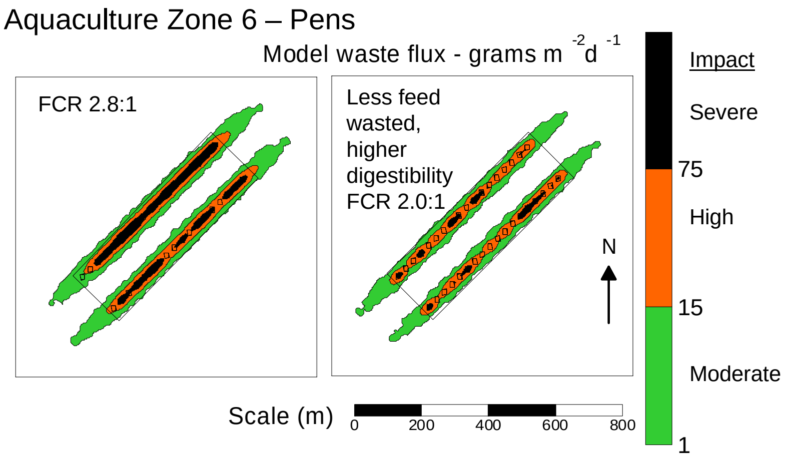


Table 8. The percentage of sea bed area in each zone predicted to be highly impacted for the two different scenarios. As FCR is reduced through better feeding practices, area of sea bed impacted is reduced as is the severity of the impact.

Zone	Scenario	% of zone HIGH and SEVERE impact	SEVERE >1% of zone? (Yes, No?)
1.0	FCR 2.8	54	Y
2.0	FCR 2.8	53	Y
3.0	FCR 2.8	50	Y
4.0	FCR 2.8	53	Y
5.0	FCR 2.8	45	Y
6.0	FCR 2.8	41	Y
1.0	FCR 2.0	36	N
2.0	FCR 2.0	35	N
3.0	FCR 2.0	36	N
4.0	FCR 2.0	44	Y
5.0	FCR 2.0	35	N
6.0	FCR 2.0	31	Y

Using TROPOMOD, 3 rows of cages were tested for each zone and the area of HIGH and SEVERE impact was found to occupy the majority of the zone area and little area was available between rows for remediation of impact. Thus, in all zones except zone 4, 2 rows of 18 cages were found to be optimum (Table 9). As larger cages were present in zone 4, 2 rows of 12 cages were recommended.

Table 9. Predicted cage numbers and spacing between cages and rows, where zone 4 has larger circular cages. The maximum biomass in each zone is also shown, assuming that all cages in the zone contain 386 grams.

Zone	Cages	Spacing between cages and rows	Zone biomass modelled **Average situation with all different fish sizes in zone (EMMA data)**	Zone biomass if all fish 386 grams in all cages **Maximum biomass in zone**
1	2 rows of 18	20 m between cages 120 m between rows	137 tonnes	353 tonnes [A]
2	2 rows of 18	20 m between cages 120 m between rows	137 tonnes	353 tonnes [A]
3	2 rows of 18	20 m between cages 120 m between rows	137 tonnes	353 tonnes [A]
4	2 rows of 12	30 m between cages 120 m between rows	277 tonnes	514 tonnes [B]
5	2 rows of 18	20 m between cages 120 m between rows	137 tonnes	353 tonnes [A]
6	2 rows of 18	20 m between cages 120 m between rows	137 tonnes	353 tonnes [A]

Zone 4 cages are large circular cages (20 m diameter* 8m deep)
Zones 1, 2, 3, 5, 6 are square cages (12m* 12m*8m deep)
[A] 386 gram fish require highest feed, 9.8 tonnes per cage *36 = 353 tonnes in zone (square cages)
[B] 386 gram fish require highest feed, 21.4 tonnes per cage *24 = 514 tonnes in zone (large circular cages)

Ranking of zones in terms of assimilative capacity

The zones were ranked in terms of assimilative capacity by examining the results of TROPOMOD in terms of the magnitude and extent of impact, depth and current. From these assessments, zone 1 was predicted to be the most dispersive, with zone 5 as the least dispersive.

Table 10. Ranking of zones according to impact area, depth and current.

Overall rank	**Zone**	Rank - magnitude of SEVERE impact	Rank - extent of SEVERE impact	Rank - depth	Rank – current
1 (most	**1**	1 (least	1 (least area	1 (deepest)	3

dispersive)		severe impact)	effected)		
2	**2**	2	2	2	2
3	**6**	3	3	6 (shallowest)	1 (fastest speeds)
4	**3**	4	4	3	4
5	**4**	6 (most severe impact)	6 (most area effected)	4	5
6 (least dispersive)	**5**	5	5	5	6 (slowest speeds)

Modelling summary and recommendations
TROPOMOD was set up with bathymetry and current speed and direction data for the six SABBAC zones, feed and faecal settling velocity data for milkfish. The model was ran with 2 different scenarios: scenario A with a Food Conversion Ratio of 2.8:1 simulating high feed wastage and poor quality feed; scenario B with a FCR of 2.0:1 simulating low feed wastage and higher quality feed.

For the following recommendations of biomass and cage spacing, HIGH impact areas were maintained to around 50 % of the total zone area and minimal impact was predicted between rows of cages to allow remediation of sediments.

From the results of the modelling study, the following recommendations are made:

- in all zones except zone 4, 2 rows of 18 cages with 20 m between cages and 120 m between rows (each cage is square – 12m*12m*8m)
- as zone 4 is an exposed site, 2 rows of 12 cages with 30 m between cages and also with 120 m between rows (each cage is circular – 20 m diameter*8m)
- all zones (excluding zone 4) with this cage arrangement would have a maximum standing biomass of 353 tonnes and 514 tonnes for zone 4
- this is equivalent to an average standing biomass of 137 tonnes for all zones and 277 tonnes for zone 4
- as the deposition footprints extend between 200 and 400 m from the edge of each zone, it is recommended the distance between zones should be a minimum of 600 m

Improvement of FCR of 2.8 to 2.0:1 resulted in:

- reducing the feed needed by 29 % without any reduction in production
- minimised or made absent SEVERE impact under cages in each zone
- reduced HIGH and SEVERE impact areas to around 35 % of the total zone area

Recommendations for aquaculture development

Existing industry. The existing aquaculture industry means that there is already the infrastructure for aquaculture production in the country. However the challenge is to improve productivity. In other countries where aquaculture is growing rapidly such as in Vietnam, new production facilities are being built and operated which can take advantage of newer and better technology. In the Philippines there is a legacy of old production systems such as the brackishwater ponds that need renovation and introduction of new production technologies.

Investment. New investment in aquaculture in the Philippines is increasingly being met by financiers who provide the investment and working capital requirements but production is undertaken in partnership with a local worker and profits are split. This allows new investment in the industry but many financiers are from other countries and so not all profits remain in the country.

There is an opportunity to encourage returning workers to invest in aquaculture. Many workers have saved money while working abroad and are looking for investment opportunities when they return to provide employment and to increase their savings.

There is the opportunity to encourage joint ventures with foreign companies. This would allow the development of larger farms and the development of hatcheries which need larger capital investment. Many joint venture companies will also have existing knowledge of the industry bringing either new technology or knowledge of the markets to the new venture.

Markets. The Philippines is well placed being close to large Asian markets such as Singapore, Hong Kong, China, Japan and Thailand. This should give the Philippines the advantage of lower transport costs to these markets compared to neighbouring countries.

There are strong markets for tilapia fillets in Europe and USA. The fast growing strains of tilapia that have been developed in the Philippines are ideal for growing larger sized tilapia necessary for the production of fillets.

Constraints

There are constraints to the development of aquaculture in the Philippines. These slow the increase in aquaculture development and should be targeted for improvement by the Government in terms of research and training, private industry and NGOs.

Infrastructure. There is generally poor infrastructure for aquaculture development in terms of roads and electricity supply. The lack of large highways means that there are long transport times from production to market causing problems with deterioration of the product during transport and higher transportation cost.

Feed. The cost of fish feed is generally high in the Philippines. This coupled to poor feed conversion ratios obtained by the farmer lead to higher production costs for the producer and lower profitability. Also the feed available in the Philippines may not be optimal for the species cultured.

Hatcheries. There is a lack of hatchery produced fry for marine fish and especially for high value species such as grouper. There is still a dependence on wild caught milkfish, rabbitfish and grouper fry which is not dependable in terms of quantity and quality. There is a need for the development of intensive and back-yard (mesocosm) hatcheries to provide sufficient and a dependable source of fry.

Species. At present production relies on only 3 main species which comprise 94.5% of the total aquaculture production, seaweed (70.6%), milkfish (15.3%) and tilapia (8.6%). Diversification into the production of other species could supply local and export market and would limit the risk to the industry from market prices fluctuations in the 3 main species.

Environment. The rapid development of aquaculture in certain areas of the Philippines (hotspots) such as milkfish cage culture in Bolinao and tilapia cage culture in Taal lake has already had some environmental consequences. These areas have suffered an increasing occurrence of fish kills due to the increase in nutrient output from aquaculture. Aquaculture production needs to be controlled by licences to limit production to within the safe production capacity for aquaculture in the aquatic ecosystem.

Quality control. There is generally a poor post-harvest quality control of production in terms of grading the harvested fish into different sizes, sorting damaged fish from un-damaged and chilling the fish after harvest and during transport to market. This reduces the shelf life, reduces market price and restricts the potential to export high quality products.

Marketing. In addition to the poor post-harvest handing of fish there is a lack of cooperation in marketing by the small-scale producers. Fish is generally purchased at individual farms by traders which allow the trader to negotiate low purchase prices with the producer. The producers would have stronger bargaining power if they consolidated production and then negotiated with the traders for a larger quantity of fish or sold their consolidated production directly to the main markets.

Competition. There is increasing competition for exports from neighbouring countries such as Vietnam and China. This is primarily due to the fact that these countries have targeted export markets and the respective governments have facilitated the organisation and administration for fish exports. This includes the development of HACCP licensed packing facilities.

Feed ingredients. There is a lack of local fish meal and fish oils. The majority has to be imported and incorporated in fish and shrimp feed. This increases the cost of the feed and feed prices are subject to fluctuation in prices due to the limited world resources of these ingredients.

Potential technology development

The Philippines could make aquaculture more efficient and increase production at a faster rate by adopting some of the latest aquaculture technology. Some of these technologies have been developed by neighbouring countries but have not yet been transferred to the Philippines. Others have been developed in other parts of the world and would need to be demonstrated and adapted for the local environmental and economic conditions.

Backyard hatcheries. A thriving back-yard hatchery industry that has been developed for grouper fry production near Gondol, on the island of Bali, Indonesia. This technology could be transferred to the Philippines and become a way to develop small-scale hatchery production of high value species.

Intensive hatcheries. For larger-scale aquaculture enterprises, the lack of large quantities of fry is a major constraint. Intensive hatchery technology for marine fish has been developed successfully in Taiwan, with individual enterprises specialising in the different aspects of marine fry production such as breeding and egg production, live food production, larval production, weaning, nursery production. This allows smaller scale operators to work together to produce large quantities of fry.

Offshore cages. At present, the main production of marine fish is from cages and pens located in estuaries or sheltered bays along the coast. This has the advantage of allowing cages to be constructed from low cost materials. But these sites are limited in the Philippines. For large scale enterprises requiring larger areas for production, there will be a need to develop cage production further offshore in deeper areas with better water circulation but with the problem that these areas are more exposed to wind and waves and require the cages to be made from stronger materials. Strong cages have been designed for exposed sites such as those used in Norway and Scotland and could be adapted for offshore sites in the Philippines.

Recirculated pond production. Primary productivity of ponds can be enhanced by adding organic and inorganic fertilisers. However, if pond water is exchanged regularly, then the fertilisers are lost to the environment. New technologies have been developed that recirculate the pond water allowing the fertilisers to be reused. The nutrient levels are monitored and adjusted to give optimal primary productivity.

Improved feeding strategy. The food conversion rate for milkfish is generally very poor. Food conversion rates can be improved by reducing food wastage by preventing over feeding. Technologies have been developed to reduce feed wastage through feedback systems that inform the farm operator when feed is being wasted.

Use of waste fish for feed. As noted above there are limited resources of fish meal and this contributes to the high cost of feed. The Philippines has a large fish processing industry especially for tuna and sardines. These industries produce a large amount of waste fish that can be utilised for fish feed. This waste feed can be converted into fish meal or fish silage or incorporated directly into moist feeds using binders such as alginates or potato starch.

Responsible aquaculture development

Recommendations for the strong continued growth of aquaculture in the Philippines are based on building on the opportunities that the Philippines has and adapting the constraints that might hold back development.

The Philippines has large natural aquatic resources that are ideal for the development of aquaculture. These resources should be identified and safe aquaculture carrying capacities calculated so that development can be prioritised for these sites.

Cooperation between producers on harvesting, post harvest quality control, control of the cold chain and marketing will strengthen their bargaining power with the fish traders so that they should be able to negotiate better prices for their products. It should also allow the producers to compete with the traders, and sell direct to the main local markets and perhaps the export markets.

Large companies should be encouraged to have integrated production by building their own hatcheries and post-harvest facilities. They should be encouraged to move their production facilities to deeper and more exposed sites and to enter the export markets.

The government should encourage the development of backyard fish hatchery technology for higher value species by adapting the technology and demonstrating the technology in different regions.

Conclusions

There will always be the small family producers using low cost cages and pens based in lakes and inshore areas. These producers can be efficient in production if they are given training in best practice. They should be encouraged to cooperate in marketing. This sector is socio-economically important (Nagothu 2007).

There will be increasing number of larger farming businesses with more access to credit. These farms will be able to afford stronger cages and pens and so should have the ability to farm offshore.

There will be an increasing number of large integrated fish farms (hatchery, production farms, packing and processing facilities, marketing departments). These larger farms will gradually take a greater share of production and develop export markets.

Larger businesses must be encouraged to follow best environmental practice and undertake regular environmental monitoring surveys to assess and avoid impacts.

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