Annex 3.

Improvement of Aquaculture Feeds for Better Profitability and Reduced Environmental Impacts

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Mitigating Impact from Aquaculture in the Philippines

INTRODUCTION

In 2005, the capture fisheries and aquaculture supplied the world with food fish of about 142 million tonnes, wherein 34% of which comes from aquaculture. Growth in supply from aquaculture more than offset the effects of static capture fishery production and a rising population. This industry continues to grow more rapidly than all other animal food-producing sectors. It has recorded an annual global growth rate 8.8% per year since 1970, compared with capture fisheries and terrestrial-farmed production systems of 1.2% and 2.8% respectively. In 2004, the bulk of world production came from China (69.57%), followed by the Asian countries (21.92%) and the rest of the world (8.51%).

Figure 1 shows the contribution of each region.

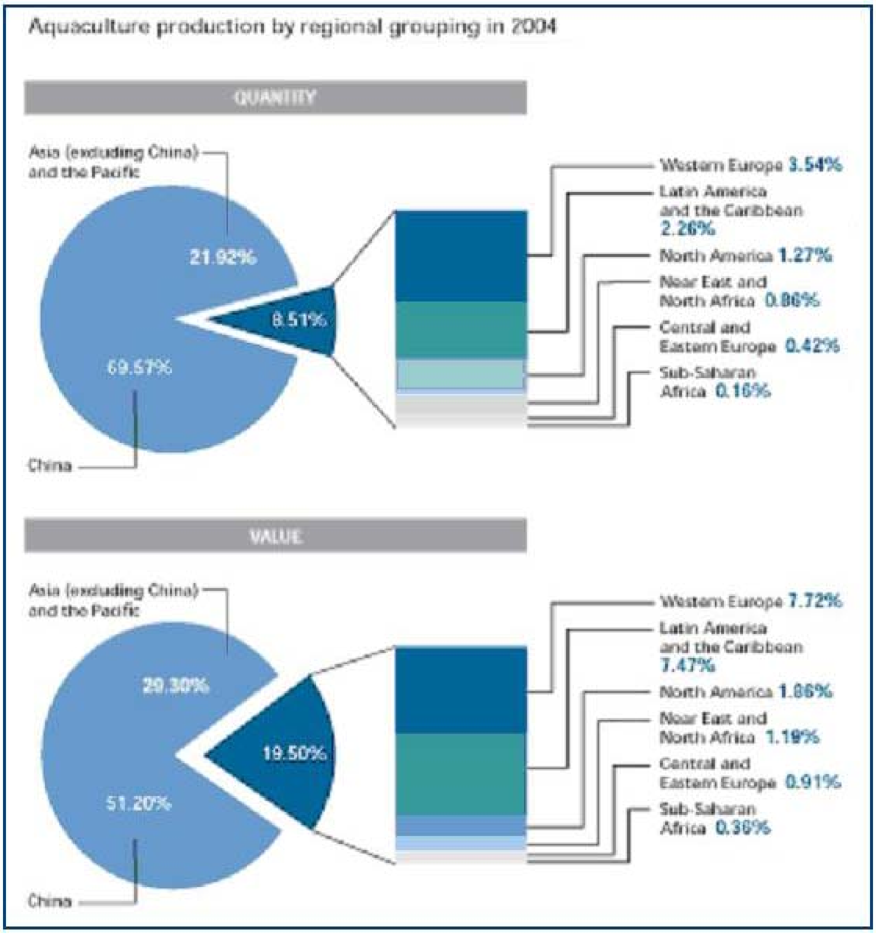


Figure 1 Aquaculture production per region (Source: FAO, 2006)

In the Philippines, there is also an increasing trend in aquaculture production (Figure 2). From the last 5 years, the industry has continued to thrive despite the fish kills and water quality degradation,.

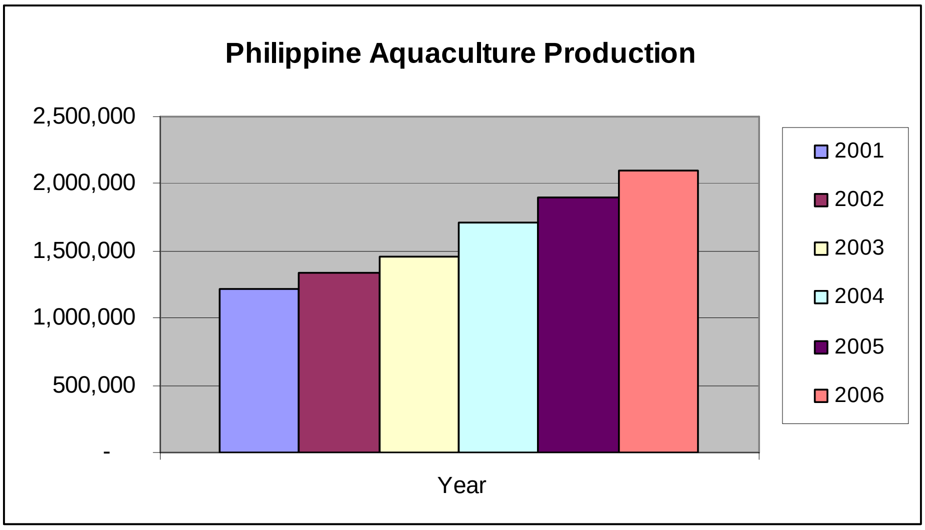
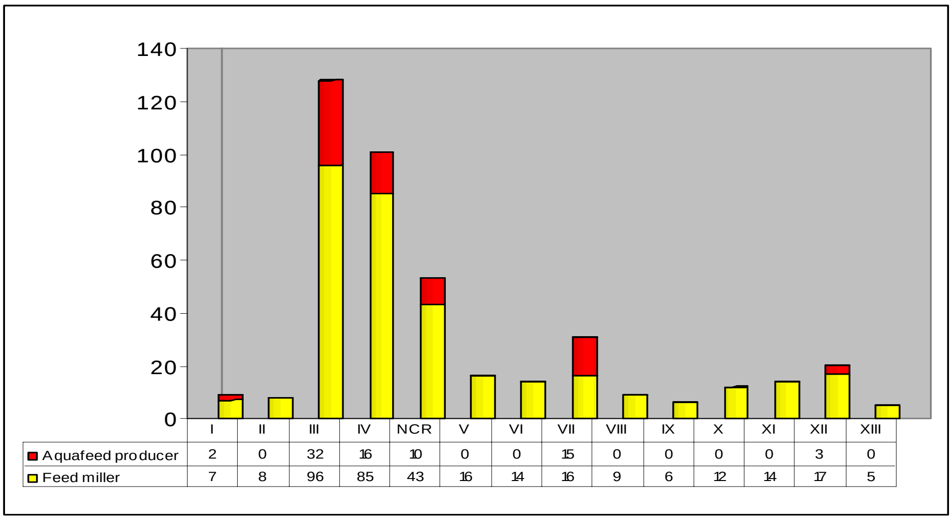


Figure 2. Philippine aquaculture production from 2001-2006. (BAS, 2007)

Overview of aquaculture feed industry

Feed accounts for about 60-80 percent of operation cost in intensive aquaculture, while feed and fertilizers represent about 30-60 percent of the total cost of aquaculture production in semi-intensive aquaculture system. Fertilizers and feed resources will, therefore continue to dominate aquaculture needs.

In 2006, there are 426 registered feed millers all over the Philippines. Out of this, 78 companies are engaged in producing feeds for aquaculture (Figure 3). In terms of production, the biggest producers can be found in Region III, followed by Region IV and NCR. (Figure 4). In total, they can produce 23,829.41 metric tons of feeds per 8-hour rated capacity.



	I	II	III	IV	NCR	V	VI	VII	VIII	IX	X	XI	XII	XIII
Aquafeed producer	2	0	32	16	10	0	0	15	0	0	0	0	3	0
Feed miller	7	8	96	85	43	16	14	16	9	6	12	14	17	5

Figure 3. Number of registered feed millers and aquaculture feeds producers in 2006 throughout the region. (Source: BAI report, 2006)

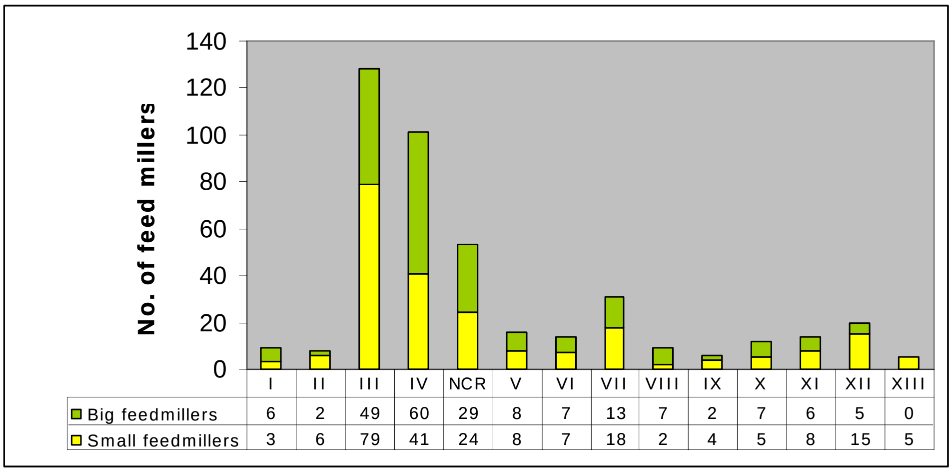


Figure 4. Feed production per region (Source: BAI report, 2006)

In 2005, it was estimated that 48, 293 (mTs) and 3,998 (mT) feeds were produced for fish and prawns alone (Sevilla, 2006) (Table 1).

Table_1. Feeds production in metric tons

Region	Feeds production
I	1496
II	938
III	8299.96
IV	4,456.30
NCR	4,395.40
V	518.7
VI	493.6
VII	1,461.35
VIII	110.5
IX	96
X	613
XI	488
XII	452.6
XIII	10
Total	**23829.41**

Objectives of the paper

This paper is written to present the current situation of the Philippine aquaculture industry, focusing on the impacts of feed wastage and inappropriate feeding to the environment, as well as its effects to the operators economically in particular, and to the whole feed miller industry in general. This paper will also provide recommendations, which are the result of the series of consultation meetings and workshop with the different stakeholders which primary aims on addressing these issues and concerns.

Aquaculture Feed Regulators in the Philippines

Generally, the function of feed regulation in general, and aquaculture feeds regulation in particular falls under the jurisdiction of the Department of Agriculture. There are three national agencies mandated to address this sector, namely, the Bureau of Animal Industry (BAI), Bureau of Aquaculture Fisheries Product Standards (BAFPS) and Fish Health, a section under the Bureau of Fisheries and Aquatic Resources (BFAR).

The Bureau of Animal Industry is mandated to regulate animal feeds, feed ingredients and veterinary drugs and products. They administer the Republic Act 1556, otherwise known as the Livestock and Poultry Feeds Act. This Act (as amended) provides for the regulation and control of manufacture, importation, labelling, advertising, distribution and selling of livestock and poultry feeds and feeding stuff. Aquaculture feeds are also subject to the provisions of this Act.

Specifically, their roles and responsibilities include the following:

- Register animal feeds, ingredients, veterinary drugs and products;
- Accredit chemical laboratories of feed manufacturers and private companies for aquaculture feed analysis;
- Accredit aquaculture feed quality control laboratories;
- Issue import permits for feeds and feed ingredients;
- Inspect and evaluate activities and product standardization; and
- Monitor quality of aquaculture feed in the market.

The **Bureau of Aquaculture Fisheries Products and Standards** (BAFPS) was created to specifically provide for Republic Act 8435, also known as the "Agriculture and Fisheries Modernization Act of 1997". Chapter 7, Sec. 60 of this Act declares that *"it is the policy of the State that all sectors involved in the production, processing, distribution and marketing of food and non-food agriculture and fisheries products shall … use of product standards in order to ensure consumer safety and promote the competitiveness …"*

In line with this, they are mandated to set and implement quality standards for preservation, packaging, labeling, importation, exportation, distribution and advertising of processed agricultural and fishery products, standards for efficient trade (import and export) of raw, fresh, primary- and secondary-processed products, both food and non-food, as well as standards related to consumer health and safety.

Their specific functions include the:

- formulation and enforcement of standards;
- development and implementation of codes of practice and guidelines for food safety and efficient trade standards in association with the Department of Agriculture and other national agencies, selected SUCs and LGUs, the;
- assist government offices, agriculture and fishery enterprises to establish the scientific basis for domestic food safety, nutrition standards, codes of practice and align all of these with internationally accepted standards and practices;
- coordinate with government offices, agriculture and fishery enterprises to develop an early warning-system on developments and trends in international food safety, nutrition standards, and codes of practice to enable adequate domestic adjustment to these;
- ensure the participation of all stakeholders in the formulation of product standards, codes of practice for commodity, food safety, and efficient trade;
- establish and maintain the database (Management Information System and Monitoring and Evaluation) and research in collaboration with the NIN, research institutions and SUCs;
- conduct product testing, surveillance and inspection of food handling, processing and storage facilities, including abattoirs, fish ports and landing areas and markets, for compliance of approved standards and codes of practice and establish and operate testing centers and research laboratories for this purpose;
- establish an inspection and certification system including third party accreditation and a professional Certification System for commodity standards and professionals to ensure cost-effective implementation of standards and codes of practice;
- serve as contact point of Philippines' Codex, Philippines' National Enquiry for SPS and other food safety and standards concerns; and
- determine and implement, in collaboration with the appropriate offices and entities, the recall from the market of commodities that are determined to be unfit for human consumption.

This office has already developed standards for dried danggit (*Siganidae* spp.), frozen tilapia (*Oreochromis* spp.), frozen milkfish (*Chanos chanos*), raw dried seaweeds (*Euchema* spp., *Chondrus* spp. and *Gigartina* spp.). Standards for squid, finfish, shrimps, prawns, abalone, grouper and the Certification Scheme for Best Aquaculture Practices (BAP) are underway.

A standard for commercial aquaculture feeds was also drafted and targeted to be finalized this year. This set of standards covers the preparation and formulation of nutritionally adequate commercial aquaculture feeds or feed ingredients such as, but not limited to, pellet, mash and crumble feed forms used in culturing any aquatic animals such as, but not limited to, finfish, mollusks and crustaceans, as well as custom-mixed feeds and feed products use as commercial aquaculture feeds.

The **Fish Health Section** of BFAR is primarily involved in fish health management, quarantine, fish health management trainings and diagnostic tests. It started out as a joint project between BFAR and the International Development Research Centre of Canada. However, some functions, such as the compliance to feed quality and farm practices are being monitored by this office.

Specifically, they are mandated to:

- assist in the implementation of national diagnostic and quarantine system for the movement of living aquatic animals, including the establishment of centralized quarantine facilities for imported live aquatic animals;
- formulate guidelines, recommend policies, procedures and regulations that will strengthen the national program on aquatic animal health certification and quarantine procedures;
- render diagnostic tests and technical assistance on fish disease;
- recommend fish diseases' prevention control and treatment measures;
- monitor/assess health status of stocks in fish and aquatic resource farms;
- provide standards and set directions to regional fish health satellite laboratories;
- repository of information on fish diseases;
- develop expertise in the field of fish disease diagnosis such as parasitology, bacteriology, histopathology and immunology;
- conduct of training programs on fish health management; and
- develop linkages and promote information exchange.

Regulations on Aquaculture Feeds

In the Philippines, as in other countries, the feed control program has three phases: laws, regulations and administrative procedures. But the three are so closely tied together that they cannot be separated in the discussion of the various measures for safeguarding feed users.

The major provisions of the feed law are as follows:

1. Registration and guarantees;
2. Labelling;
3. Creation of the Animal Feed Control Division (now called Animal Feeds Standard Division by virtue of Executive Order No. II 6 promulgated in 1986) and Animal Feed Control Advisory Committee (Animal Feed Standardization Committee) in the Bureau of Animal Industry (BAI);
4. Inspection and sampling;
5. Laboratory analysis and publication of results;
6. Quality control services; and
7. Penalties and other enforcement procedures.

To upgrade the quality of medicated and commercial feeds, the BAI has been mandated to implement the following laws and regulations:

1. **R.A. 1556**, as amended, otherwise known as the "Livestock and Poultry Feeds Act," and its implementing rules and regulations (Animal Industry Administrative Order Nos. 35, 35-A and 40; and General Memorandum Order No.1);
2. **R.A. 3720**, as amended by Executive Order No. 175, otherwise known as "Food, Drugs and Devises and Cosmetics Act," and its implementing rules and regulations;
3. **R.A. 6675**, otherwise known "Generic Acts of 1988".

The above-mentioned laws and regulations are administered and implemented by the Secretary of Agriculture through the Director of Animal Industry. The BAI, through its Animal Feed Standards Division (AFSD), oversees the manufacture, importation, distribution, advertisement and sale of livestock, poultry, aqua and specialty feeds, veterinary drugs, and chemical feed additives.

The Department of Agriculture and the Department of Health signed a Memorandum of Agreement to delineate the responsibilities regarding registration of veterinary drugs and products.

R.A. 3720, as amended by Executive Order No. 175, defines veterinary drugs and products as "any substance, including biological products, applied or administered to food-producing, companion, aquatic, laboratory and exotic animals, whether used for therapeutic, prophylactic or diagnostic purposes or for medication of physiologic functions or behaviours." This law is comprehensive and all-embracing than R.A. 1556, as amended, when it comes to coverage, registration and quality control procedures.

Presidential Decree No. 7: Prescribing the orderly marketing of livestock, animal products and new regulations

Administrative Order No. 26: Registration of all commercial aquaculture and specialty feeds manufacturers, importers, suppliers, distributors and retailers under RA 1556 as amended by PD No. 7

Administrative Order No. 35 (1975). Rules and regulations governing the manufacture, importation, labelling, advertising, distribution and sale of livestock and poultry feeds and feeds/feedstuff.

LC No. 1-1977. Prohibition on the sale of sub-standard or poor quality feed supplements and premixes

Administrative Order No. 84. Nutrient standards for aquaculture

Table 2. Prescribed nutrient standards for aquafeeds in the Philippines

Feed	Moisture (max %)	Crude protein (min %)	Crude fat (min %)	Crude fibre (min %)	Ash (max %)
Shrimp feeds (pellets/crumbles)					
Pre-starter	10	45	4	4	10
Starter	10	40	4	4	10
Grower	10	35	4	4	10
Finisher	10	30	4	4	10
Fish feeds (mash/pellets crumbles/flakes granules/powder)					
Prestarter	10	45	4	4	10
Starter	10	40	4	4	10
Grower	10	35	4	4	10
Finisher	10	30	4	4	10

Source: Administrative Order No. 84, Series of 1990, Bureau of Animal Industry, Department of Agriculture, Quezon City, Philippines

IMPACT ON THE ENVIRONMENT

In conducting clinical trials, due regards shall be taken on the effect of the product on the environment, on residues produced in treated animals and the eventual fate of animals used for food production.

REGISTRATION AND LICENSING

To closely monitor and observe the activities of concerned parties in the compound feed industry, the above-mentioned laws require all feed/veterinary drug manufacturers and dealers to register with BAI, either annually or semi-annually. It is considered illegal when any person, firm, partnership, corporation, cooperative or association engages in the manufacture or sale of animal feeds/veterinary drugs without having first registered a description of the feed/veterinary drug by name, chemical composition and physiologic/therapeutic benefits.

No change in the brand of a registered feed/veterinary dru- can be made without a written notification to the proper authorities. The Director of Animal Industry is empowered to caiicel the registration of any feed/veterinary drug that does not conform to the provisions of those aforementioned laws (i.e., labeling and quality standards).

INSPECTION AND SAMPLING

In the implementation of the feed/veterinary drug laws, the BAI's feed/veterinary drug inspectors may enter the premises of any registered feed/veterinary drug establishment in order to 'inspect animal feed/veterinary drug equipment, conveyances, feed/veterinary drug laboratory reports and other relevant documents and to take small amounts for chemical analysis and feed microscopy. Samples are taken by carefully prescribed methods, so that each sample will truly be representative of the entire "lot" of each brand sampled.

Analytical methods for feed evaluation are also carefully prescribed. R.A. 1556, as di- nended, mandates that the government and private feed laboratories shall adopt the methods of analysis published in the official methods of Analysis of the Association of Official Agricultural Chemists (AOAC) in evaluating the quality of animal feeds. This is another provision for uniformity, as well as accuracy.

CODED SAMPLES

Collected samples from feed manufacturers and suppliers are properly coded before they are sent to the BAI Central Feed Analysis Laboratory in Dilimaii, Quezon City for chemical/ microscopic evaluation.

Feed samples are analyzed for their nutrient composition (minimum percentage of crude protein and crude fat, ash, mineral and moisture), purity (absence or presence of adulterants and other extraneous materials, which are harmful to livestock or man) and toxicity (by using experimental animals). Results of the analysis are returned to the AFSD for proper decoding and interpretation.

Decoded results are used to monitor the different feed mills or fari-ns. Feeds failing below minimum standards or substantially below guarantees and containing substances injurious to the animals, may be condemned and impounded.

In cases of willful or repeated violations of the law, the registration certificates of erring ('persons or entities may be temporarily suspended or cancelled, depending oil tile degree of tile violations). Persons responsible for such violations may also be prosecuted.

Laws regulating the compound feed industry are as vibrant and dynamic as the industry itself. They do change, depending on the needs of the industry; but the change is always for the better. For after all, these laws are specifically designed to safeguard everyone - the producer, trader, end-user and, ultimately, the consuming public.

Aquaculture Feeds and the Environment

Finfish and shellfish farming operations can have noticeable impacts on the quality of water and sediments. Impacts on the water column are influenced by the nature and amount of wastes produced, and the characteristics of the recipient environment. The actual quantity of wastes from feeds varies considerably, depending on feed type, feeding method, feed quantity and other environmental and physiological factors, the effects of which are largely undetermined. Feed type is important, for example, estimates from freshwater trout culture suggest a wastage of 1-5% for dry feed, 5-10% for moist feed and 10-30% for wet feed (trash fish). Common estimates of feed wastage, including dust and uneaten food, from farms using dry feeds vary from 5% to 20%. Fish faeces, on the other hand, are the second source of solid waste and estimates from laboratory studies suggest that 25-30% of the dry weight of consumed feed is voided as faeces.

Wastes from fish culture can be subdivided into two major fractions: solid and soluble. The solid fraction is composed of uneaten feed pellets and faecal particles, together with smaller quantities of fish scales, mucus and other detritus, most of which have a density greater than water and will tend to sink out of the water column. The soluble fraction consists of materials excreted in urine or across the gills and leached out from the solid fraction as it sinks. The most significant characteristics of these wastes as they affect water quality and sediments are the suspended solids, the various nitrogen and phosphorus compounds and the oxygen-consuming properties.

There are major differences between the fate of phosphorus and nitrogen wastes in the environment. Phosphorus wastes are concentrated within the solid fraction, whereas the vast majority of nitrogenous wastes are found as dissolved nitrogen, particularly ammonia, as an end product of protein metabolism. Ammonia is an important waste product because it can be directly toxic to aquatic organisms. Ammonia exists in water in two forms, unionised ammonia (NH_3) and the ammonium ion (NH_4^+); the relative proportion of the total ammonia pool in these different fractions depends on pH, temperature and salinity. Unionised ammonia is generally regarded as being the most toxic to fish and other aquatic animals. The waste loadings of dissolved nitrogen are also particularly important because nitrogen is generally regarded as the limiting nutrient within marine waters. The oxygen content of water will be reduced by the fish themselves and by bacteria which decompose the wastes. Consequently, there will be a reduction in oxygen content on a localized basis. Moreover, in the absence of oxygen, hydrogen sulfide, ammonia and methane are accumulated on the sediments and may be released back to the water column through the water movement. Hydrogen sulfide and methane are also highly toxic to fish and has been implicated in gill damage and mortalities. Phosphorus is also regarded as a limiting nutrient, thus high concentrations can trigger algal blooms.

Impacts from solid wastes, on the other hand, depend on their settling velocity and current velocity, turbulence, and depth at individual sites. The settling velocity of marine fish feed pellets is greater than faecal particles because of their higher density. Consequently there is a tendency for faecal wastes to spread over a wider area than feed pellets. The amount of solid accumulating below cages varies, from up to 40cm of soft, light brown flocculent material in low velocity sites to no visible accumulation on high velocity sites. The solids falling to the seabed below fish cages are enriched in carbon, nitrogen and phosphorus relative to the natural sediments, hence fish farming may alter the physicochemical nature of sediments below and adjacent to the operation but is usually limited to the vicinity (50 m) of the cages. This increase in carbon sedimentation results in an increase in oxygen consumption by bottom-living animals. The sediments will become anoxic if this additional oxygen demand exceeds oxygen supply, at which point there may be severe consequences for both benthic organisms and the fish farming operation itself.

Knowledge on the impacts of fish farming to environment, specifically the uneaten feeds and faecal matter is important to sustainably manage aquaculture. Information on the fluxes of particulate matter and dissolved substances from fish farms and the exchange of nutrients between farms and the environment can be looked into as these can provide more understanding on the processes involved in organic-enriched environment.
The uneaten feed pellets below the fish farms have negative impact on the seabed. It overloads the area with nutrients and organic matter (Macleod et al., 2004).

Neumeier et al. (2007) conducted a study on the effect of uneaten feed pellets on the stability of fine sediments. A "bacterial veil", i.e. a bacterial biofilm at the bed surface had developed after a few days of pellet loading, preventing the biostabilisation of diatom biofilm. This translates to increased erodibility of fine sediments below the fish farms, resuspending the nutrients and the pollutants and disrupting the benthic organisms during high-energy movements, e.g. spring tides, storms, etc.

A study conducted by Holmer et al. (2002) in Bolinao, Pangasinan showed that sedimentation rate is highest inside the fish pens, wherein it increased by one order of magnitude at starter and finisher pens and by 30% at frymesh and grower fish pens. Moreover, this study also showed that the feed wastage increases as the fish reaches the harvestable size (Table 3).

Table 3. Sedimentation rates inside and outside fish pens in various stages of fish production

Feed type	**Fish pen and distance**	**Sedimentation rate (g DW m-2 d-1)**
Fry mesh	Inside fish pen	292 $\pm$ 18
	15 m away from fish farm	273 $\pm$ 39
	50 m away from fish farm	192 $\pm$ 17
Starter	Inside fish pen	242 $\pm$ 19
	15 m away from fish farm	72 $\pm$ 36
	50 m away from fish farm	54 $\pm$ 54
Grower	Inside fish pen	339 $\pm$ 46
	15 m away from fish farm	253 $\pm$ 39
	50 m away from fish farm	180 $\pm$ 13
Finisher	Inside fish pen	493 $\pm$ 12
	15 m away from fish farm	44 $\pm$ 44
	50 m away from fish farm	41 $\pm$ 41

Sedimentation rates are given as mean (+SEM, *n*=4)

Maintaining a healthy environment is critical in sustaining the aquaculture industry. However, this concept is not yet ingrained in the economics of aquaculture, as more and more incidences of fish kill and eutrophication of water bodies are still evident. Instead of minimising the intensity of aquaculture activities to counteract the situation, losses in fish kills are being compensated by increased in stocking density, thus, increasing feed wastage and faecal wastes being discharged into the water bodies, an impact more than the environment's threshold to assimilate. This is a vicious cycle wherein economic, social and environmental factors are intertwined. Unless one give way, this situation will never be reverted. Water pollution, losses in production, fish kill will continuously occur in increasing order of magnitude.

Farming Systems, Feeding Methods and Aquaculture Feeds Use and Wastage

There are three different farming systems being used in aquaculture. These are extensive system, semi-intensive, and intensive. The major difference lies on the intensity of the production. However, the following are the generalizations that can be derived based on Fast and Menasveta, 2000; Rosenberry, 2000; and Wyban and Sweeney, 1991.

Extensive System
This type of farming system have low stocking densities, none to little supplementary feeding, low labor inputs, low production costs, employ low water exchange, no artificial aeration and low production yield. An earthen pond is usually used, ranging from less than a hectare up to 100 hectares. Some examples of organisms normally cultured in this system are milkfish, tilapia and carp.

Since this system relies on the organisms naturally present in the pond and influent water and does not generally employ supplementary feeding, pollution from uneaten feeds is low to none.

Semi-intensive System
This type of system uses moderate water exchange, with partial or continuous aeration, and more labor inputs. It aims to increase the production of fish beyond the level supported by natural food from extensive systems through the use of supplementary feeding, which comes from, cereals, fishery by-products, formulated feeds, etc. Thus, when compared with extensive system, since it has more nutrient inputs and higher stocking density, it also has higher wastage from uneaten feeds and faeces.

Intensive System
In intensive culture system, there is a decreased dependence on the availability of natural food but greater dependence on the use of commercial feeds. Most commonly farmed species are milkfish and prawn. Among the three systems, this is the one that has the highest nutrient loading to the environment, in terms of feed wastage and faecal matter.

Issues on Aquaculture Feeds Quality, Regulation and Management

The serious of consultation meetings have brought out issues which is unique for each sector, from the physical properties of the feeds to the feeding habits of the farmer/caretakers, up to the policies involved in regulating the feeds. The following is the summary of the issues that were raised during these meetings:

A. Regulatory
1. Overlapping and/or mixed-up mandates of national agencies
2. Lack/inadequate regulations addressing aquaculture feeds
3. Lack and/or weak regular aquaculture feed market monitoring

B. Physical properties
1. Poor stability
2. Poor digestibility

C. Environmental
1. High dependence on trash fish, thus net loss of wild-caught fish
2. Water pollution
3. Sedimentation
4. Eutrophication
5. Anoxic environment for benthos communities

D. Economic
1. Inappropriate use of pellet size and formulations to save feed costs
2. High cost of raw materials
3. Poor fish meal quality

E. Linkaging

1. Lack and/or inadequate cooperation/link between farmers and feed millers

RECOMMENDATIONS

The problems and issues in aquaculture are multi-faceted, thus it is only appropriate to address them involving all the major players. Some of the recommendations presented here are the result of consultations and meetings with the major sectors involved in aquaculture, namely, the national agencies, farmers, producers and feed millers.

A. Regulation

1. Creation of standards for pellet stability, feed digestibility, grinding level of raw materials, level of fines (volume per sack)

a. Pellet stability

Ideal pellets lure fish by their size, shape, and organoleptic properties and are available in water without loss of components. This last factor, called "pellet quality" is important for good feed conversion. A measure of pellet quality as applied to dry feeding conditions is the amount of small broken pieces of fines created during handling. This may be related to the abrasive pressure required to break them down. However, dry pellet quality expressed as hardness or in the percentage of fines does not necessarily correlate with water stability. The average high-quality feed pellet made for poultry, swine, and beef, high in cereal grains, becomes mushy within minutes after immersion in water. There is evidence that coarse-textured feeds, water soluble, and hygroscopic ingredients weaken pellet structure in water, allowing components to separate and making the feed only partially accepted.

A laboratory technique for measuring pellet stability) in water is useful for establishing feed formulation and processing specifications. One such test described by Hepher (1968) which has given reproducible values and shown good correlation with pellet recovery from feeding platforms and bottom sampling devices, is as follows:

Step 1. Ten grams of pellets of equal diameter and length are distributed uniformly on a screen tray approximately 100 cm^2 in an area with raised sides. Mesh openings are slightly less than pellet diameter.

Step 2. Duplicate samples are lowered into quiet water of an aquarium or tank. If clumping or floating occurs, a piece of cut screen is placed on top of the pellets to hold them under water in a scattered position.

Step 3. After 10 minutes, the trays are removed from water, slanted to drain, and placed in a moisture oven at 130°C for 2 hours, then cooled in a dessicator.

Step 4. The residue on the screen is recorded as dry solids not lost in water. Total solids in 10 grams of air-dry pellets are determined by oven-dry duplicate samples. Nutrients lost by leaching in water may be measured at this point by freeze-drying the residue on trays and comparing the chemical analysis with untreated pellets.

Step 5. The ratio of dry solids on the screen after 10 minutes in water to total dry solids in air-dry pellets, is used as a comparative measure of pellet water stability.

During the early days of using hard pellets for fish culture, a random selection of commercial feed was examined for water stability by this technique and none was found to have more than 60 percent retention after 10 minutes in water.

The following are the recommendations for feed millers in order to obtain more stable fish feed pellets and thereby improve feed conversion:

- Before pelleting, grind the mixed feed through a 2 mm screen to an effective size of 125 microns.
- Replace at least 5 percent of a non-essential ingredient with an organic flour such as rice dust, dried wood pulp liquor, wheat endosperm, or other binder. (Formulae containing 25 - 30 percent ground wheat or byproducts of wheat endosperm, may not require the use of a binder).
- Operate the pellet mill at its optimum rated amperage for maximum compression and extrusion pressures.

- Add sufficient dry steam to condition the soft feed to a temperature of 85-90°C, thus causing gelatinization of raw starch on the surface of all starch-containing ingredients.
- Cool and dry pellets before conveying to storage or bag-off bins.

Table 4 shows the formula of a standard feed used in testing water stability of pellets. It is typical of commercial catfish rations used in the southern part of the United States. Basically it complies with the requirements of a 30% protein feed, 25% of which is of animal source, with a protein:calorie ratio of 90 (grams protein in 100 grams feed × 100 divided by kcal/100 grams feed).

Table 4. Physical Measurements of Pellet Stability of a Standard Catfish Feed

Process variable	**Water stability % retained 10 minutes in running water**	**Broken by Stokes pellet hardness tester**
Unground, no steam, thin die	21.5	zero pressure
Unground, no steam, thick die	24.3	zero pressure
Unground, added steam, thin die	31.3	1 kg
Unground, added steam, thick die	78.9	3 kg
Ground, no steam, thin die	65.8	3 kg
Ground, no steam thick die	74.5	4 kg
Ground, added steam, thin die	84.9	8 kg
Ground, added steam, thick die	88.0	13 kg
Ground plus 20% gelatinized potato starch and 6% added water, no steam	**98.9**	**20 kg**

Note: Water movement through the test container may be used as an alternative to use of quiet water.

One way of increasing feed stability and prevent nutrient leaching is through the addition of binders. Some sources that can be used are alginates, gum, gelatin and starches. High-wheat feeds are very water-stable if properly steam conditioned before compression and extrusion in a pellet mill. Feeds low in starch require a thick ring die and extra steam for conditioning. Special binders of starch-origin provide some degree of water stability for pellets made with low-starch formula.

b. Feed digestibility

Although fish meal is still the most ideal source of crude protein (CP) for aquaculture, particularly for carnivorous fish, the increasing cost, availability and its impact to fisheries drove many manufacturers to shift to plant-based protein. However, plant protein has generally lower CP value and lower protein efficiency ration. Moreover, it contain heat-labile and heat-stable secondary compounds which negatively affects the diet utilization. However, these can be addressed in many ways. Heat-labile secondary compounds can be destroyed through heat systems such as, extrusion and expander processing (Drew et al. 2007). Extrusion is the process of exposing the feeds into high temperature (125-150°C) and pressure. On the other hand, heat-stable secondary compounds can be removed through crop fractionation. Other means that can be considered are addition of enzymes, appropriate choice of raw materials, appropriate feed particle size vis a vis fish size. Grinding level of raw materials is also a good consideration. The ingredients of well-grounded feeds are well-mixed and easier for the fishes, especially the small ones to ingest.

c. Level of fines

The content of fines per unit volume of feeds should also be considered. The farmers will not benefit from fines content and these are part of economic losses on their part. From the ecological standpoint, fines will increase the nutrients in the water and decrease the productivity of aquaculture in return.

During the workshop, some claimed that there are feed milling companies that supply feeds with almost 70% fines content, while other farmers receive 5%. Both are unacceptable. The 5% fines when translated into cost and tonnage of feeds per production is a huge sum of money wasted.

2. <u>Develop Better/Good Management Practices</u>
Better practice guidelines were developed for small-scale fish cage and pen operators with emphasis on mitigating environmental impact. The guidelines covered the feed and feed management

Better Practice Guidelines aim to give farmers sensible and practical guidelines to follow in the planning, management and operation of their farms. These guidelines were based on lessons learned from local and international practice or scientific research. An extract of the section on feeds and feed management is given at the end of this report.

3. <u>Create a policy specific for regulating aquaculture feeds</u>
At present, the aquaculture feeds are being regulated using Republic Act 1556. However, the specific issues of aquaculture are not addressed since RA 1556 is drafted mainly for poultry and livestock. The only existing policy is regarding the regulations on residuals. There is none dealing with the physical properties, such as feed stability and digestibility.

4. <u>Provide provisions on incentive system and sanctions</u>
At the moment, the draft aquaculture feed standards under BAFPS was proposed to be mandatory. However, there are no sanctions and incentive systems that were stipulated. Incentive mechanisms can be laid out to encourage compliance. One example is the certification program, wherein, those who comply will get a seal certifying the good management practices and safe and good quality product. Less

Feed quality inspection: Thailand Case Study
In Thailand, the basis for feed regulations is stipulated under Animal Feed Control Act of 1992, wherein it is being administered by the Department of Livestock of the Ministry of Agriculture and Cooperative (MAC) through collaboration with other units of the government- the Aquatic Animal Feed Research Institute and the Feed Inspection Unit of the Department of Fisheries (DoF). The Department of Livestock regulates the content and quality of aquaculture feeds being sold in the market while the Aquatic Animal Feed Research Institute is responsible for their analysis. Feeds registration and monitoring of feed quality in the market and farm sites are under the jurisdiction of the Feed Inspection Unit (FIU). They are responsible in ensuring the compliance of the manufacturers and farmers on the required feed content and standards.

All manufacturers are required to register at FIU. A sample of not less than 500 g and including a copy of its formulation are submitted for inspection to FIU. This will then be analysed by the Aquatic Animal Feed Research Institute. A certificate valid for 6 months is issued to companies that passed the quality control. However, those companies with feeds found positive for banned drugs and chemicals will be banned from selling their products, and all their products recalled from the market. They will also be reported to the police for selling products with banned chemicals. The farmers who used these feeds will also be banned from selling their produce to the market until such that the withdrawing period is lifted up.

In addition to this, the government also trains farmers in making their own feeds semi-moist pellets based on their given formulation. The farmers are taught to produce feeds, from preparing the raw materials and ingredients up to pelleting.

There are three things that are commendable in this

1. **Organizational structure**. Although there are different units involved with feed regulation, these are collaborative efforts in nature rather than overlapping. Although it is true that one agency that is charged with everything will make the implementation easier, there is always a hard fact that governments do not always have enough funds for the facilities, employees, etc. Thus, it is always practical to share resources and manpower.

2. **Monitoring and enforcement**. The enforcement mechanism is from top to bottom. They not only conduct monitoring at the manufacturer's level, they also do on-site inspection. Moreover, products are recall from the market, thus ensuring the safety of the consumers. This system is also effective in putting pressure to the manufacturers and farmers, as the government puts control to the market of their products.

3. **Inspection procedure**. They are using a cheap kit that can provide results in minutes. This is ideal especially when conducting on-site monitoring.

4. **Community-based pellet-making**. This is a good intervention since this will cut costs of commercial feeds. The farmer can gain more from their products, empower to choose species to culture and the intensity of aquaculture activities. They are not bound with the terms and conditions being handed down by the feed manufacturers selling their products by credit. Moreover, the government can also the control the content and quality of feeds, thus making the monitoring for compliance more effective. However, from the business point of view, this may not be good.

B. Aquaculture Feed Millers

1. Increase feed stability by adding binders and/or through extrusion
2. Improve digestibility of feeds
3. Develop Good/Better Management Practices for Feed Millers

The Local Government of Dagupan Experience

The city of Dagupan has been given the Guiness Book of Records title "the Bangus Capital of the World". In this town, milkfish fishpen flourishes along the rivers, giving high profits which encouraged a lot of people to engage in this lucrative business. A study conducted by Cruz Corp. showed that 18% of the river system was installed with 1,500 units of fish pens producing 3,000 metric tons per annum. The industry has also provided jobs for 4,000 workers. However, this highly intense activities coupled with poor practices such as polluting the water, over-stocking, poor feed conversion efficiency have resulted to the degradation of the environment. Before long, disease outbreaks begin to occur, followed by periodic fish kill episodes which increases in frequency through time. These translated to big losses to business which once had earned them the prestigious title.

To counteract this continuing losses, the local government of Dagupan has issued various ordinances. However, the rationalizing of the aquaculture industry has started during the enactment of Fisheries Ordinance No. 1768-2003 "providing for the sustainable management, development and conservation of all Dagupan city waters and coastal and fishery resources". This ordinance harmonized and integrated all the other ordinances issued. An Executive Order No. 71, Series of 2003 was signed to ensure the proper implementation of this ordinance. Among the significant provisions included herein are:

1. the Dagupan fisheries resources are only for Dagupenos;
2. "One unit-one operator" policy; and
3. the demarcation of delineation of specific use along the river system;

Other provisions were also issued to strengthen the implementation of this ordinance, namely, Executive Order No. 98 s, 2004 (Code of Practice for Aquaculture in the city), Executive Order No. 99 s, 2204 (Setting aquaculture feed requirements for Dagupan City), Executive Order No. 102 s, 2004 (Resource-use deposit), Executive Order No. 214 s, 2004 (an Order creating the Fishery Ordinance Enforcement Task Force) and Fishery Management Ordinance No. 01 s, 2005 (Requiring all Aquaculture Lease Agreement holders/operators and motorboat operators to procure and install the required plates upon approval and issuance of permits to operate).

In effect, aquaculture operators are required to obtain an Aquaculture Lease Agreement (ALA) in order to operate aquaculture activities. Without this permit, the operations will be considered illegal. Among other things, an annual permit and license fees and resource-use deposit needs to be paid. These fees are used to finance the initiatives of the local government in ensuring the sustainability of the industry. Some examples are the accreditation of feed dealers. Only those accredited by the local government are allowed to sell their products and be used by the fish farmers. This is to ensure that the quality of feed complies with the standards. Branding and labelling to increase marketability of products are also being done by the local government.

Dredging and river clean-ups and regular water quality monitoring are also conducted to ensure the quality of the water environment. Moreover, advisories on the condition of the water are given to operators. This lessens the losses incurred by incidents such as fish kills, disease outbreaks etc.

The experience of Dagupan City in rationalizing the aquaculture industry is a long and hard road. However, the local government's strong political are starting to pay off. Its continuous efforts to battle poor aquaculture practices and environmental degradation will be repaid, and their hard-earned title as the "Bangus Capital of the World" will never be taken away from them.

C. Recommendations for LGU:

1. Accreditation of aquaculture feeds
2. Aquaculture area zonation
3. Regulate the number of cages and stocking density of production based on the carrying-capacity of the water body
4. Implement resource-use fees to be used as source funds for regular monitoring of aquaculture activities and water quality
5. Provide trainings on feeding techniques, e.g. Patrick White tray, appropriate pellet size to fish size, to increase the awareness of local farmers and operators on good management practices
6. Provide provisions on incentive system and sanctions, i.e. tax per sack of feeds. In this way, the farmer is encouraged to practice good feeding management buy only feeds that can provide with low FCR.

D. Producer Organisations

The organisation of big producers, such as bangus producer association, tilapia producer association, etc. can pressure the feed millers to produce feeds that will give them low FCR with higher digestibility and stability.

E. Farmers

1. Good Feeding Management

It makes economic, environmental and common sense to feed any stock of fish in a well-managed fashion. Any method employed has to satisfy the appetite demands of the stock, promote good growth, economically-efficient and with high potential of assimilation. Feeding can be divided into a number of areas, which are ration size (how much should be fed, how does the ration fit in with growth potential, how often should rations be given and at what time of day (feeding regimes), how are rations best delivered and how to monitor the efficiency of the diet and its performance. These factors all interact and need consideration in order to get the best out of both the diet and the stock. If one factor is outside the optimal range, stock quality and income will ultimately suffer. There may also be a need to utilise specialist diets at certain points of the production cycle.

a. Ration size and fish growth

The economy and productivity of a farm operation is influenced by both ration size and the way the ration is fed. Use of the best diets, equipment and fry/fingerlings can still result in poor growth rates and food conversion ratios if proper feeding was not employed. Feeding revolves around two main factors, the amount of food that should be given with reference to the numerous biotic and abiotic criteria which determine the appetite and nutritional requirements of fish and the mode of feeding with respect to times of day, the number of feeds per day, the duration of each meal and the rate of application of feed. The appetite at any one meal can be more or less than the preceding or succeeding one. This meal-to-meal variation is compounded by longer term seasonal variations in temperature, photoperiod and body size. In order to match appetite to the food ration to be fed, there is therefore a requirement to have some means of monitoring feeding by the fish in any particular cage. Such systems include detecting feed falling through the bottom of the cage (by sonar or video) or through mechanical retrieval systems which return uneaten feeds to the surface. However, none of these is cheap and are only cost-effective in large-scale production units. Smaller units will have to rely on visual surface operation which is not very effective with regard to knowing when feeding has stopped. this implies that feeding tables are not sufficiently accurate when feeding stock to appetite on a meal-to-meal basis.

Ration size and growth rate interact to determine Feed Conversion Ration (FCR) and are used to determine the daily ration of a particular fish stock. Like all animals, fish will lose weight when their nutrient intake rate falls below what is required for daily maintenance. As food availability increases, the quantity consumed by the fish will also increase, giving a linear increase in specific growth rate (SGR as % body weight per day) up to the point of maximum voluntary food intake. The mathematical relationship between food intake and growth rate determines that gross FCR decreases from infinity in fish fed at a level that satisfies their maintenance requirement, to some maximum value at the maximum consumption rate. If fish are fed above their appetite, then the extra food will only be wasted and an artificially high FCR will result. Thus, high FCRs can result from both over- and underfeeding. It is therefore important for the farmers to determine the nearest FCR of their cultured species to maximize the feeding potential, lessen costs incurred from feeds, thereby reducing the environmental impacts of food wastage and faecal wastes.

b. Feeding rate and fish' growth efficiency

Studies show that maximum growth efficiency of fish does not necessarily coincide with maximum food intake. Instead the growth-ration relationship indicates that that growth rates initially increases with increasing ration but then plateau out at the highest feeding rates. In some quarters it is felt that the optimum ration, i.e. the point just prior to growth starting to plateau, is achieved if fish are fed at restricted ration levels rather than to appetite. It is because the appetite of fish is not constant, varying from feed to feed under the influence of different factors such as the presence of predators, stormy weather, etc. Thus, it is important for farmers to note over-feeding will not make their cultured fishes bigger, nor grow faster. It is more important to determine the satiation levels to maximize the benefits out of the feeds.

c. Determination of optimal feeding regimes

Feeding efficiency is also affected by the rate at which food is dispersed, the number of feeds per day and the duration of each feed. These factors also play a part in determining satiation. Analysis of the feeding process in terms of the number of pellets fed is one way of developing an optimal feeding regime. Based on fish size and pellet diameter the number of pellets a fish requires for its daily ration can be estimate ed and used to examine the influence of feeding techniques.

To determine the optimum number of feed pellets per day, lets take as example 1kg of fish fed at 1% of body weight per day, i.e. 31 pellets/fish/day. This means that feeding once a day would result in each fish obtaining its full ration (31 pellets) and all the fish would be satiated. If fed twice a day, there would be 15.5 pellets per fish at each meal. In this case, either 50% of the fish would be satiated at each meal or each fish obtains only 50% of its daily requirement in the first feed and the other half at the second meal. At the other extreme, feeding 31 times in a day means that there is one pellet per fish at each meal, i.e. either 3% of the fish could be satiated at each meal or each fish obtains around 3% of its daily need at each feed. This principle shows that increasing the number of meals reduces the feeding opportunities through reduction in feed availability. In addition many small meals will result in the formation of dominance hierarchies and increased competition leading large size/weight variations, which the farmer wishes to avoid. The dominant fish will ensure that all the food offered with many small meals will mean that the use of waste feed detection systems is not feasible as there will be no waste feed at any of the meals. Similarly, comparison of growth rates and FCRs will have no meaning. Depending on fish size, the maximum number of meals per day would be the one which ensures at least one pellet per fish per meal. From numerous studies the optimum number of meals appears to be in the range 1-6 per day to satiation, the actual number depending on the species and water temperature. Except for first-feeding fry, the number of meals does not relate to size as gut evacuation rate appears to be independent of body weight.

The rate at which feed is offered to fish and the length of each meal is related to the number of pellets a fish will take per minute. This is a function of how hungry the fish is and the number of available pellets at any one time. Studies show that feeding rates are initially high but slow down as the fish attain. Cage and laboratory studies indicate that hungry fish consume around two pellets a minute except at high (>18°C) and low (<5°C) water temperatures when rates of 0.5 pellets a minute are the norm. Knowing the number of pellets an individual fish will eat for a given daily ration size and the number of feeds per day for a given temperature, the number of pellets eaten per feed can be calculated. Dividing the number of pellets per feed by either 2 or 0.5 (above) gives the duration of the meal time. For example, for different biomasses of fish the feed quantity will differ but the duration of the meal will remain the same. Thus a cage holding 5 tonnes of 1 kg fish at 26°C will require 18.7 kg of food to be delivered in 5-6 minutes. Reducing the number of meals from 4 to 3 for the same cage would result in the need to deliver around 25 kg of feed in 7-8 minutes. These rates may appear high to the husbandry person but from the fishes' point of view, eating one pellet every 30 seconds means high food availability, thus competition is much reduced.

The best time to feed is when the fish are hungry. If the time interval between meals varies considerably the fish will adapt in terms of how much they will eat at each meal. The time interval between satiation and return of appetite appears to be relatively constant for any given temperature within a range of +-20°C. Naturally fish should not be fed when environmental factors are limiting, e.g. when it is too dark. The best known and simplest form of feed delivery is through the use of the scoop. This is perfectly adequate for small production units (up to 12 metres square or 50 metres diameter) and producing small tonnages (up to 100 tonnes maximum). Minor increases in cage size and production output will force a change in technique - this may simply be use of a larger scoop. Large-scale increases in cage size and/or production necessitate radical changes in feed delivery by virtue of the amount of food potentially required and the optimum delivery times. One of the simplest ways to step up feed delivery rates is to use a feed cannon. Obviously, as with scoops, feed has to be delivered downwards for it to be effective.

d. Feed conversion rate

The efficiency with which food is converted into fish weight is usually expressed as a feed conversion ratio (FCR). Commercially available pelleted diets usually give FCRs between 1 and 2 depending on fish size, temperature, feeding rate and feed composition. An FCR of 1 means that every kg of food fed is converted to 1 kg of fish flesh; an FCR of 1.5 means that every 1.5 kg of feed will produce 1 kg of fish flesh. It should be remembered that this is comparing a feed with a 10% moisture content producing a wet weight gain in the fish which is about 70% water. On a dry weight basis (dry feed to dry flesh), the FCR would be about 5:1, i.e 5 kg of food for 1 kg of flesh. To calculate FCRs, several things need to be measured, calculated and understood. It also requires the maintenance of good, accurate records whether they be paper or computer generated. Without these, the calculations are impossible. Accurate records include information on daily water temperatures, mortalities, number of fish in a cage, and weight of fish. One year's records can then be used to predict/ calculate the following year's food requirements based on that year's smolt intake.

The next thing to understand is feeding charts and how to use them. They all give the same basic information. Each manufacturer provides a chart detailing fish weight, feed type and size and the feeding rate as a percentage of body weight/day for different water temperatures. There will obviously be differences in feeding rates between feed companies for the same size fish and water temperature - but these are relatively minor.

To calculate daily, weekly, or monthly feed requirements, FCRs, etc. the following steps should be followed:

1. Sample weigh the fish in the cage or holding unit. The sample should be as representative as possible and should not be based on a single fish - use at least 10. Weigh the fish using an appropriate method e.g. place a water-filled bin/bucket on a scale and note its weight. Place fish in the bucket - increase in weight = weight of fish. If fish are placed directly on scale, the reading will be hard to take and fish will suffer damage/stress.

2. Having kept accurate records of both the number of fish put into the cage at the start and the number of mortalities, the number of fish in the cage at the time of weighing will be known. From (1) and (2), the total biomass (or weight) of the cage can be calculated.

3. From the feed tables, ascertain the feeding rate for the temperature and size of fish.

4. Using the information from (1)-(4) the daily feed requirements can be calculated. Multiplying by 7 gives the weekly feed requirement.

5. If the fish are weighed at a later date, e.g. 15 or 30 days after, the weight gain of the fish can be measured. Knowing this and the amount of food fed in the time period allows the FCR to be calculated.

6. Knowing the FCR allows future daily/weekly feed requirements to be calculated. This allows a farmer to order his feed well in advance of its being needed and so to avoid potential distribution problems. Being able to understand feed tables, calculate feeding rates and FCRs allows the farmer to check how his stock is doing and to budget his money with regard to how much feed is required over a certain length of time.

2. Feeding Strategy

As most farmers know, feed costs constitute a very large proportion of the overall production costs, typically in the range of 30-60%. Increasing the level of production technology has the added benefit of reducing feed costs and manpower costs. Anything which reduces feed costs is going to benefit the farmer. There are a number of inter-related issues that need consideration with respect to feed management and cost reductions. On the consumer side, there is a need to consider such things as food safety, health aspects and the product's nutritional value. Producers need to evaluate such things as food and stock performance and availability, stock health, environmental impacts and legislation, and the implicit costs of these. Despite these potential hurdles, there is opportunity to reduce feed costs through feed selection, reduction of wastage and use of appropriate ration sizes - all these influence the cost-effectiveness of a diet.

a. Feed selection

Farmers usually select a diet on the basis of cost and perceived quality with additional inputs from extras such as feed company backup, computer feed programmes and so forth. Very little detail exist which compares one diet with another, either within one company or between companies. The only comparison a farmer can make between diets is historical, i.e. comparison between the new one with one used previously by analysis of his farm records (growth rates, FCRs, etc.). When a new diet becomes available, the benefits from it must be obvious in terms of improved growth, FCRs or product quality. If a new diet is more expensive than existing ones, there must be an accompanying decrease in the FCR if feed cost per unit of fish produced is not to go up. This is illustrated in the diagram on the screen which also shows that small changes in FCR can have a large impact on feed costs.

Feed comparison can also be made between diets where potential FCRs and price are known. For example, a new diet (ND) promises an FCR of 1.8 but at a price of 35 peso per bag. How does this compare to an old diet (OD) at 30 peso per sack giving an FCR of 2.2? Diet ND has a feed cost per kg of fish produced of 35/25 x 1.8 = 2.52 peso per kg, while cost of diet OD is 30/25 x 2.2 = 2.64 p/kg. Thus the newer, more expensive diet is actually cheaper in terms of production costs.

b. Feed wastage

Any reduction in the wastage of feed will have a significant effect on production costs. It is essential that overfeeding is avoided and that feeding practices do not become lax. Continual monitoring and review of feed amounts and feeding regimes is necessary. Use of performance indicators (growth rates, FCRs) both currently and historically is recommended so that any problems can be picked up at the earliest opportunity. There is a need either for a visual feedback system using a feed tray to prevent this.

As with all industries, it is possible to waste money through a combination of a lack of thought, knowledge and bad practices. Given thought, knowledge and good attention to husbandry practices it is possible to utilise fish diets extremely and cost-effectively. As they form one of the largest portions of the production costs, this becomes a necessity. To maximise this cost-effectiveness, a farmer has to ensure that he uses the best diet in such a way that growth and feed conversion are maximised and wastage is minimised within the physiological limits of the stock. This necessitates constant monitoring and continual re-evaluation. Some improvements on fish feed and its formulations should be done. Some of the waste in feed (dust, etc.) can be removed and the unit feed production costs can perhaps be reduced through alternative ingredients, and so on. Through these methods it may be possible to reduce FCR values below 1.8, perhaps down to 1.5. At these levels feed becomes very cost-effective, particularly in the light of recent low prices for some aquaculture products. It is felt there is a biological FCR limit which has a value of 1.2 but it is unlikely to be achievable in practice.

c. Feeding tables

Feed wastage can be attributed to overfeeding and not consulting feeding tables which takes into consideration fish size, water temperature etc to estimate optimum feed ration. Feed tables were developed for milkfish and these can be found at the end of the report.

CONCLUSION

As of this writing, the BAFPS has already initiated the standards for aquaculture, incorporating the recommendations that were identified here, such as the feed stability, digestibility, level of fines and good/better management practices of farmers/operators. This standard is expected to come out next year.

During the Philminaq national workshop in 2008, there we some studies on FCR improvement that were identified and were planned to do by the Universities in the Philippines in collaboration with the universities in Europe. These studies aim to maximize the utilization of nutrients by the fish and converting it into body mass.

Consultation with the LGUs of Pangasinan

Simple experiment on feed stability using four of the most common aquaculture feeds used in the Philippines. This picture shows the dissolution of the feeds after 5 minutes.


W
X
Y
Z

Extract on Feeds and Feed management from the Better operational practice guidelines for small scale farmers

Feed and feed management

Control and rationalization of feeds and feeding in modern fish farming is of critical importance in maintaining a cost-effective and environmentally sound industry.

This is due to many factors including:

- Feeds and feeding account for 50-60% of the operational costs of semi and intensive shrimp farming.
- Wasted (uneaten and unmetabolized) feed in addition to affecting water quality and predisposing fish to disease is also a major contributor to the discharge of nutrients and organic matter from fish farms leading to eutrophication of the environment.
- Increasing concern is also being expressed regarding the wasteful use of increasingly scarce resources of fishmeal going into shrimp diets for a net loss of protein resources and allied losses due to by-catch from the fishmeal industry. Usage of fishmeal in fish cage feeds for Bangus and Tilapia is minimal. Shrimp is grown in ponds not possible in fish cages.
- Formulation of cost-efficient and high quality, low polluting diets, and proper management of the feeding regime are thus crucial in attempting to optimize the efficient use of feeds in fish farming.

Efficient feeding practices will improve feed conversion efficiency (reduce FCR) and economic returns

Principles

Utilize feeds and feed management practices that make efficient use of available feed resources, promote efficient shrimp growth, minimize production and discharge of wastes.

- Use good quality formulated feeds.
- Make efficient use of fish feed resources. Does this mean using locally available trash fish?
- Minimize feed wastage.
- Feeds must meet the nutritional requirements of the fish

Legal

Practices embodied under Sec. 9 of the DA-BFAR FAO No. 214, shall be adopted to improve the efficiency of supplemental feeds and feed management in aquaculture and reduce the amount of waste entering the ponds.

DA Administrative Order No. 16 on the “Nutrient Standard for Aquaculture Feeds” and other regulations of the Bureau of Animal Industry shall be complied with.

Trash fish

- Avoid using trash fish
- Ensure that where ‘trash’ fish is used, it is sourced from sustainable stocks

Inert feeds – feed quality

- Feeds should be selected as to their high digestibility rates and include binders to reduce nutrient pollution from uneaten feeds and excretory products. Use of artificial binders tend to reduce digestability and thus increase FCR. Unlike shrimp feed which sinks to pond bottom and are fed on by shrimp for longer periods of time, fish feed tend to be consumed immediately. Extrusion process also converts starch to binder.

- Feed characteristics should include balance levels of amino acids and other nutrients appropriate for the age of the fish, high palatability to stimulate rapid consumption, and high stability to prevent rapid nutrient release.
- Ideally, extruded feeds should be used.
- Feed correct formulation for species

Inert feeds- feeding strategy

- Feed correct quantities. Follow feeding tables, adjust feed quantity daily
- Good feeding practices should include frequent feeding in small quantities of feed several times through the day, using feeding trays and even distribution of feeds in the cage and pen.
- Do not over feed as this releases additional nutrients into the environment and wastes money
- Avoid feeding when water temperatures are highest (or lowest. Most species feed at temp ranging from 24deg C to 32 deg C. Feeding during cold temp also result in unconsumed feed) and oxygen levels are lowest.
- Use feed-back feed monitoring systems to ensure that there is no feed wastage
- Feed at appropriate number of times according to size of stock;
- Feed correct size for the size of fish
- Ensure that feed is distributed evenly to all fish
- Records of daily feed application rates should be kept to assess feed conversion ratio (FCR) and assess feed performance regularly.

Inert feeds – feeding management – lakes

- Feeding management in lake –based aquaculture should be in conformity with the carrying capacity of the lake as specified under Chapter B, Sec. 13 of the DA BFAR FAO No. 214, to control stocking density and feeding requirements, as follows:
    - the carrying capacity of a lake shall be determined through the conduct of physico-chemical and biological study to determine plankton/algae density, nutrients, transparency and fish biomass and composition.
    - The carrying capacity of fish pens, cages in the lake shall be based on the physico-chemical and biological productivity measured in terms of biomass (g/m^3) and nutrient uptake ($g/C/m^3$); and
    - The level of primary productivity in inland water that could support the good growth of planktivorous species like tilapia, carp, and milkfish shall not be less than 9 gC/m^3 or 33,000 cells per ml.

Inert feeds – storage and use

- Feeds should be stored in cool dry areas to prevent mold and other contaminants from forming.
- Use oldest feed first. “First in, first out” policy in feed handling
- Store feed to prevent contamination
    - ➢ Ventilated place
    - ➢ out of the sun
    - ➢ off the ground
    - ➢ in a dry place.
- Ensure that feed is fed within the recommended shelf life period.

Inert feeds – Medicated feeds

- Use only regulated medicated feeds
- Medicated feeds should be used only if and when necessary for the control of specific diseases for which the medication is thought to be effective.

Feeding tables developed for milkfish.

2

MILKFISH

SPECIFIC GROWTH RATE (SGR)

Temp min	max	mean weight (gr.) min 35 / max 48	48 / 60	60 / 80	80 / 100	100 / 150	150 / 200	200 / 250	250 / 300	300 / 350	350 / 400	400 / 450	450 / 500	500 / 600	Temp C	Average
18	20	**0.32**	**0.26**	**0.20**	**0.18**	**0.16**	**0.12**	**0.12**	**0.10**	**0.10**	**0.08**	**0.08**	**0.08**	**0.06**	**19**	**0.11**
20	22	**0.74**	**0.58**	**0.44**	**0.42**	**0.38**	**0.30**	**0.26**	**0.24**	**0.20**	**0.18**	**0.16**	**0.14**	**0.14**	**21**	**0.25**
22	24	**1.28**	**1.00**	**0.78**	**0.72**	**0.64**	**0.52**	**0.46**	**0.42**	**0.36**	**0.30**	**0.26**	**0.24**	**0.22**	**23**	**0.43**
24	26	**2.18**	**1.74**	**1.38**	**1.26**	**1.10**	**0.88**	**0.78**	**0.70**	**0.60**	**0.50**	**0.46**	**0.40**	**0.34**	**25**	**0.72**
26	28	**3.26**	**2.70**	**2.16**	**1.96**	**1.68**	**1.34**	**1.18**	**1.06**	**0.92**	**0.76**	**0.68**	**0.60**	**0.50**	**27**	**1.09**
28	30	**4.12**	**3.48**	**2.82**	**2.52**	**2.14**	**1.70**	**1.50**	**1.34**	**1.16**	**0.98**	**0.88**	**0.78**	**0.68**	**29**	**1.41**
30	32	**5.14**	**4.32**	**3.50**	**3.14**	**2.68**	**2.12**	**1.88**	**1.68**	**1.46**	**1.22**	**1.08**	**0.96**	**0.84**	**31**	**1.75**
32	34	**5.54**	**4.66**	**3.78**	**3.38**	**2.88**	**2.28**	**2.02**	**1.80**	**1.56**	**1.30**	**1.18**	**1.04**	**0.90**	**33**	**1.88**
34	36	**5.62**	**4.72**	**3.84**	**3.44**	**2.92**	**2.32**	**2.06**	**1.84**	**1.58**	**1.32**	**1.20**	**1.06**	**0.92**	**35**	**1.92**
36	38	**4.42**	**3.72**	**3.02**	**2.70**	**2.30**	**1.82**	**1.62**	**1.44**	**1.26**	**1.04**	**0.94**	**0.84**	**0.72**	**37**	**1.51**
38	40	**3.32**	**2.80**	**2.26**	**2.04**	**1.72**	**1.36**	**1.22**	**1.08**	**0.94**	**0.78**	**0.70**	**0.62**	**0.54**	**39**	**1.13**

Optimal temperature for growth is 35 'C

	Growth	13	12	20	20	50	50	50	50	50	50	50	50	100
Average	Size	42	54	70	90	125	175	225	275	325	375	425	475	550
Average	SGR	3.27	2.73	2.20	1.98	1.69	1.34	1.19	1.06	0.92	0.77	0.69	0.61	0.53

DAILY FEEDING RATE (SFR)

Temp min	max	mean weight (gr.) min 35 / max 48	48 / 60	60 / 80	80 / 100	100 / 150	150 / 200	200 / 250	250 / 300	300 / 350	350 / 400	400 / 450	450 / 500	500 / 600	Temp C	Average
18	20	**1.6**	**1.2**	**1.0**	**1.0**	**1.0**	**0.8**	**0.8**	**0.8**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**19**	**0.75**
20	22	**1.8**	**1.4**	**1.2**	**1.2**	**1.2**	**1.0**	**1.0**	**1.0**	**0.8**	**0.8**	**0.8**	**0.6**	**0.6**	**21**	**0.90**
22	24	**2.6**	**2.0**	**1.6**	**1.6**	**1.6**	**1.4**	**1.4**	**1.2**	**1.2**	**1.0**	**1.0**	**0.8**	**0.8**	**23**	**1.21**
24	26	**3.8**	**3.2**	**2.6**	**2.4**	**2.4**	**2.2**	**2.0**	**1.8**	**1.8**	**1.6**	**1.4**	**1.2**	**1.2**	**25**	**1.82**
26	28	**4.8**	**4.0**	**3.4**	**3.2**	**3.0**	**2.8**	**2.6**	**2.4**	**2.2**	**2.0**	**1.8**	**1.6**	**1.4**	**27**	**2.31**
28	30	**5.8**	**5.0**	**4.2**	**4.0**	**3.6**	**3.2**	**3.0**	**2.8**	**2.6**	**2.4**	**2.2**	**2.0**	**1.8**	**29**	**2.78**
30	32	**7.2**	**6.2**	**5.2**	**5.0**	**4.6**	**4.2**	**3.8**	**3.6**	**3.2**	**3.0**	**2.8**	**2.4**	**2.2**	**31**	**3.49**
32	34	**8.2**	**7.0**	**6.0**	**5.6**	**5.2**	**4.6**	**4.4**	**4.0**	**3.8**	**3.4**	**3.0**	**2.8**	**2.6**	**33**	**3.97**
34	36	**8.8**	**7.4**	**6.4**	**6.0**	**5.6**	**5.0**	**4.6**	**4.4**	**4.0**	**3.6**	**3.2**	**3.0**	**2.8**	**35**	**4.25**
36	38	**7.2**	**6.2**	**5.4**	**5.0**	**4.6**	**4.2**	**3.8**	**3.6**	**3.4**	**3.0**	**2.8**	**2.6**	**2.2**	**37**	**3.53**
38	40	**5.6**	**4.8**	**4.2**	**4.0**	**3.6**	**3.2**	**3.0**	**2.8**	**2.6**	**2.4**	**2.2**	**2.0**	**1.8**	**39**	**2.77**

optimal temperature for food consumption is 35 'C

	Growth	13	12	20	20	50	50	50	50	50	50	50	50	100
Average	Size	42	54	70	90	125	175	225	275	325	375	425	475	550
Average	SFR	5.22	4.40	3.75	3.55	3.31	2.96	2.76	2.58	2.38	2.16	1.98	1.78	1.64

FEED CONVERSION RATE (FCR)

Temp min	max	mean weight (gr.) min 35 / max 48	48 / 60	60 / 80	80 / 100	100 / 150	150 / 200	200 / 250	250 / 300	300 / 350	350 / 400	400 / 450	450 / 500	500 / 600	Temp C	Average
18	20	**4.72**	**4.79**	**5.08**	**5.37**	**5.74**	**6.54**	**6.90**	**7.23**	**7.63**	**8.17**	**8.43**	**8.68**	**9.08**	**19**	**7.44**
20	22	**2.53**	**2.57**	**2.72**	**2.88**	**3.07**	**3.50**	**3.70**	**3.87**	**4.09**	**4.38**	**4.51**	**4.65**	**4.86**	**21**	**3.98**
22	24	**2.02**	**2.05**	**2.18**	**2.30**	**2.46**	**2.80**	**2.96**	**3.10**	**3.27**	**3.50**	**3.61**	**3.72**	**3.89**	**23**	**3.19**
24	26	**1.75**	**1.78**	**1.89**	**2.00**	**2.13**	**2.43**	**2.56**	**2.68**	**2.83**	**3.03**	**3.13**	**3.22**	**3.37**	**25**	**2.76**
26	28	**1.47**	**1.49**	**1.58**	**1.67**	**1.79**	**2.04**	**2.15**	**2.25**	**2.38**	**2.54**	**2.62**	**2.70**	**2.83**	**27**	**2.32**
28	30	**1.39**	**1.41**	**1.50**	**1.58**	**1.69**	**1.92**	**2.03**	**2.13**	**2.24**	**2.40**	**2.48**	**2.55**	**2.67**	**29**	**2.19**
30	32	**1.40**	**1.42**	**1.51**	**1.60**	**1.70**	**1.94**	**2.05**	**2.15**	**2.27**	**2.43**	**2.50**	**2.58**	**2.70**	**31**	**2.21**
32	34	**1.47**	**1.49**	**1.58**	**1.67**	**1.79**	**2.04**	**2.15**	**2.25**	**2.38**	**2.54**	**2.62**	**2.70**	**2.83**	**33**	**2.32**
34	36	**1.55**	**1.58**	**1.67**	**1.77**	**1.89**	**2.15**	**2.27**	**2.37**	**2.51**	**2.68**	**2.77**	**2.85**	**2.98**	**35**	**2.44**
36	38	**1.65**	**1.67**	**1.77**	**1.87**	**2.00**	**2.28**	**2.41**	**2.52**	**2.66**	**2.85**	**2.94**	**3.03**	**3.16**	**37**	**2.59**
38	40	**1.71**	**1.74**	**1.84**	**1.95**	**2.08**	**2.37**	**2.50**	**2.62**	**2.77**	**2.96**	**3.06**	**3.15**	**3.29**	**39**	**2.70**

optimal temp for Food conversion rate is 29 'C

	Growth	13	12	20	20	50	50	50	50	50	50	50	50	100
Average	Size	42	54	70	90	125	175	225	275	325	375	425	475	550
Average	FCR	1.97	2.00	2.12	2.24	2.39	2.73	2.88	3.02	3.18	3.41	3.52	3.62	3.79

NUMBER PELLETS PER DAY AND FISH

feed	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12	Marina12
size	3	3	3	3	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	7
pellets / kg	19500	19500	19500	19500	7600	7600	7600	7600	7600	7600	7600	7600	2300

Temp min	max	mean weight (gr.) min 35 / max 48	48 / 60	60 / 80	80 / 100	100 / 150	150 / 200	200 / 250	250 / 300	300 / 350	350 / 400	400 / 450	450 / 500	500 / <
18	20	**12.4**	**13.0**	**13.8**	**17.4**	**9.0**	**11.0**	**13.0**	**16.0**	**17.2**	**19.0**	**21.8**	**24.4**	**7.4**
20	22	**15.2**	**15.8**	**16.6**	**21.0**	**11.0**	**13.8**	**16.6**	**19.2**	**20.8**	**21.8**	**23.2**	**24.4**	**7.8**
22	24	**20.8**	**21.8**	**23.0**	**29.0**	**15.2**	**19.4**	**23.4**	**26.6**	**28.8**	**29.6**	**30.8**	**31.4**	**9.8**
24	26	**30.8**	**32.8**	**35.4**	**43.8**	**22.4**	**28.6**	**34.4**	**39.4**	**42.6**	**43.8**	**45.8**	**46.6**	**13.6**
26	28	**38.8**	**42.4**	**46.8**	**57.4**	**28.4**	**36.2**	**43.6**	**49.8**	**53.8**	**55.4**	**58.2**	**59.2**	**17.4**
28	30	**46.4**	**51.6**	**57.6**	**70.2**	**34.4**	**43.6**	**52.4**	**60.0**	**64.8**	**66.8**	**70.0**	**71.4**	**21.8**
30	32	**58.4**	**64.8**	**72.4**	**88.2**	**43.2**	**54.6**	**65.8**	**75.2**	**81.4**	**84.0**	**88.0**	**89.8**	**27.6**
32	34	**65.8**	**73.2**	**81.6**	**99.6**	**48.8**	**61.6**	**74.2**	**85.0**	**91.8**	**94.8**	**99.4**	**101.4**	**30.8**
34	36	**70.4**	**78.4**	**87.4**	**106.6**	**52.4**	**66.0**	**79.6**	**91.0**	**98.4**	**101.4**	**106.4**	**108.6**	**33.0**
36	38	**59.0**	**65.6**	**73.0**	**89.0**	**43.8**	**55.2**	**66.6**	**76.2**	**82.4**	**84.8**	**89.0**	**90.8**	**27.4**
38	40	**46.0**	**51.2**	**57.0**	**69.6**	**34.2**	**43.2**	**52.0**	**59.4**	**64.2**	**66.2**	**69.4**	**70.8**	**21.4**

THESE RATES HAVE TO BE ADAPTED TO THE PARTICULAR CONDITIONS OF EACH FISHFARM. 9801