Analysis of feeds and fertilizers for sustainable aquaculture development in the Philippines

Neila S. Sumagaysay-Chavoso
University of the Philippines Aquaculture Society, Inc.
College of Fisheries and Ocean Sciences, Miag-ao, Iloilo
Philippines

Sumagaysay-Chavoso, N.S. 2007. Analysis of feeds and fertilizers for sustainable aquaculture development in the Philippines. In M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon (eds). Study and analysis of feeds and fertilizers for sustainable aquaculture development. *FAO Fisheries Technical Paper*. No. 497. Rome, FAO. pp. 269–308.

SUMMARY

Production from fisheries and aquaculture in the Philippines has increased from 2 721 000 tonnes valued at US$1 458 million in 1994 to 3 926 173 tonnes valued at US$2 777 million in 2004. In 2004, total aquaculture production reached 1 717 026 tonnes and accounted for over 44 percent of total fisheries production. Seaweed production contributes 70 percent to total production, followed by milkfish (15.9 percent), tilapia (8.5 percent) and shrimps (2.1 percent). The main species produced in land-based pond culture are milkfish, tilapia, shrimp, mudcrab and catfish.

Depending on stocking density, life support systems, fertilizer and feed inputs aquaculture systems in the Philippines can be classified as extensive, semi-intensive and intensive. Inorganic and organic fertilizers are applied in extensive and semi-intensive pond systems to stimulate growth of natural food. The most widely used fertilizers in aquaculture are mono-ammonium phosphate, di-ammonium phosphate, urea and ammonium sulphate. Except for di-ammonium phosphate the country is not self sufficient with respect to the supply of fertilizers. The most widely used organic fertilizer for ponds is chicken manure. Most farmers prefer low-cost unprocessed organic fertilizers and the use of compost is also becoming popular.

Feeding is employed when natural food, enhanced by fertilization, becomes inadequate. The aquaculture feed industry depends on local rice, corn and copra meal and imported soybean meal and wheat by-products. Fishmeal is either imported or locally sourced.

Fish farmers use commercially manufactured feeds, farm-made feeds as well as raw, unprocessed feedstuffs. Farm-made feeds or single-feed ingredients are used as feed for milkfish, shrimps, crabs and tilapia in extensive and modified extensive farming systems. Catfish are fed chopped trash fish, fresh chicken entrails and commercial swine pellets, while grouper are fed on trash fish, commercial fish pellets and live juvenile tilapia. Commercial feeds are also used in semi-intensive and intensive culture of milkfish, tilapia and shrimp.

In 2004, there were 505 registered feedmills in the Philippines. Of these, 395 were commercial feed manufactures, while the remainder were smaller, non-commercial feed producers. Of the 395 commercial feed manufacturers 78 (20 percent) produce aquafeeds. The production capacity of the aquafeed milling industry is 3.81 million tonnes/year, which far exceeds the 2003 production of approximately 204 395 tonnes. The major constraints facing the aquafeed industry are the high and volatile costs of raw materials that lead to high feed costs and reduce the demand for feed. Collectively, these factors affect fish production. Data for 2003 show that some 28 800 tonnes of commercial feeds were consumed by tilapia, milkfish and tiger shrimp. However, these figures exclude farm-made feeds, imported feeds and feed sales by the smaller feed producers.

There is an adequate local supply of organic manure to cater for the needs of the aquaculture sector in the future. Current chicken manure production exceeds 52 million tonnes, while the demand by the extensive and semi-intensive aquaculture sectors in 2003 and in the next 10 years is estimated at 489 998 tonnes.

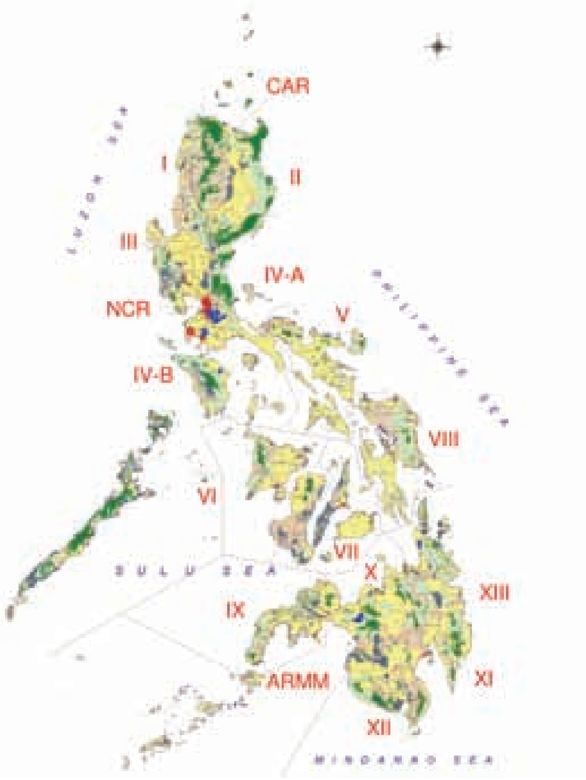
Fish production costs are significantly lower in extensive systems (US$0.47/kg), which rely mainly on fertilization and are highest in intensive systems (US$0.84/kg) due to high feed input and installation of life support systems. To sustain the growth of the aquaculture sector in the Philippines it is recommended that greater efforts be made with respect to the sourcing of raw materials for the feed industry. Also, there is a very real need to enhance farm-made feed technologies for small-scale farmers, focusing in particular on the use of local raw materials. Feed formulations must be further improved for better feed conversion efficiency and to minimize environmental impacts. Moreover, effluent volumes and composition must be regulated to minimize nutrient discharge into the environment. Government programs such as the clustering of feedmillers and fish farmers, balancing the fertilizer requirements and the rapid composting programme should be more effectively promoted and implemented.

1. OVERVIEW

1.1 Land and water resources of the Philippines

The Philippines is a tropical country in the Pacific Ocean consisting of 7 107 islands that lie between 4.23° and 21.25°N / 116° and 127°E. The islands are geographically divided into three main areas: Luzon (northern Philippines), Visayas (central Philippines) and Mindanao (southern Philippines). The country is composed of 79 provinces that are grouped into 17 administrative regions. These are shown in Figure 1 and referred to throughout the report. Luzon consists of eight regions: CAR (Cordillera Administrative Region), Region I (Ilocos), Region II (Cagayan Valley), Region III (central Luzon), Region IV-A (Calabarzon), Region IV-B (Mimaro), NCR (National Capital Region), and Region V (Bicol). Three regions are located in the Visayas: Region VI (western Visayas), Region VII (central Visayas) and Region VIII (eastern Visayas). Mindanao is divided into six regions: Region IX (western Mindanao), Region X (northern Mindanao), Region XI (southern Mindanao), Region XII (central Mindanao), Region XIII (CARAGA), and ARMM (Autonomous Region of Muslim Mindanao).

FIGURE 1
Map of the Philippines showing the 17 administrative regions



Source: NAMRIA (2005)

The country has a total land area of 29 624 660 ha, of which 11 681 040 ha are cultivated. The aquatic resources of the country are summarized in Table 1. Total fish pond area, depending on the source, ranges between 219 460 ha (NAMRIA, 2005) and 253 854 ha (BFAR, 2005; BAS, 2005a). There are approximately 239 323 ha of brackish-water and 14 531 ha of freshwater ponds (Table 1), while Table 2 provides a measure of the distribution of ponds by administrative region. Inland waters including lakes, rivers and reservoirs comprise ~250 000 ha. There are approximately 102 lakes in the Philippines, with an area greater than 100 ha. The country is also endowed with 240 million ha of coastal marine areas, including coral reefs, sea grass and algal beds. These aquatic resources support fisheries that provide income and employment, export earnings and the bulk of domestic fish supply.

1.2 Total fish production

Total fisheries production (capture fisheries and aquaculture) increased from 220 000 tonnes in 1950 to 2 721 000 tonnes (US$1 458 million) in 1994 to 3 926 000 tonnes (US$2 777 million; at $1:Php 50) in 2004 (Figure 2). The annual growth rate in fisheries production between 1994 and 2003 was 3.8 percent by volume. As a whole, the fisheries sector, which is valued at US$2 214 million at current prices, accounted for 2.3 percent of the Philippine GDP in 2004. The sector directly and indirectly employs approximately 990 000 people. In 2004, exports of fish and fishery products were valued at US$524 million, while imports were valued at US$79 million with a positive trade balance of US$445 million (BFAR, 2005).

TABLE 1
The aquatic resources of the Philippines, 2004

Resources	Area	% of		
		Marine resources	Inland resources	Country total
Marine resources (ha)				
Coastal	26 600 000	12.1	-	12.05
Oceanic	193 400 000	87.9	-	87.61
Marine Total (including EEZ) (ha)	220 000 000	100.0	-	99.66
Shelf area (ha) (depth, 200 m)	18 460 000	8.4	-	8.36
Coral reef area (ha) (within 10–20 fathoms where reef fisheries occur)	2 700 000	1.2	-	1.22
Coast length (km)	17 460	-	-	-
Inland resources (ha)				
Freshwater	106 328	-	14.2	0.05
Brackish water	139 735	-	18.6	0.06
Total swamplands	246 063	-	32.8	0.11
Freshwater	14 531	-	1.9	0.01
Brackish water	239 323	-	31.9	0.11
Total existing fish pond	253 854	-	33.8	0.12
Lakes	200 000	-	26.7	0.09
Rivers	31 000	-	4.1	0.01
Reservoirs	19 000	-	2.5	0.01
Total other inland resources	250 000	-	33.3	0.11
Inland Total	749 917	-	100.0	0.34
Country Total (ha)	220 749 917	-	-	100.00

Source: BFAR (2006); BAS (2005a)

TABLE 2
The distribution of fish ponds and inland water resources in the Philippines by region

Region	Total area (ha)	Fishponds (ha)	Inland waters (ha)
CAR	1 807 680	-	6 970
I	1 256 420	21 550	12 170
II	2 646 060	100	19 310
III	2 088 640	48 980	23 390
NCR	72 590	2 900	7 700
IV-A	1 683 750	5 850	106 660
IV-B	2 686 760	7 690	11 440
V	7 733 050	15 870	8 330
VI	1 996 950	58 720	6 850
VII	1 416 840	9 030	1 260
VIII	2 084 280	2 340	3 540
IX	1 455 430	25 010	1 770
X	1 727 020	4 150	1 620
XI	1 828 360	6 710	5 270
XII	1 928 430	3 260	10 740
XIII	1 867 470	5 830	23 640
ARMM	1 244 930	1 470	47 880
Total	**29 624 660**	**219 460**	**298 640**

Source: NAMRIA (2005)

1.3 Aquaculture

Total aquaculture production reached 1 714 860 tonnes in 2004 and continued to be the leading growth industry in the fisheries sector (BAS, 2005b). Aquaculture accounted for 32 percent of total fisheries production in 1994 and 44 percent in 2004. The substantial increases in the contribution by aquaculture to total fisheries production is largely ascribed to the rapid expansion of seaweed farming, which now contributes approximately 70 percent to total aquaculture production.

Of the 16 reported aquaculture species in the Philippines, milkfish (*Chanos chanos*), Nile tilapia (*Oreochromis niloticus*) and tiger shrimp (*Penaeus monodon*) are the three most important. Milkfish, which are mainly produced in brackish-water ponds, contributed 15.9 percent to total aquaculture production, while tilapia accounted for 8.5 percent, followed by tiger shrimp (2.1 percent) from brackish-water ponds (Table 3). Analysis of production by culture systems revealed that seaweed culture (mariculture) contributed the highest proportion (70 percent), followed by brackish-water ponds (14.8 percent) and freshwater ponds (4.4 percent). Freshwater cage and pen culture contributed 3.2 and 2.9 percent, respectively, while other minor sectors (oysters, mussels, crabs etc.) collectively

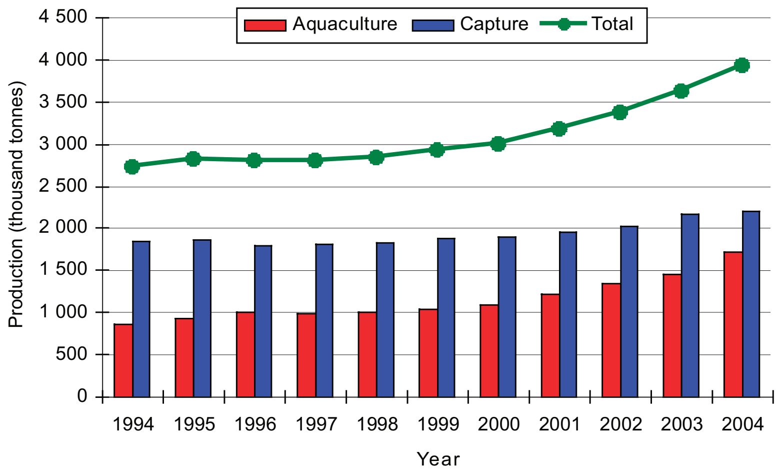
TABLE 3
Aquaculture production (tonnes) by species and production system in 2004

Species	Production System									Total production (tonnes)	% of total production
	Pond		Pen			Cage			Mariculture		
	BW	FW	BW	FW	Marine	BW	FW	Marine			
Milkfish (*Chanos chanos*)	200 531	-	4 388	25 685	14 173	4 056	1 581	23 179	-	273 593	15.9
Nile tilapia (*Oreochromis niloticus*)	9 046	71 831	97	11 769	-	116	53 010		-	145 869	8.5
Tiger shrimp (*Penaeus monodon*)	35 916	-	-	-	-	-	-	-	-	35 196	2.1
Carp (*bighead carp, Aristichthys nobilis and common carp, Cyprinus carpio)*	-	378	-	12 541	-	-	805	-	-	13 724	0.8
White shrimp (*Penaeus setiferus*) and endeavor prawn (*Metapenaeus endeavori*)	2 030	-	-	-	-	-	-	-	-	2 030	0.1
Catfishes (waliking catfish, *Clarias batrachus* and North African catfish, *Clarias gariepinus*)	-	1 930	-	-	-	-	-	-	-	1 930	0.1
Snakehead murrel (*Channa striata*)		1 272								1 272	0.1
Grouper (*Epinephelus* sp.).		-	-	-	34	-	-	136	-	170	< 0.1
Others*	6 326	73	14	-	88	34	-	227	-	6 762	0.4
Oysters (slipper cupped oyster *Crassostrea iredale, Saccostrea* spp.)	-	-	-	-	-	-	-	-	15 915	15 915	0.9
Mussel (green mussel *Perna* viridis)	-	-	-	-	-	-	-	-	15 038	15 038	0.9
Seaweeds (*Kappaphycus* and *Eucheuma* spp.)	-	-	-	-	-	-	-	-	1 204 808	1 204 808	70.2
Total	**253 849**	**75 484**	**4 499**	**49 995**	**14 295**	**4 206**	**55 396**	**23 542**	**1 235 761**	**1 717 027**	**100**

Note: BW = Brackish water , FW = Freshwater; *Others include Mozambique tilapia (*Oreochromis mossambicus*), giant gourami (*Osphronemus goramy*), Asian seabass/barramundi (*Lates calcarifer*), orange-spotted spinefoot (*Siganus guttatus*), vermiculated spinefoot (*Siganus vermiculatus*), spotted scat (*Scatophagus argus*), Indian white prawn (*Fenneropenaeus Indicus*), banana prawn (*Fenneropenaeus merguiensis*), greasyback shrimp (*Metapenaeus ensis*), mud crab (*Scylla serrata, Scylla oceanica*), giant freshwater prawn (*Macrobrachium rosenbergii*) and lobsters (*Panulirus* spp.).

Source: BFAR (2006)

FIGURE 2
Fish production in the Philippines from 1994 to 2004



Source: BFAR (2006)

TABLE 4
Aquaculture production (tonnes) by systems in the Philippines during 2000-2004

Production system	2000	2001	2002	2003	2004
Pond					
Brackish water	235 729	268 120	254 167*	254 744*	253 849
Freshwater	45 909	57 678	70 250	71 970	75 484
Pond sub-total	281 638	325 798	324 417	326 714	329 333
Cage					
Brackish water	2 485	-	-	-	4 206
Freshwater	38 595	42 061	49 657	52 832	55 396
Marine	2 900	4 582	8 665	12 120	23 542
Cage sub-total	43 980	46 643	58 322	64 952	83 144
Pen					
Brackish water	3 241	-	-	-	4 500
Freshwater	27 529	23 927	27 468	35 876	49 995
Marine	6 296	5 738	9 113		14 294
Pen sub-total	37 066	29 665	36 581	45 949	68 789
Mariculture	738 218	818 350	919 073	1 016 888	1 235 761
Total	1 100 902	1 220 456	1 338 393	1 454 503	1 717 027

*Includes production in brackish-water cages and pens

contributed about 4.7 percent. Table 4 shows the trends in aquaculture production by systems in the Philippines during the period 2000 to 2004.

The percent contribution by production systems has remained fairly constant over this five year period. Excluding seaweeds, Region III recorded the highest production among the administrative regions and this is attributable to milkfish and tiger shrimp production in brackish-water ponds and tilapia in freshwater ponds. Region IV-A ranked second mainly due to tilapia from freshwater fish cages and pens, while milkfish production in brackish-water ponds placed Region VI in the third position.

1.4 Culture systems

Farming of fish in brackish-water ponds is a centuries old tradition in the Philippines, while freshwater ponds, as well as pen and cage culture in the freshwater, brackish-water and marine environments are later innovations. Mussels and oysters are cultured on stakes and lines are used for seaweed culture. The majority of milkfish, tilapia, shrimp, mudcrab and catfish are farmed in land-based pond systems enclosed either

TABLE 5
Overview of freshwater and brackish-water systems in the Philippines, extensive system

System	Culture species	Area (ha) or volume (m^3)	Stocking density (fish/ha)	Fertilization and feeding	Rearing period (months)	Harvest size (g)	Yield (kg/ha)
Polyculture							
Brackish-water pond	Milkfish Shrimp	1	3 000–3 500 5 000–10 000	Organic/inorganic fertilizer, supplemental feed	4	250 30	600–800 120–240
	Crab Milkfish	200	5 000–15 000 1 000–2 500	Organic/inorganic fertilizer, trash fish	4–5	200–400 250	800–4 800 200–600
	Grouper Tilapia	0.5–1.0	5 000 5 000–10 000	Organic/inorganic fertilizer, tilapia fingerlings, trash fish	5–7	400–800	1 600–3 200
Monoculture							
Brackish-water pond	Milkfish	1	1 000–4 000	Organic/inorganic fertilizers, supplemental feed, commercial feed	4	200–300	400–1 000
	Tilapia	1	3 000–5 000	Organic/inorganic fertilizer	4	100–200	300–800
	Shrimp *Extensive* *modified*	 >5 2–5	 >10 000 20 000–50 000	 Organic/inorganic fertilizers, supplemental feed, commercial feed	 3–4 3–4	 >40 28–32	 200–300 500–900
Mangrove areas	Mudcrab	200	5 000–7 000	Organic/inorganic fertilizer trash fish	3–5	150–400	800–1600
	Mudcrab fattening	200	5 000–20 000	Organic/inorganic fertilizer, trash fish	1	350–400	1 400–6 400
	Mudcrab		5 000	Trash fish		275	1 200
	Mudcrab fattening	200	5 000–20 000	Trash fish	1	350–400	1 400–6 400
Freshwater pond	Catfish	>0.1–0.5	50 000–60 000	Inorganic fertilizer, supplemental feed	4	100	3 000–4 000
Freshwater pen	Bighead carp	≥1	5 000–10 000	No fertilizer, no feed	6	1 500	4 500–9 000

TABLE 5. CONTINUED

Overview of freshwater and brackish-water systems in the Philippines, semi-intensive and intensive systems

System	Culture species	Area (ha) or volume (m^3)	Stocking density (fish/ha)	Fertilization and feeding	Rearing period (months)	Harvest size (g)	Yield (kg/ha)
Semi-intensive							
Polyculture							
Brackish-water pond	Milkfish Shrimp		10 000 35 000	Organic/inorganic fertilizer, supplemental feed, commercial feed	4	250 30	2 250 840
Monoculture							
Brackish-water pond	Milkfish	0.5–1	8000–15 000	Organic/inorganic fertilizers, commercial feed	4	200–-300	1 500–3 500
	Shrimp	1–2	100 000–150 000	Commercial feed	4–5	28–35	2 000–3 000
Brackish-water cage	Grouper	75 m^3	7/m^3	Trash fish, mussel meal, etc.	5–7	450	2.5/m^3
Freshwater pond	Tilapia	0.25–1	10 000–50 000	Organic/inorganic fertilizer, commercial feed	3–4	150–250	1 300–7 000
	Catfish	0.05	100 000–150 000		4	100	6 000–15 000
Freshwater cage	Tilapia	100 m^3	15–25/m^3	Supplemental feed, commercial feed	3–4	250–300	2.7–7.0
Freshwater pen	Milkfish	$\geq$1	1/m^3	Supplemental feed	4	300	2 700
Iintensive							
Monoculture							
Brackish-water pond	Milkfish	0.5	$\geq$20 000	Commercial feed	4	200–300	$\geq$4 000
	Shrimp	<2	>200 000	Commercial feed	5–6	25–30	>3 000
Freshwater pond	Tilapia	0.5–1.0	50 000–100 000	Commercial feed	4–5	250	7 000–15 000
Freshwater cage	Tilapia	100–400 m^3	50–250/m^3	Commercial feed	3–5	150–250	5–37/m^3
	Milkfish	400	12.5–25/m^3	Commercial feed	3–5	300	3–6/m^3
Tanks	Tilapia	>0.5	100–200/m^3	Commercial feed	4–5	300	20–50/m^3

Source: milkfish - Bagarinao (1997), Sumagaysay-Chavoso (2003), author's survey (2005); tilapia - Guerrero (2002), Aldon (1998), Corpuz-Uy, pers. comm., author's survey (2005); shrimp - Regalado (2001), author's survey (2005); mudcrab - Baliao, de los Santos and Franco (1999), Rodriguez (2001), Triño *et al*. (1999); catfish - Tan-Fermin and Coniza (2003), Bombeo (2001), Surtida and Buendia (2000); grouper - Baliao *et al.* (1998), Baliao *et al.* (2000), Toledo (2001); carp - Frio (1999), Eguia (2003) with earthen or cement dykes, provided with a sluice gate for water exchange. Fish pens are large enclosures made of stakes and netting material and these are set in lakes, rivers or sheltered bays and in which the fish have access to natural benthic and planktonic food. The primary pen culture species are milkfish (marine and brackish water), tilapia (fresh and brackish water) and carp (freshwater). Fish cages are relatively small and are staked in shallow waters or set in deeper waters with appropriate floats and anchors. Tilapia, milkfish, groupers and siganids are the main cage culture species.

Table 5 provides an overview of the various freshwater and brackish-water aquaculture systems in the Philippines and their mode of operation. The data clearly show how stocking density, fertilization, feeding intensity and the complexity in life support systems increase with systems intensification.

2. REVIEW AND ANALYSIS OF AQUACULTURE FEEDS AND FEEDING

2.1 Fertilizer and feed resources of the Philippines

2.1.1 Fertilizers

Inorganic fertilizers

The most widely used fertilizers in aquaculture are mono-ammonium phosphate (16-20-0) and di-ammonium phosphate (18-46-0) as nitrogen and phosphorus sources, urea (46-0-0) as a nitrogen source and ammonium sulphate (21-0-0). Ammonium sulphate in combination with lime is used to kill unwanted species in ponds prior to stocking.

Though some fertilizers are produced locally the bulk is imported. Table 6 shows the 2003/04 supply and demand for inorganic fertilizers commonly used in aquaculture. Urea dominated the country's fertilizer imports averaging 35.4 percent in 2003 and 2004 followed by 21-0-0 (22.8 percent) and 18-46-0 (8.1percent). Fertilizer exports, on the other hand, decreased from 456 636 tonnes in 1997 to 21 356 tonnes in 2004, due to a decrease in domestic demand (Cipriano, 2002).

Average sales in 2003 and 2004 were dominated by 14-14-14 (30.0 percent), urea (25.1 percent), 16-20-0 (17.3 percent) and 21-0-0 (11.9 percent). Since 2002 there have been five companies that produce fertilizers and which have blending facilities. These are Philphos, AFC Fertilizer and Chemical Inc., International Chemical Corp (INCHEM), Farmix Fertilizer Corp., and Soiltech Agricultural Products Corp. (Cipriano 2002; FADINAP, 2002)

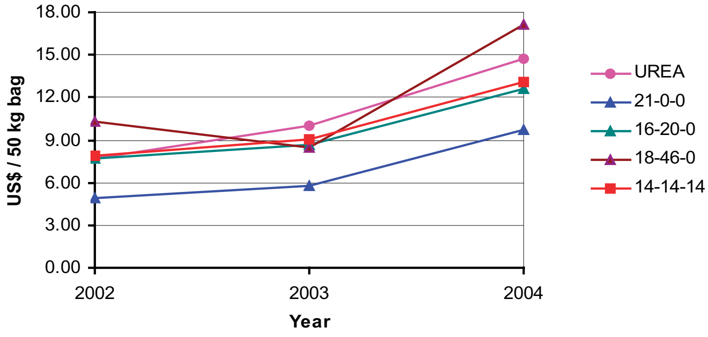
Government support for the fertilizer industry is historically strong. The deregulation of the fertilizer industry in 1986 encouraged the entry of more traders. This fostered competition to the benefit of consumers (ADB, 2002). Quality assurance and monitoring systems are being institutionalized. Government support is

TABLE 6
Domestic supply and demand (tonnes) of inorganic fertilizers commonly used in aquaculture

Grade	Import	Production	Sale	Export
2003				
Urea	733 683	-	466 413	1 600
21-0-0	398 620	116 656	212 053	58 176
16-20-0	63 170	203 755	252 621	19 390
18-46-0	163 911	65 820	32 000	36 500
14-14-14	43 200	368 543	416 980	-
Total	**1 640 386**	**1 059 315**	**1 540 179**	**334 944**
2004				
Urea	426 190	-	172 333	-
21-0-0	348 206	33 780	86 568	500
16-20-0	91 106	83 106	158 666	-
18-46-0	103 193	43 937	18 087	15 096
14-14-14	58 455	122 730	286 946	-
Total	**1 639 752**	**371 404**	**869 513**	**21 356**

Source: FPA (unpublished report)

FIGURE 3
Average retail prices of major fertilizer grades



Source: FPA (unpublished report)

manifested through price control and incentives (ADB, 2002). A tariff of 3 percent is set on 21-0-0, 18-46-0, and 16-20-0, and 1 percent on urea for MFNs and free for ASEAN member countries (Philippine Tariff Commission 2004). A 10 percent value-added tax exemption is also granted to direct users (cooperatives, farmer's associations, partnership and other entities directly involved in agriculture or fisheries) by way of value-added tax exemption certificates approved by the FPA. This incentive is in line with the R.A. (Republic Act) 8435, otherwise known as the Agriculture and Fisheries Modernization Act (Arboleda, 1998).

In 2003/04, 18-46-0 was the most expensive (US$199–242/tonne), followed by urea (US$171–240/tonne). World prices and currency exchange rate fluctuations influence the domestic prices of inorganic fertilizers. Between 1995 and 2001, inorganic fertilizer retail prices increased annually by 4.0–5.5 percent. However, at real or constant prices, the retail price actually declined by 6.7–7.6 percent during this period. (*Real or constant prices are determined after the effects of inflation have been eliminated. Nominal prices refer to the current value of a good or commodity during a particular period or year.*) However, between 2002 and 2004 the retail price of 16-20-0 increased by 64 percent and by 97 percent for 21-0-0 (Figure 3). It is for this reason that farmers are now seeking alternatives and are looking more towards organic fertilizers.

Organic fertilizer (manures and compost)

The FPA of the Department of Agriculture has recently formulated guidelines on good agricultural practices to optimize fertilizer use. In particular, the guidelines advocate the use of organic fertilizers to promote sustainable production and development. The most widely used organic fertilizer in ponds is chicken manure at prices ranging from US$16–22/tonne. Other livestock manures, mudpress (agricultural waste from sugar mills) and rice bran are also used but to a much lesser extent. Fish farmers usually apply organic fertilizers during pond preparation, although some apply manure during the production cycle to maintain plankton growth. It was estimated that between 56.8 million and 107.8 million tonnes of manure was produced in 2004 (Table 7).

TABLE 7
Estimated animal manure production

	Animals (tonnes live weight)[1]		Dry manure production (tonne/year)	
Year	2003	2004	2003	2004
Carabao[a]	132 384	138 048	174 868–347 926	182 350–362 812
Beef cattle[b]	129 225	127 990	170 695–339 624	169 064–336 378
Dairy cattle[c]	129 255	127 990	320 790–528 415	317 651–523 244
Swine[d]	1 733 087	1 709 404	3 767 346–7 155 146	3 715 864–7 057 369
Chicken[e]	1 188 738	1 231 794	50 557 544–96 021 604	52 388 734–99 499 499
Total			54 991 243–104 392 716	56 773 663–107 779 303

[a] Manure production based on assumption for beef cattle; [b] Total solids in waste: 1 643–3 269 g/day/454 kg animal; [c] Total solids in waste: 3 087–5 085 g/day/454 kg animal; [d] Total solids in waste: 268–509 g/day/45 kg animal; [e] Total solids in waste: 268–509 g/day/2.3 kg animal
[1] Total production by region and by quarter, 1999-2004

Source: BAS, unpublished report

TABLE 8
Distribution of fishponds and livestock in the Philippines in 2004

Region	Fishpond area[1] (ha)	Animals (tonnes live weight)[2]			
		Carabao	Cattle	Swine	Chicken
CAR	none	4 766	6 492	40 588	7 478
I	21 550	9 062	30 505	77 235	51 082
II	100	13 889	15 390	96 714	53 520
III	48 980	5 216	17 575	267 095	384 072
IV-A	5 850	5 019	19 706	213 742	283 725
IV-B	7 690	8 081	10 580	55 086	7 330
V	15 870	9 968	13 700	95 132	29 874
VI	58 720	17 326	25 106	139 351	63 711
VII	9 030	5 305	31 086	130 564	81 185
VIII	2 340	7 912	3 598	112 410	38 305
IX	25 010	9 947	16 343	93 659	28 027
X	4 150	7 423	28 103	102 000	57 782
XI	6 710	10 289	11 091	128 112	88 777
XII	3 260	14 127	14 511	91 581	32 943
XIII	5 830	3 644	1 482	59 251	15 310
ARMM	1 470	6 074	10 713	6 884	6 884

Source: [1] NAMRIA (2005); [2] total production by region and by quarter, 1999-2004 (BAS, unpublished report)

TABLE 9
Specifications for organic fertilizers and compost/soil conditioners

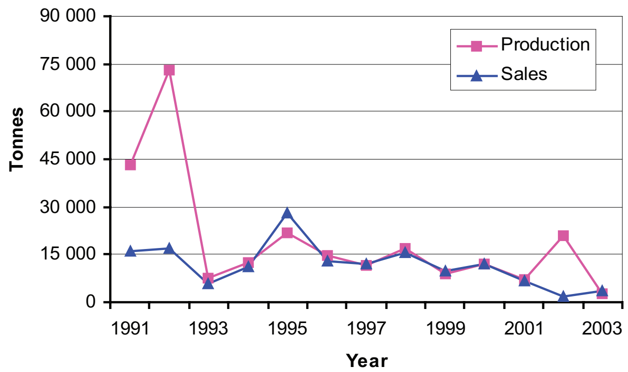
	Pure organic fertilizer	Compost/soil conditioner	Fortified organic fertilizer
Total NPK	5–7%	3–4%	8% minimum
C:N	12:1	12:1	12:1
Moisture content	≤35%	≤35%	≤35%
Organic matter	≥20%	≥20%	≥20%

Source: FPA (unpublished report)

The demand for chicken manure by tilapia farmers in Central Luzon (Region III) and by milkfish farmers in Region IV is particularly high (Table 8) (ADB, 2002). As mentioned earlier, most farmers prefer low-cost unprocessed organic fertilizers of animal origin, but the use of compost is also becoming popular. Compost is commonly made from rice hulls, rice straw, grasses, hog and chicken manures, leucaena leaves or other leguminous material. Bacteria or fungi are usually added as activators (Cuevas, 1997). Other techniques include vermicomposting (Dugeno 2005). All commercially produced composts must also conform to regulatory standards (Table 9).

Production of composted organic fertilizers began in 1974 (Cuevas, 1997). Highest production levels were attained in 1992 when some 75 000 tonnes were produced but by 2003 had decreased to less than 5 000 tonnes per annum. Production again increased to 19 000 tonnes in 2004 (Figure 4).

FIGURE 4
Domestic organic fertilizer supply and demand



Source: FPA (unpublished report)

Marketing of fertilizers. The market chain for inorganic fertilizers starts with the producers or importers to the distributors (wholesalers) in regional or provincial sale offices. The distributors transfer the products to local dealers and retailers who sell directly to farmers. Dealers are distributed throughout the country and in isolated areas play a particularly important role. Fertilizer companies advertise their products through sponsorship of related activities and distribution of promotional items (ADB, 2002).

Several importers are also distributors, giving them an advantage in terms of direct access to retailers. At the wholesale level, some distributors are authorized dealers themselves and sell directly to plantations and/or farmers in areas where local dealers may be absent. In some instances, traders access cooperatives to distribute fertilizers to their farmer-members. The geographical isolation of most Philippine islands adds to the marketing and distribution costs (ADB, 2002). Organic fertilizers, on the other hand, are usually sold in the area where they are produced.

2.1.2 Availability of feedstuffs and their use in aquaculture

Most of the high quality feed ingredients are imported, though efforts are being made to partially or fully replace these with locally produced materials. There are many locally available raw materials that are either used or have potential as ingredients for aquafeeds (Table 10). The major feedstuffs used are fishmeal, rice bran, soybean meal, copra meal, wheat flour, coconut oil, soybean oil and fish oil. Rice, corn and copra meal are produced locally, while soybean meal and wheat by-products are imported. Fishmeal is either imported or locally sourced. Import and export figures of agricultural products and by-products used by the animal feed industry are shown in Tables 11 and 12.

To foster efficiency and global competitiveness, individual farmers as well as farmer associations or cooperatives are eligible for exemption from value-added tax on all types of agricultural products including feed ingredients like fishmeal, wheat, and soybeans. To be eligible, the imported products must be exclusively consumed by the enterprise and may not be sold. Eligibility for the certificate of exemption is determined and approved by the Department of Agriculture (DA). Exporters from MFN are charged a 1 percent tariff for fishmeal, starch residues, and shrimp feeds; 3 percent for rice bran, wheat and soya; and 10 percent for copra, corn bran and corn germ. ASEAN member countries are exempted from paying tariff duties (CEPT - Common Effective Preferential Tariff for ASEAN countries) except for the export of some products such as rice bran (3 percent), corn bran (5 percent), corn germ (5 percent), and copra (3 percent) (Philippine Tariff Commission, 2004).

Fishmeal

The country is heavily dependent on imported fishmeal especially from the United States of America, Peru and Chile. Imports decreased from 84 546 tonnes in 2001 to 44 567 tonnes in 2003. Most of the local fishmeal is obtained from Mindanao and is preferred by feedmills because of the lower cost.

Agricultural by-products

The availability and use of domestic agricultural by-products for animal feed is increasing. This is due to increased agricultural output, particularly of rice and corn (Table 13). However, seasonal supply and price fluctuations are substantial. After rice, corn is the second most important agricultural product in the Philippines. About 43 percent of the world copra production is produced in the Philippines. Copra meal and oil are used in aquafeeds.

Livestock

By-products of slaughtered livestock and poultry dressing such as blood meal, poultry by-product meal and feather meal are potential components for animal feeds. Meat and bone meal is already used in the formulation of some commercial aquafeeds. Slaughtered livestock and poultry (Table 14) registered a positive average growth per year from 2000-2004, except for cattle and goats.

TABLE 10
Available and potential aquaculture feed ingredients in the Philippines

Ingredients and recommended inclusion levels	Description
Animal by-products	
Fishmeal Carnivorous fish: 50%; omnivorous/ herbivorous fish: 25%; penaeid shrimps: 25%	A high quality protein feedstuff; excellent source of amino acids; high ash content; rich in water soluble vitamins but low in fat soluble vitamins. High cost is limiting its use and local fishmeal is of low quality.
Blood meal: <5–10%	High in leucine, lysine and iron. Included into some Nile tilapia and grouper diets at 10% and 15% of total protein.
Feather meal (hydrolysed): 5–10%	Contains up to 87% protein, deficient in some essential amino acids; digestibility decreases as processing pressure increases. Digestibility by grouper is high (74%)
Meat and bone meal: 15–20%	Can replace up to 25% of fishmeal in diets of Nile tilapia and 8% of shrimp head meal protein in diets of milkfish fry.
Poultry by-product meal Carnivorous fish: 25%; omnivorous fish: 35%; crustaceans: 15% max	Contains about 61% protein; good source of essential amino acids, iron, zinc and choline.
Shrimp meal Carnivore: 20%; omnivore/herbivore: 10%	Rich in highly unsaturated fatty acids; good source of choline; calcium and phosphorus; with chemo-attractant properties; commonly used in crustacean feed rather than in fish feed; limited inclusion levels due to high crude fibre, ash and chitin.
Squid meal Grower and finisher feed: 5–10%; broodstock feed: 20–30%; larval food: 20–30%	High protein level, well balanced amino acid profile; with chemo-attractant (glycine and betaine) and growth promoting properties; excellent ingredient in aquafeeds; fresh squid is also recommended in moist diets.
Rice by-products	
Rice bran Omnivorous & herbivorous fish: 35%; carnivorous fish: 15%; crustaceans: 10%	An energy feedstuff; contains 12–15% oil; high levels of unsaturated fatty acids causes rapid deterioration; contains high phytate phosphorus, iron and manganese; rich in B group vitamins; used more often in diets of omnivorous and herbivorous fish.
Rice hull Omnivorous fish: 5%; herbivorous fish: 10%	Suitable for feeding in extensive production system; may serve as feedstuff or fertilizer in low density milkfish culture or as supplemental food in diets of grass carp
Wheat and wheat products	Relatively low in protein (13–16%); low in calcium but high in phosphorus; good source of Vitamin B; high protein and fat digestibility.
Wheat gluten Fish feed: 2–5%; crustacean feed: 5–10%	By-product of starch manufacture from wheat.
Wheat pollard Fish feed: 10–20%; crustacean feed: 3–5%	Used as binder for shrimp feeds.
Wheat flour Wheat flour as binder in shrimp diet: up to 25%	An energy source and common pellet binder for shrimp feeds
Maize products	
Corn starch Carnivorous fish & crustaceans: 15%; omnivorous & herbivorous fish: 35%	Product of wet milling of maize; can be gelatinized to improve digestibility; serves as energy source and spares protein.
Corn gluten meal Carnivorous fish/crustaceans: 10–15%; omnivore/herbivore: 20%	By-product of wet milling in the processing of starch; protein portion of corn kernel
Corn bran Carnivorous fish: 5%; omnivorous/ herbivorous fish: 20%	Outer coating of corn kernel; contains hulls and other parts of the kernel not separated from the starch; about 21% of corn kernel is corn bran.
Pulses	
Cow pea, lupin, feed pea Treated seeds: ≤ 15% Untreated seeds should not be used	Dehulled lupin can replace up to 50% protein of soybean meal in tiger shrimp diet; feed pea can replace 20% protein in milkfish diet and 25% in tiger shrimp diet; cowpeas must be dehulled for inclusion into shrimp feeds.
Oilseed meal and cakes	
Copra meal/cake Herbivorous & omnivorous fish: 5–15%; carnivorous fish: 5–10%	Copra meal is a protein feedstuff; limiting in lysine and methionine; coconut cake contains higher fat than the meal; cake is more prone to rancidity; meal and cake contains high choline and phosphorus but low in calcium. More suitable for herbivores and omnivores than carnivores.
Soybean meal Fishes: carnivore: 5–15%; omnivore/ herbivore: 10–30% Crustaceans: marine shrimps: 15%; freshwater shrimp: 20%	High protein content with best amino acid profile of all vegetable meals and oilseed cakes; methionine and cystine limiting; contains trypsin inhibitor and urease which is deactivated by heat treatment. Can replace 50% of fishmeal in diets of tilapia; 67% of fishmeal in milkfish diet with methionine supplement; 15–55% of fishmeal in diets of tiger shrimp cultured in ponds at 10 to 20 shrimps/m^2

TABLE 10 CONTINUED
Available and potential aquaculture feed ingredients in the Philippines

Live food	
No standard formula; varies with species, density and larval stage	Several live feeds (phytoplankton and zooplankton) are cultured and used in Philippines and include *Chlorella*, rotifers, *Daphnia*, *Moina*, copepods and *Artemia* (imported).
Leaf and leaf meal	
Cassava leave	Potential source of low cost plant protein, high lysine content but low in methionine; can supplement cereals in fish diets that are deficient in lysine. Good performance by milkfish at inclusion of 13%.
Leucaena leaf meal (ipil-ipil) 5–10% only for herbivorous and omnivorous species	Processed dried leaves of tropical legume; fresh leaves contain mimosine, a toxic glycoside, which can be reduced and removed through soaking, sun-drying and heat treatment; good quality protein (29%); Nile tilapia and tiger prawn respond better to soaked than unsoaked leaves.
Oil	
Fish oil: 3–6%	Crude fish oil is obtained from manufacture of fishmeal.
Beef tallow: 5–10%	An energy source with high levels of saturated fatty acids (48.2%) and unsaturated fatty acids (46.6%); cholesterol content is 1 000 mg/kg. Incorporated into milkfish diets.
Coconut oil	Milkfish performance improved with equal amounts of coconut oil (5%) and fish oil (5%).
Soybean oil	Combination of fish oil and soybean oil at 1:1 ratio is best for milkfish and seabass; practical diets for tiger shrimp may contain 2.5% soybean oil and 2.5% fish oil for good performance in grow-out systems.

Source: Devendra (1985); Sumagaysay and Borlongan (1995); Hertrampf and Piedad-Pascual (2000); Eusebio, Coloso and Mamauag (2004)

TABLE 11
Volume of imported agricultural products used by the animal feed industry, 2004

Commodity description	Quantity (tonnes)
Flours, meals and pellets of fish, unfit for human consumption	44 125
Flour, meals and pellets of crustaceans, unfit for human consumption	1 215
Flour, meal and pellet of meal, meat offal, unfit for human consumption	11 281
Wheat used as feed	198 581
Wheat, corn, rye, rice and other cereal flours	15 488
Groats (hulled grain) and meal of maize and other cereals	192
Tapioca and substitutes prepared from starch	1 193
Bran and other residues from maize, rice and wheat	47 190
Oil cake and other solid residues (except dregs[1]), pellet form	1 213 827
Soybean	284 139
Sunflower, sesame, rape/colza, mustard, copra, palm and kernels, linseed, other oil seeds and oleaginous fruits	49 840
Flour and meal of soybeans, non-/partially-/wholly defatted	2 149
Flour and meal of oil seed/oleaginous fruits	37
Residues of starch manufacture and similar residues	61 785
Wheat, maize, potato, manioc (cassava), and other starches	108 654
Wheat gluten; casein and casein derivatives and the casein derivatives; protein isolates	5 330
Dextrin, soluble or roasted starch; esterified or etherified starches; other modified starches	24 139
Cod liver oil, fats and oils of fish other than liver oils	170
Lard, poultry and pig fat; pig fat free of lean meat; animal tallow	23 318
Other fats of bovine animals, sheep and goats, raw/rendered; lard-/oleo-strearin, lard tallow oils; animal oils and fats and their fractions, refined or not	9 498
Soybean oil and its fractions, crude and refined	14 481
Active natural and inactive yeasts, other single-cell microorganisms	4 699
Bagasse and other waste of sugar manufacturing	21
Brewing and distilling dregs and wastes	506
Brine shrimp eggs	7
Prawn feeds	34 890
Feed additives	19 822
Feed supplements	1 984
Other preparation used for animal food	3 365

[1] Product of processing, precipitate

TABLE 12
Volume of exports of agricultural products, 2004

Commodity Description	Quantity (tonnes)
Flours, meals and pellets of fish, unfit for human consumption	267
Rice, semi- or wholly-milled	983
Maize seed (not including sweet corn), un-milled	137
Flour of wheat, enriched or not	1 785
Rice flour, other cereal flour, flour and meal of potatoes	82
Tapioca and substitutes, prepared from starch	112
Flour, meal and powder of dried leguminous vegetables	0.02
Meal and powder of cassava, vam, sago pith and other roots and tubers	44
Flour, meal and powder of coconut	816
Maize, cassava, and other starches	13
Wheat used as feed	63
Wheat gluten	502
Desiccated coconut	105 829
Copra	38
Soybean	0.15
Cotton, sesame seeds	616
Oilcake and other solid residues from extraction of oil from coconut/copra	364 245
Oilcake and meal of other solid residues (except dregs), ground or pelleted	566
Corn cobs after removal of grain; corn stalks and leaves, hydrolyzed	4 168
Waste fruit (peel and cores) and fruit pomace (pulpy residue)	6 682
Other vegetable residues and by-products, vegetables materials and wastes	552
Bran, and other residues of maize, rice, other cereals	1 649
Tobacco refuse	2 268
Bagasse and other waste of sugar manufacturing	710
Brewing and distilling dregs and waste	6
Shark liver oil and fats; oils of marine mammals, and their fractions	34
Lard; other pig and poultry fat; animal tallow	22
Soybean oil and its fractions, refined	7 049
Coconut (copra) oil, crude, refined and its fractions	959 400
Preparations for making complete/supplementary feeds (premixes)	1 393
Prawn feeds	138
Feed additives	0.66
Other preparation used for animal food	4 572

The available agricultural by-product resources for use in aquafeeds in 2004 and a forecast of requirements for 2014 are presented in Table 15. The forecasts were estimated from current production rate increases and the average percent by-product. The data suggest that the Philippines have adequate resources of energy-rich feedstuffs to cope with the future expansion of the sector.

TABLE 13
Major crop production in the Philippines (tonnes)

Crop	1999	2004	% annual average growth over 5 year period (1999-2004)
Rice	11 786 625	14 496 784	4.25
Corn	4 584 593	5 413 386	3.66
Soybean	NA	974	0.72
Coconut	11 589 010	14 336 618	4.42
Sugar cane	23 777 828	25 579 214	1.77
Cassava	1 890 315	1 640 520	-2.74

NA: data not available
Source: BAS (unpublished report; 2006)

TABLE 14
Livestock and poultry production

Animal	Number of heads			Production (tonnes) (2004)	% annual average growth over 5 year period (1999-2004)
	2002	2003	2004		
Carabao	281 189	277 138	280 960	40 626	5.0
Cattle	660 136	649 079	595 717	78 068	-3.3
Horse	2 974	4 822	11 284	1 571	54.2
Swine	8 522 092	8 944 878	9 118 437	502 841	4.9
Goat	97 599	89 872	87 813	1 197	-2.5
Chicken	228 145 975	186 747 121	221 743 933	255 119	7.1

Source: BAS (unpublished report)

TABLE 15
Available feed resources (raw materials and by-products) in the Philippines in 2004 and forecasts of by-product availability in 2014 (tonnes)

Feedstuffs	Raw material (2004)	By-product (%)*	By-product (2004)	Growth of raw material (%/year)	By-product (2014)*
Common feedstuffs					
Rice bran	14 496 784	10	1 449 678	4.2[e]	2 058 543
Corn bran	5 413 386	21	1 136 811	3.7[e]	1 557 431
Corn starch	5 413 386	69	3 735 236	3.7	5 117 274
Cassava flour	1 677 564	62	1 040 090	3.7[e]	1 424 923
Total (energy sources)	**27 001 120**		**7 361 815**		**10 158 171**
Coconut oil	14 366 184	10	1 436 618	4.4[e]	2,068,730
Soybean oil	974	19	185	0.7 [e]	198
Total (oils)	**14 367 158**		**1 436 803**		**2 112 027**
Copra meal/cake	14 366 184	4.9	703 943	4.4	1 013 678
Soybean meal	974	82	799	0.7	855
Shrimp head meal	17 958[a]	40	7 183	-0.8	6 609
Meat and bone meal	624 303[b]	39	243 478	2.3[f]	299 478
Fishmeal (local)	no record of local production				
Potential feedstuffs					
Poultry by-product meal	255 119[c]	18	45 921	7.1[g]	78 526
Feather meal	255 119[c]	9	22 961	7.1[g]	39 263
Blood meal	624 303[b]	7.5	46 823	2.3[f]	57 592
Leucaena leaf meal	2 907[d]	19.8	576	11.8[h]	1 255
Cassava leaves	1 677 564	12	201 308	-2.7	146 955

*Amount of raw material x % by-product
[a] Assuming that 50% of shrimp production (35 916 tonnes) is processed, shrimp production growth from 1998-2004; [b] Total weight of slaughtered livestock (cattle, carabao, horse, hog, goat) in abbatoirs; [c] Weight of slaughtered chicken in poultry processing plants; [d] Log production in 2003 (Philippine Forestry Statistics, FMB-DENR); [e] Based on increase crop production, 1994-2004; [f] Based on the increase number of slaughtered livestock (carabao, cattle, swine, goat) in abbatoirs, 1994-2004; [g] Based on the increase number of slaughtered chicken in poultry processing plants, 1994-2004; [h] Based on log production from 1999-2003 (Philippine Forestry Statistics, FMB-DENR), no available data yet for 2004

Source: (for estimates of % by-products of raw materials): Blair (1990) (leucaena leaves); Devendra (1985) (cassava leaves); Hertrampf and Piedad-Pascual (2000) (other feedstuffs)

2.1.3 Nutritional value of feedstuffs

The choice of ingredients for feed formulation depends on their nutrient content, digestibility, presence or absence of anti-nutritional factors, availability and price. The proximate composition of some feed ingredients is shown in Table 16. Feedstuffs containing protein with a good amino acid profile are usually expensive and their use is constrained by price. The bio-availability and digestibility of nutrients present in feedstuffs vary between species and influences the level of inclusion in feed formulations. The digestibility of various feedstuffs by Philippine aquaculture species are listed in Table 17. Fishmeal and soybean meal digestibility in milkfish varies with salinity (Ferraris *et al*., 1986).

2.1.4 Nutrient requirements

Tables 18, 19, and 20 list some of the known nutrient, vitamin, and mineral requirements of fish and crustaceans cultured in the Philippines. These data are used as a guide by commercial and non-commercial feed manufacturers in formulating feeds.

2.1.5 Commonly used feedstuffs

Omnivorous fish. Milkfish larvae in hatcheries are fed flaked microbound diets in combination with *Brachionus* (zooplankton) and copepod (*Acartia* and *Pseudodiaptomus)* nauplii. In extensive grow-out systems, milkfish are only fed on commercial feeds or on single, energy rich ingredients such as rice bran, corn bran and / or biscuit and noodle factory rejects during the last month of culture.

Tilapia broodstock, larvae and fry are fed on rice bran or a combination of rice bran and fishmeal. Locally available feedstuffs such as rice bran, wheat pollard, copra meal,

TABLE 16
Proximate composition (percent dry matter) of selected feed ingredients available in the Philippines

	Moisture	Crude protein	Crude lipid	Crude fibre	NFE**	Ash
Feed ingredients of animal origin						
Fishmeal (local)	10.3	64.1	6.5	0.8	8.5	20.1
Fishmeal, Chilean	8.4	70.1	8.5	0.5	4.1	16.8
Fishmeal, Danish	9.5	73.9	9.4	0.3	2.4	14.0
Fishmeal, Peruvian	7.7	68.1	8.0	1.1	5.9	17.0
Fishmeal, tuna	9.4	65.4	8.0	0.8	8.8	17.0
Fishmeal, white	7.2	69.0	7.6	0.6	4.8	18.0
Meat soluble	4.2	76.5	1.2	0.2	10.3	11.8
Poultry feather meal	4.8	70.9	17.7	0.6	8.3	2.5
Prawn head meal	6.5	51.2	5.2	13.3	5.3	25.0
Shrimp meal, *Acetes* sp.	8.2	68.6	3.9	3.6	7.6	16.3
Squid meal	6.9	78.5	5.5	1.3	6.7	8.0
Squid meal, scrap	5.5	74.1	7.1	0.9	8.1	9.8
Blood meal	6.3	87.7	3.0	0.4	3.3	5.6
Meat and bone meal	5.6	46.8	9.6	2.0	7.5	34.1
Feed ingredients of plant origin						
Corn germ meal	4.5	47.4	8.5	6.4	36.9	0.8
Corn gluten meal	8.0	60.6	7.0	3.4	27.8	1.2
Leucaena leaf meal, giant	7.8	25.1	6.8	10.6	44.0	13.5
Leucaena leaf meal, native	10.3	29.3	8.8	11.5	43.5	6.9
Copra meal	7.9	22.0	6.7	17.3	44.3	9.7
Corn meal	8.4	7.8	4.7	2.6	83.1	1.8
Corn starch	11.9	0.4	0.2	1.1	98.2	0.1
Flour, bread	12.1	12.9	1.2	0.3	84.9	0.7
Flour, whole wheat	11.3	15.3	1.7	0.8	81.1	1.1
Germ, wheat	6.0	27.8	4.3	3.4	59.6	4.9
Gluten, corn	7.3	62.6	7.7	2.2	25.9	1.6
Gluten, wheat	8.9	80.7	1.4	0.4	16.4	1.1
Rice bran	9.2	13.3	14.1	8.5	53.4	10.7
Rice bran, tiki-tiki	10.7	18.0	2.0	8.0	62.4	9.6
Rice hull	7.0	3.3	2.0	32.4	41.6	20.7
Soybean meal, full fat	5.6	35.8	19.8	4.9	33.9	5.6
Soybean meal, defatted	8.4	43.6	1.5	5.5	41.7	7.7
Soy protein concentrate	5.7	56.9	1.0	5.1	28.7	8.3
Wheat flour	13.2	10.9	1.1	0.6	86.9	0.5
Wheat, pollard	9.5	15.4	4.5	10.3	64.0	5.8
Feed ingredients of other sources						
Casein	7.2	89.7	0.1	0.3	8.9	1.0
Crab meal	4.2	37.9	4.1	10.7	8.9	38.4
Gelatin	7.9	94.4	0	0.1	5.1	0.4
Frog meal	7.6	62.5	1.7	1.2	4.7	29.9
Mussel meal, green	5.9	64.6	8.6	3.0	12.5	11.8
Oyster meal	4.4	54.6	9.4	4.0	20.1	11.9
Scallop meal	7.3	65.2	10.9	1.4	8.8	13.7
Snail meal, kuhol	4.0	52.1	1.8	2.1	15.7	28.3
Yeast, Brewers	7.2	49.4	1.6	2.4	34.5	12.1
Yeast, Candida	8.3	55.2	0.8	1.7	35.1	7.4
Natural food						
Acartia sp.	7.8	71.2	8.3	5.4	9.9	5.2
Artemia	8.0	55.5	6.8	11.3	15.0	11.4
Azolla	8.0	27.2	3.4	12.9	36.5	20.0
Brachionus sp.	8.1	51.9	10.4	3.5	15.3	18.9
Chaetoceros calcitrans	7.6	24.4	7.1	2.5	26.7	39.3
Chlorella, marine	10.1	35.1	4.2	5.6	27.7	27.4
Isochrysis galbana	10.4	33.6	18.1	4.4	23.0	20.9
Moina macrocopa	8.5	57.8	7.6	8.4	17.2	9.0
Sargassum	10.4	9.0	0.8	9.6	36.4	34.2
Skeletonema sp.	10.4	24.7	2.6	0.7	20.2	51.8
Spirulina	8.0	55.7	2.8	0.6	28.1	11.8

TABLE 16 CONTINUED

Natural food						
Tetraselmis sp.	5.5	49.1	10.7	2.1	19.0	19.1
Digman	9.8	20.6	3.3	16.4	35.9	23.8
Enteromorpha (lumot)	15.2	13.8	1.9	9.3	36.9	38.1
Gracilaria sp.	7.0	10.2	0.4	5.8	44.8	38.8
Kappaphycus sp.	6.1	5.4	0.8	6.1	57.3	30.4

** Nitrogen-free extract

Source: Catacutan (2002a); Eusebio, Coloso and Mamauag (2004); Millamena *et al.* (2000); Centralized Analytical Laboratory, SEAFDEC

bread and biscuit rejects and commercial poultry feeds are sometimes provided as supplemental feeds. Commercial feeds are only used in intensive tank culture, earthen ponds or floating cages. Commercial feeds for milkfish and tilapia contain high levels of plant material, such as rice bran, soybean meal and low levels of fishmeal (see Table 21). Catfish are also omnivorous but have a higher protein demand and they fed on decaying organic matter supplemented with kitchen waste, blanched chicken entrails and rice bran. Catfish cultured in net pens are fed a commercially formulated feed.

Carnivorous fish. Raw fish and chopped shrimp (*Acetes* sp.) is generally fed to carnivorous species such as grouper and red snapper in cages or pens. An alternative feeding strategy employed in brackish-water pond culture of grouper is to use tilapia fry as live food, together with chopped trash fish. To decrease the dependence on trash fish, formulated feeds have now also been developed for carnivorous marine species.

Herbivorous fish and plankton feeders. Herbivorous species like rabbitfish are grown in brackish-water ponds and fed on filamentous algae such as *Enteromorpha*.

Crustaceans. Shrimps cultured in extensive systems feed mostly on detritus, diatoms, *Cyanobacteria* and green algae. In semi-intensive systems shrimp are given commercial feeds (Table 21).

Mudcrabs. Raw fish and freshly ground mussel meat are typical feeds for mud crab in ponds or pens installed in tidal flats. If available, *Acetes*, green filamentous algae, animal hides and entrails and snails are also given to mud crabs. A mud crab diet has been developed but has not yet been commercialized. The formulation contains high levels of fishmeal and brown mussel meat (Table 21).

2.2 Feeding strategies and pond management

2.2.1 Milkfish

Pond culture. Culture practices for milkfish in brackish-water ponds range from extensive, modified extensive, semi-intensive to intensive. Most milkfish farmers use extensive and modified extensive farming practices. The practices differ with respect to stocking density, feeding strategy and water management (Table 22 and 23). Under extensive conditions, ponds are prepared to produce adequate quantities of natural food. Chicken manure is applied at 1–2 tonnes/ha, 16-20-0 at 50 kg/ha and 46-0-0 at 15 kg/ha. To maintain natural food productivity throughout the production cycle, inorganic fertilizers are applied after water exchanges that occur every 15 days at equal or half of the application rates applied for pond preparation. *Lab-lab* (bacterial/algal floc) and plankton are the two preferred natural feeds.

Feed is only provided in the last month of the cycle when natural food cannot sustain fish growth. Fertilization alone can only support fish biomass of around 600 kg/ha (Sumagaysay, Marquez and Chiu-Chern, 1991). A small number of fish farmers practice the ‘kitchen pond method’, which entails growing and transferring of natural food from a small pond (kitchen pond) to rearing ponds. Polyculture of milkfish with shrimp is also practised in extensive systems, with or without supplemental feeding.

Under semi-intensive conditions, ponds are prepared and fertilized as above. Feeding with commercial feeds commences one month after stocking. Water exchange is more frequent and for which a pump is normally required. Aeration is employed when biomass reaches 1 tonne/ha. Milkfish in ponds was reportedly to effectively use only about 12 percent of the feed provided (Luckstädt, 2003). Rice bran may therefore not directly contribute to fish growth but plays an important role in natural food production.

Marine pen and cage culture. The stocking density of milkfish in pens is between 5–20 fish/m^2. For floating and stationary cages, total biomass is between 10–30 fish/m^3. In offshore cages, stocking density is increased to 35–100 fish/m^3 and fish are given commercial feeds. The average FCR in pens and cages is 2.5:1 and this needs further improvement. Pen culture of milkfish is also practiced in lakes, particularly in Laguna de Bay where some 12 000 ha are used for pen culture (Santiago, 2001; Filart, 2005).

The feeding scheme for grow-out culture of milkfish in shown in Figure 5.

With the high demand for milkfish fry, hatcheries have been established all over the country and feeding protocols are well established (Borlongan, Marte and Nocillado, 2000).

TABLE 17
Apparent protein digestibility coefficients (APDC) of feedstuffs by Philippine aquaculture species

Species	Feedstuffs	APDC (%)
Milkfish	Fishmeal	45–81*
	Soybean meal, defatted	45–94*
Tiger shrimp	Fishmeal	61
	Soybean meal, defatted	93
	Squid meal	96
	Shrimp meal	95
	Shrimp head meal	89
	Meat and bone meal	74
	Yeast, *Candida* sp.	93
	Copra meal	75
Carp	White fishmeal, mechanically extracted	95
	Soybean meal, solvent extracted	81–96
Grouper	Fishmeal, Chilean	98
	Fishmeal, white	99
	Fishmeal, tuna	76
	Shrimp meal, *Acetes* sp.	95
	Squid meal	94
	Soy protein	86
	Meat soluble	98
	Meat and bone meal, Philippines	84
	Meat and bone meal, Australia	99
	Poultry feather meal	81
	Blood meal	15
	Rice bran	43
	Wheat flour	83
	Cowpea meal, white	94
	Lupin seed meal	97
	Corn gluten meal	99
	Corn germ meal	83
	Leucaena leaf meal	79
Mud crab	Fishmeal, Peruvian	95
	Squid meal	98
	Shrimp meal, *Acetes* sp.	95
	Meat and bone meal	95
	Copra meal	94
	Bread flour	95
	Rice bran	94
	Corn meal	96
	Soybean meal, defatted	96

* Tested at different salinities (Ferraris *et al*., 1986)

Source: Milkfish - Ferraris *et al.* (1986); tiger shrimp – Catacutan (1997); carp – NRC (1977); grouper – Eusebio, Coloso and Mamauag (2004); mudcrab – Catacutan, Eusebio and Teshima (2003)

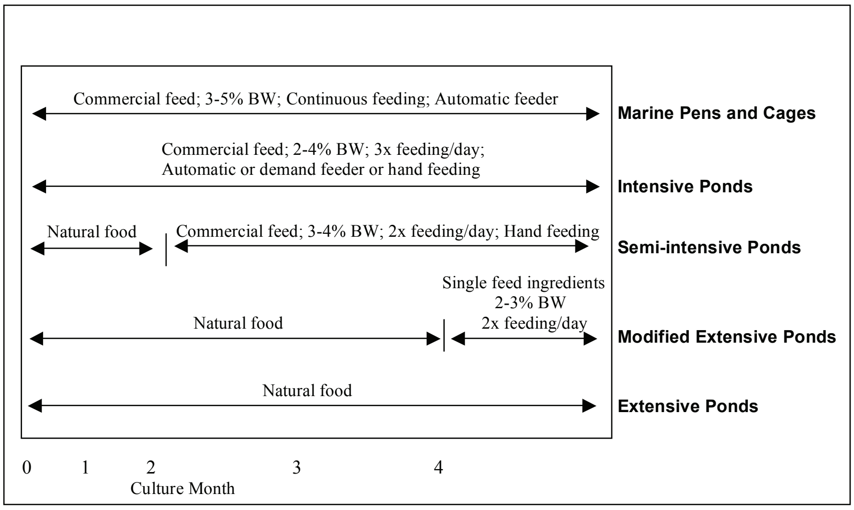
2.2.2 *Tilapia*

Tilapias in the Philippines are reared in cages, tanks and ponds under mono- or polyculture conditions with other fish. Culture techniques may be extensive, semi-intensive or intensive and these differences are summarized in Table 23.

Cage culture. Tilapia cage culture is well established in Luzon and Mindanao. The proliferation of fish cages in most lakes has severely depleted natural food resources and has forced farmers to rely on commercial pellets. Sinking or floating commercial pellets are used as feed and fish are fed to satiation two to three times a day. FCRs vary widely (1.8–3:1) and are affected by water quality. Feeds are either broadcast or applied on feeding trays. Aeration is also employed in lakes regardless of biomass or fish size.

Pond culture. The management of tilapia in ponds is similar to milkfish. *Lab-lab* and plankton are grown in extensive and semi-intensive systems. In addition, sacks of fertilizer are suspended in the water column (Aldon, 1998). Chicken manure or hog manure is applied at 500–1 000 kg/ha per week, while inorganic fertilizers, 16-20-0 or

FIGURE 5
Feed management protocols for milkfish grow-out in different systems



Source: FPA (unpublished report)

TABLE 18
Nutritional requirements of some species cultured in the Philippines

Species	Crude protein (%)	Crude lipid (%)	Carbohydrate (%)	Digestible energy (kcal/kg)
Milkfish	30–40[1]/24 (pond)[2]	7–10[11]	25[14]	2 500–3 500[17]
Nile tilapia	28–30[3]	6–10[12]	25[15]	2 500–4 300[18]
Tiger shrimp	40[4]	8–12[13]	20[16]	2 850–3 700[19]
White shrimp	28–32[5]	-	-	-
Mud crab	32–40[6]	-	-	-
Common carp	31–38[7]	-	-	-
Grouper	40–50[8]	-	-	-
Asian seabass	43[9]			-
Red snapper	44[10]	-	-	-
Species	**Essential fatty acid (%)**	**Lecithin (%)**	**Cholesterol (%)**	
Milkfish	1–1.5 n-3 PUFA[20]	-	-	
Nile tilapia	0.5 18:2n-6 PUFA[21]	-	-	
Tiger shrimp	2.6 n-3 PUFA[22]	1-2[25]	1[26]	
	<5 n-6 PUFA			
Grouper	1 n-3 HUFA[23]	-	-	
Asian seabass	0.5 n-3 PUFA[24]	-	-	
	0.5 n-6 PUFA			

Source: [1]Lim, Suchawongs and Pascual (1979); [1, 11,14,17]Pascual (1989a); [2]Sumagaysay and Borlongan (1995); [3]Santiago *et al.* (1986); [3]Wang, Takeuchi and Watanabe (1985); [4]Alava and Lim (1983); [4]Millamena and Triño (1994); [5]Sedgewick (1979); [6]Catacutan (2002b); [7]Takeuchi, Watanabe and Ogino (1979); [8]Teng, Chua and Lim (1978); [9]Catacutan and Coloso (1994); [10]Catacutan, Pagador and Teshima (2001); [12,15,18]Jauncey and Ross (1982); [13,22]Catacutan (1991); [16,19]Bautista (1986); [20]Borlongan (1992); [21]Takeuchi, Satoh and Watanabe (1983); [23]Millamena and Golez (1998); [24]Borlongan and Parazo (1991); [25]Pascual (1989b); [26]Nalzaro (1982)

18-46-0 are applied at 25–50 kg/ha every two weeks. In intensive systems commercial feeds are broadcast at several sites. Water is exchanged frequently.

Concrete tank culture. Production levels of up to 86 tonnes/ha/year can be achieved under intensive tank culture conditions. However, operational costs are high and maintenance of water quality is critical (Aldon, 1998).

2.2.3 Catfish

The native catfish, *Clarias macrocephalus,* has disappeared from the Philippine market due to pesticide poisoning, loss of habitat and overfishing. Walking catfish *C. batrachus* was introduced in the early 1980's but was not readily accepted by

TABLE 19
Vitamin requirements of some important species cultured in the Philippines (values in mg/kg diet unless otherwise indicated)

Vitamins	Tilapia	Tiger shrimp	Common carp	Seabass	North African catfish
Thiamine		60			
Riboflavin		25	7–14		
Pyridoxine			5–6		
Cobalamin		0.2			
Pantothenic acid		75 or 101–139	30–50		
Nicotonicacid		40	28		
Biotin		2.0–2.4	1		
Inositol		400	440		
Choline		600	4000		
Folic acid		10			
Ascorbic acid		200		700	0.1–0.7 g ASA/100 g for wound healing
Vitamin A		5 000 IU	10 000 IU		
Vitamin E	50–100	100	1 000 IU		
Vitamin D		0.1			
Vitamin K		5			

Source: Erazo-Pagador (2001); Millamena (2002); Shiau and Chin (1998); Shiau and Hsu (1998)

TABLE 20
Mineral requirements of some species cultured in the Philippines

Minerals	Nile tilapia	Tiger shrimp	Common carp	Milkfish
Ca		1:1 (Ca:P)		
P	0.8–-1.0%		0.6–-0.7%	0.85
Mg	0.05–-0.07%		0.04–-0.05%	
Cu	3–-4 ug/g			
Fe			150 ug/g	
Mn	12 ug/g		13 ug/g	
Zn	10 ug/g		15–-30 ug/g	

Source: Borlongan and Satoh (2001); Watanabe, Satoh and Takeuchi (1988); Bautista and Baticados, (1990); Millamena (2002)

consumers. The introduction of the North African catfish, *Clarias gariepinus*, in the early 1990's, has helped to revive the catfish culture industry. Catfish are cultured in freshwater ponds or in cages (Surtida and Buendia, 2000). A formulated feed for catfish grow-out is available (Table 21). Smaller catfish farms use ponds of around 1 000 m^2 at a stocking density of 5–6/m^2 and use the water from the ponds to grow vegetables. In these systems, swine pellets are fed twice daily at 1–3 percent of body weight per day. Semi-intensive catfish farmers use ponds of up to 5000m^2, stock their ponds at 10/m^2 and feed the fish on trash fish, processed chicken entrails or swine pellets and change water twice weekly.

2.2.4 Grouper

Grouper culture in the Philippines is still dependent on the use of fry and juveniles caught from the wild or produced from the hatchery. Fish are reared either in ponds or in cages (Baliao *et al*., 1998; Baliao *et al*., 2000). Detailed feeding and water management protocols for larval and early juvenile grouper are described by Duray, Estudillo and Alpasan (1997).

Pond culture. Pond preparation procedures for growing natural food (*lab-lab* and plankton) are similar to milkfish culture. Adult tilapia are stocked in the ponds at 5 000–10 000 fish/ha to breed and the fry and early juveniles serve as prey for the grouper. Juvenile grouper are stocked at 5 000 fish/ha, one month after the release of the adult tilapia. Trash fish is also provided at 5 percent of biomass per day. If trash fish is the only feed then the ration is increased to 10 percent of biomass per day. Water is changed twice weekly. A formulated feed for grouper is now available (Table 21).

Cage culture. Net cages are installed in sheltered lagoons, coves, bays, behind an island or in river mouths. For the nursery phase the fish are stocked at 10–20/m^3. Feeds include mysids, shrimps or finely chopped trash fish at a ration of 10 percent body weight per

TABLE 21
Practical diet formulation for milkfish, tilapia, waliking catfish, grouper, mud crab and tiger shrimp (g/kg as fed basis)

Ingredient composition	Milkfish[1]	Tilapia[2]	Catfish[3]	Grouper[4]	Mud crab[5]	Shrimp[6]
Fishmeal (local)		182.5	200	-	-	
Chilean/Peruvian fishmeal	110	-	-	200	250	250
Meat and bone meal				200		
Brown mussel meat	-	-	-		250	
Blood meal				80		
Squid meal	-	-	-	10	-	
Shrimp meal (*Acetes* sp.)	-	-	-	100	-	150
Soybean meal	308	250	300	60	-	250
Copra meal	-	100			-	
Rice bran	492	60	310	70	125	69.5
Corn bran	-	-	-		100	
Cassava flour	-	364.2	-		-	
Bread flour	50	-	90		-	130
Wheat flour	-	-	-	150	170	
Seaweed (*Gracilaria* sp.)	-	-	-		50	50
Cod liver oil	20	-	-	60	25	25
Soybean oil	20	-	50		25	25
Vitamin mix	-	-	-	40	-	20
Mineral mix	-	-	10	30	-	10
Vitamin-mineral mix	-	43.3	10		-	
Dicalcium phosphate	-	-	30		-	20
Ethoxyquin	-	-	-		5	0.5
Proximate composition (% dry matter)						
Crude protein	26.7	28.1	34.2	44.0	40.1	41.7
Crude lipid	10.9	3.8	9.5	11.5	11.9	8.8
Crude fibre	8.4	3.6	5.8	1.8	1.4	5.9
Nitrogen-free extract	45.1	54.6	36.3	25.8	38	29.2
Ash	8.9	9.9	14.2	16.9	8.6	14.4
Cost (US $/tonnes)**	**375**	**559**	**402**	**1 300**	**781**	**806**

*Cost of feed calculated based on average retail cost of ingredients

Source: [1]Sumagaysay (1998); [2]Santiago, Aldaba and Reyes (1987); [3]Coniza, Catacutan and Tan-Fermin (2001); [4]Millamena *et al.* (2001) in Alava (2002); [5]Triño, Millamena and Keenan (2001); [6]Millamena and Triño (1994)

day, fed twice a day. A 50 Watt incandescent bulb is sometimes installed above the cages to attract live food (mysids, copepods and other juvenile fish). In grow-out cages, chopped trash fish is provided twice daily at 5 percent of body weight per day.

2.2.5 Mudcrab

Mudcrab are farmed in bamboo fenced brackish-water ponds. Net enclosures are installed along the inner side of the pond dykes to prevent escape. Prior to stocking, the pond is prepared by liming, application of 21-0-0 and organic and inorganic fertilizers. In polyculture with milkfish the ponds are modified to suit the needs of the two species. Peripheral and central canals are constructed where crabs can seek refuge in deeper water when temperature rises above 32^{o} C, while lab-lab as food for milkfish can still grow in the shallow parts of the pond. Mudcrab are also reared in mangrove areas or on tidal flats in net pens (1–2 cm mesh size). Stocking density less than 5 000 crabs/ha is recommended to attain bigger size and higher survival.

Crabs are fed on fresh or frozen trash fish or in combination with brown mussel meat (75 percent brown mussel and 25 percent trash fish). Animal hides or entrails, snails, *Acetes* and green filamentous algae are also used as feed. Crabs are fed at 10 percent of body weight when carapace length is less than 6 cm and at 5 percent when carapace length is 6 cm or more. A dry formulated feed (Table 21) is also used at 5 percent of biomass daily when carapace length is $\leq$ 6 cm and at 2 percent of biomass when carapace length is $\geq$ 6 cm (Alava, 2002).

TABLE 22
Different milkfish culture systems in brackish water

Culture System	Optimum stocking density/ha	Yield (kg/ha/crop)	Food supply management	Water management
Extensive polyculture				
Milkfish	3 000–3 500	600–800	Natural food +	Tidal
Shrimp	5 000–10 000	120–240	supplemental feed	
Extensive monoculture				
Traditional	1 000–2 000	500–600	Natural food + freshwater filamentous algae	Tidal; water depth, 60 cm or less
Improved	2 000–3 000	700–1 000	*Lab-lab* (high salinity)	Water depth, 50 cm or less
Modified extensive monoculture				
Modified stright-run	4 000	1 000	Mainly natural food + supplemental feed	Tidal; water depth 80 cm
Modular	3 000	2 000	Natural food (*lab-lab* and plankton)	Tidal
Semi-intensive polyculture				
Milkfish	10 000	2 250	Natural food + supplemental or commercial feed	Tidal: supplemental pumping
Shrimp	35 000	840		
Semi-intensive monoculture				
	8 000–15 000	1 500–3 500	Natural food + supplemental or commercial feed	Tidal: supplemental pumping; water depth, 50-100cm
Intensive				
	≥20 000	≥4 000	Commercial feed	Pumping with aeration; water depth, 12 cm

Source: Bagarinao (1997); Sumagaysay-Chavoso (2003); author's survey (2005)

TABLE 23
Tilapia culture systems in the Philippines

Parameters	Extensive	Semi-intensive		Intensive		
	Ponds	Cages	Ponds	Cages	Ponds	Tanks
Culture period	4–5 months	4–6 months	4–6 months	4–5 months	4–5 months	4–5 months
Size at stocking	10–20 g	10–20 g	10–20 g	10–20 g	10–20 g	10–20 g
Stocking density	3 000–5 000/ha	15–25/m³	10 000–50 000/ha	50–250/m³	50 000–100 000/ha	100–200/m³
Water management	50% water change after 2 months	None	Frequent water change	None	5–10% daily	Flow-through
Fertilization	2 weeks after pond preparation	None	Applied in first two months	None	Only at stocking	None
Feeding	None	Natural food + supplemental feed	Natural food + supplemental feed	Commercial feed	Commercial feed	Commercial feed
Use of aerator	No	No	Optional	Optional	Yes	Yes
Size at harvest	100–200 g	250–300 g	150–200 g	150–250 g	250 g	>300 g
Survival rate	80–100%	70–90%	60–85%	60%	60%	70–85%
Yield	300–800 kg/ha	2.7–7.0 kg/m³	1 000–3 000 kg/ha	4–40 kg/m³	7 000–15 000 kg/ha	20–50 kg/m³

Source: Guerrero (2002); Aldon (1998); Corpuz-Uy (pers. com.); author's survey (2005)

2.2.6 Tiger shrimp

Broodstock conditioning. Broodstock shrimp are fed with a variety of live, fresh or frozen marine worms, mussel meat, squid, clam meat and other mollusc meat. Brown mussel meat and squid are chopped into small pieces, while marine worms are fed alive. A formulated feed is also used but is supplemented with fresh wet feeds to ensure nutrient balance (Alava, 2002). Broodstock tanks are operated on a flow through basis or water is changed daily.

Larval rearing. The protocols described by Bautista, *et al.,* (1991) are generally used for larval and PL rearing up to PL_5. From PL_6 onwards, postlarvae are gradually introduced to minced mussel meat, raw fish and shrimp meal or crumbled artificial feed. Shrimp larval diets are readily available and are easy to use (Alava, 2002).

Grow-out culture in ponds. Extensive shrimp farming at densities of 30 000-50 000 shrimp/ha can attain production of 0.8-1.1 tonnes/ha/crop (Bordeos, 2004). Pond preparation involves sun drying of pond bottom, excavation of peripheral canals, scraping of black soil, liming, and application of tea seed powder as pesticide. Algal growth is stimulated by seeding green water from the river or adjacent ponds and by fertilization. These techniques were developed to prevent occurrence of diseases and to remove organic matter from the pond bottom. Feeding with commercial feed commences 5 days after stocking until harvest. Stocking density in semi-intensive and intensive systems is recommended not to exceed 250 000/ha for sustainability (Corre *et al*., 1999). Like in extensive system, farmers follow the feeding scheme suggested by feed manufacturers or developed their own.

3. THE AQUACULTURE FEED INDUSTRY

Fifteen years ago, pelleted animal feeds in the Philippines were rarely available and used (Solalela, 2001). Today, approximately 80 percent of animal feeds are in pellet or crumble form. Mash is used as a poultry feed and by cost conscious fish farmers. The animal feed industry (including aquafeeds) is now sophisticated and well established and all types of feeds are available, either produced locally or imported.

3.1 Cost of raw materials and feeds

Raw material comprises approximately 85 percent of the feed production cost, hence is considered as the primary concern by feed manufacturers. The balance of 15 percent covers all other production costs including amortization (Solalela, 2001). The cost of feed ingredients varies widely depending on quality, source and time of purchase (Table 24). For various reasons the cost of animal feeds is higher in the Philippines than many other countries (Solalela, 2001). The country is highly dependent on imported fishmeal, corn and soybean meal and this is compounded by the poor quality of locally produced corn, fishmeal and rice bran. The supply of corn in the country is regulated and monitored by the NFA (AFSD-BAI, 2005).

3.2 Available aquafeeds

Over 60 brands of milkfish feeds, 65 tilapia feeds and 9 shrimp feeds where available on the market in December 2004. The cost of feed depends on the nutrient composition, quality, manufacturing process and competition between milling companies and distributors. Average prices of the available aquafeeds are presented in Table 24. Generally, fish feeds are available in mash form for fry (pre-starter), crumble (starter) for small juveniles and pellets (grower and finisher) for later stages. The protein content of the available commercial feeds for different species are: milkfish, 35–26 percent (fry to 500 g weight); tilapia, 31–23 percent (0.01 g fry to 1000 g); catfish, 34–29 percent (<5 g fry to >80 g); grouper, 48–42 percent (<2 g fry to >300 g); shrimp, 45–37 percent (<1 g post-larvae to >15 g). All of the reputable manufacturers provide a guaranteed composition of their various feed and also provide farmers with a feeding guides for each feed type. Three examples of feed composition and feeding schedules are provided in Tables 25 (a-f). These data exist for all species specific feeds. Specific formulations are also available for different culture systems and conditions. The survey revealed that floating/extruded pellets are between 6–25 percent (average = 14 percent) more expensive than sinking pellets with similar nutrient composition.

Feed companies are required to register with the Bureau of Animal Industry (BAI) and comply with feed standard regulations (Table 26). The government sets nutrient standards for different species according to feeding habits and life stages, though discrepancies between the standards and the nutrient specifications provided by manufacturers do sometimes exist.

3.3 Marketing of aquafeeds

Aquafeeds (except in mash form) are usually sold in standard 25-kg polypropylene bags. These are distributed and sold together with livestock and poultry feeds by agricultural supply stores. The marketing chain for aquafeeds is well organized and begins with the manufacturer who distributes products either to a wholesaler or to an authorized area distributor. Wholesalers sell to dealers who have their own set of retailers for final distribution to end-users. Authorized dealers sell directly to farmers. Some major feed companies have their own distribution warehouses in key areas. In such cases, the company deals directly with large customers. Feed manufacturers provide sales incentives to wholesalers and/or dealers depending on the volume of their total sales. Technical and sales agents provide technical services and promotional activities to boost feed sales. Promotions are done through sponsorship of community and industry activities (*e.g.* exhibits, seminars), feed trials and distribution of promotional items (ADB, 2002 study).

TABLE 24
Approximate cost of selected ingredients and aquafeeds

Ingredient	Cost (US$/tonnes)
Fishmeal, Peruvian	855–1 000
Fishmeal, local (sardine, tuna, various species)	236–536
Prawn head meal	300
Squid meal	11 212
Soybean meal	345–527
Copra meal/cake	58–236
Rice bran	55–175
Wheat (whole)	148–218
Bread flour	444
Corn starch	409
Corn bran	58
Soybean oil	727
Cod liver oil	2 273
Fish oil	509
Crude coconut oil	600–618
Used oil from fast foods	444
Vitamins/minerals	2 182–8 335
Dicalcium phosphate	509
Species/feed type	
Milkfish	
Mash	431–1051
Starter crumble	417–464
Starter pellet	407–445
Grower/juvenile	379–465
Finisher/adult	373–455
Shrimp	
Pre starter crumble	1 298
Starter pellet	931–1 022
Grower	895–967
Finisher	876–931
Catfish	
Starter	432
Grower	407
Finisher	400
Grouper	
Fry mash	949
Crumble	958
Starter	912
Grower	876
Finisher	849
Tilapia	
Mash	469
Starter crumble	458
Starter pellet	451
Grower/juvenile	429
Finisher/adult	418

Source: Feed distributors and manufacturers

3.4 Status of commercial feedmills

Capacity and production. The total rated capacity of all registered commercial animal feedmills is approximately 23 470 tonnes per eight-hour shift, of which the 78 aquafeed milling companies have a capacity of 10 451 tonnes per eight-hour shift (Table 27). Approximately 61.8 percent of all registered manufacturers are small-scale producers with a rated capacity of less than 25 tonnes per 8-hr shift, while 25.6 percent are large-scale producers with a capacity of 50 tonnes or more per 8-hr shift. The large-scale millers manufacture approximately 80 percent of the total animal feed produced in the country. To improve efficiency and to save costs feedmillers have formed several industry associations, of which the Philippine Association of Feedmillers, Inc. is at the forefront.

Total animal feed production (including aquafeeds) in 2003 was 2.6 million tonnes, of which 8 percent (204 396 tonnes) comprised aquafeeds (Table 28). Shrimp feed production declined from 50 000 tonnes in the late 1980s to 11 472 tonnes in 2003. The growth of finfish aquaculture has contributed to the expansion of the aquafeed industry. Fish feeds now comprise between 94–96 percent of all aquafeeds. Aquafeed production increased by an average of 10 percent per annum from 1996-2003 (Solalela 2001). The overall production capacity of aquaculture feedmills based on the 8-hr rated

TABLE 25A

Guaranteed analysis of several commercial milkfish feeds

Feed type	Crude protein % (min)	Crude lipid % (min)	Crude fibre % (max)	Ash % (max)	Moisture % (max)
B-MEG Bangus					
Fry mash	31	8	7	16	13
Starter crumble	31	8	7	16	13
Starter pellet	31	8	7	16	13
Grower pellet	31	8	7	16	13
Finisher pellet	29	8	7	16	13
HP Premium Bangus Feeds					
Fry mash	32–35	7	4	12	12
Starter crumble	30	7	4	12	12
Starter pellet	30	7	4	12	12
Juvenile	28	7	4	12	12
Adult	26	7	4	12	12
HP Regular Bangus Feeds					
Juvenile	27	6	5	11	12
Adult	25	6	5	11	12

TABLE 25B

Recommended feeding schedules for milkfish provided by feed manufacturers

Feed type	Average body weight (g)	Feeding rate (% BW/day)	Growth rate (g/day)	Feeding frequency (x/day)	Feeding duration (days)
B-MEG Bangus					
Fry mash	0.01–2.00	12.5–20.0	0.15±0.02	-	-
Starter crumble	2.1–25.0	7.2–10.0	0.77±0.12	-	-
Starter pellet	26.0–70.0	5.1–6.9	2.30±0.34	-	-
Grower pellet	71.0–170	3.5–4.8	2.90±0.58	-	-
Finisher pellet	171.0 and above	1.5–3.2	3.20±0.80	-	-
HP Premium and Regular Bangus Feed					
Fry mash	fry - 15	8.5–10.0	-	5	30
Starter crumble	15–30	5–7	-	4	20
Starter pellet	30–100	4.0–4.5	-	4	45
Juvenile 2.4[a]	100–200	3–4	-	3	30
Juvenile 3.0[a]	200–400	2.8–3.0	-	3	30
Adult 2.4 & 3.0	400–500	2.5–3	-	3	30

[a]Number refers to pellet diameter

Source: San Miguel Foods, Inc (B-MEG); Hoc Po Feeds Corp (HP)

TABLE 25C

Guaranteed analysis of various commercial tilapia feeds

Feed type	Crude protein % (min)	Crude lipid % (min)	Crude fibre % (max)	Ash % (max)	Moisture % (max)
B-MEG Tilapia					
Fry mash	30	8	7	16	13
Starter crumble	30	8	7	16	13
Starter pellet	30	8	7	16	13
Grower pellet	30	8	7	16	13
Finisher pellet	28	8	7	16	13
Vitarich					
Premium					
Fry mash	≥31	≥4	≤8	-	≤13
Fry crumble	≥31	≥4	≤8	-	≤13
Extruded juvenile pellet	≥28	≥8	≤10	-	≤13
Extruded adult pellet	≥27	≥8	≤10	-	≤13
Extruded adult pellet with molasses	≥27	≥8	≤10	-	≤13
Extru-edge aqua float juvenile[a]	≥30	≥4	≤8	-	≤13
Extru-edge aqua float adult[a]	≥28	≥4	≤8	-	≤13
E-qual					
Extruded juvenile pellet	≥24	≥6	≤8	-	≤10
Extruded adult pellet	≥24	≥6	≤8	-	≤10
Extru-edge juvenile float[a]	≥25	≥4	≤8	-	≤13
Extru-edge adult float[a]	≥23	≥4	≤8	-	≤13

[a]Refers to extruded floating pellet

TABLE 25D

Recommended feeding schedules for tilapia provided by feed manufacturers

Feed type	Average body weight (g)	Feeding rate (% BW/day)	Growth rate (g/day)	Feeding duration (weeks)
B-MEG Tilapia				
Fry mash	0.01–2.00	15–20	0.02±0.01	-
Starter crumble	2–15	7–10	0.35±0.05	-
Starter pellet	16–37	5.9–7.0	0.47±0.07	-
Grower pellet	38–83	4.4–5.8	0.86±0.20	-
Finisher pellet	91–1 000	1.5–4.1	1.8±0.40	-
Vitarich				
Fry mash	3–15	6–13	-	1–3
Fry crumble	2262	5–6	-	4–7
Extru-edge aqua float juvenile[a]	62–130	3–5	-	7–10
Extruded juvenile pellet	77–105	3–4	-	8–9
Extruded adult pellet	130–250	2–3	-	10–14
Extru-edge aqua float adult[a]	160–250	2.0–2.5	-	11–14
Extruded adult pellet with molasses	16–250	2.0–2.5	-	11–14

[a]Refers to extruded floating pellet

Source: San Miguel Foods, Inc (B-MEG); Vitarich Corp. (Vitarich)

TABLE 25E

Guaranteed analysis of various commercial shrimp feeds

Feed type	Crude protein % (min)	Crude lipid % (min)	Crude fibre % (max)	Ash % (max)	Moisture % (max)
B-MEG CE 90					
Pre-starter/PL	38.5	4.0	2.5	13	10
Starter	38.0	4.0	3.0	13	10
Grower	37.0	4.0	3.0	14	10
Finisher	37.0	3.5	4.0	15	10
Tateh Shrimp Feed					
Pre-starter (mash)	45.0	8.0	4.0	16	12
Pre-starter (crumble)	45.0	8.0	4.0	16	12
Starter (pellet)	42.0	6.0	4.0	16	12
Grower (pellet)	40.0	6.0	4.0	17	12
Finisher (pellet)	38.0	6.0	4.0	17	12

TABLE 25F

Recommended feeding guide for shrimp provided by feed manufacturers

Feed typ	Average body weight (g)	Feeding rate (% BW/day)	Feed distribution per feeding (%)					Tray allocation (%)[a]
			6 am	10 am	2 pm	6 pm	10 pm	
B-MEG CE-90								
PL/Pre-starter	PL15-DOC14[b]		30	-	-	35	35	-
Starter	DOC15-DOC21	6.0–4.0	20	20	-	30	30	2.4[a]
Starter	DOC22-DOC30	3.7–-3.4	20	15	15	30	20	2.7
Starter	2.0–5.0	3.7–-3.4	20	15	15	30	20	2.7
Grower	6.0–8.0	3.7–3.4	20	15	15	30	20	2.7
Grower	9.0–12.0	3.2–3.0	20	15	15	30	20	3
Grower/finisher	13.0–19.0	2.9–2.6	20	15	15	30	20	3.3
Finisher	20.0–28.0	2.6–2.4	20	15	15	30	20	3.6
Finisher	29.0–34.0	2.4–2.3	20	15	15	30	20	3.9
Finisher	35.0–60.0[c]	2.3–1.8	20	15	15	30	20	4.1–4.9
Tateh Shrimp Feed								
Pre-starter (mash, crumble)	<1.5	blind feeding[c]	30	-	-	40	30	none
Pre-sStarter (crumble)	1.5–5.0	9.0–6.5	25	15	-	30	30	1
Starter (pellet)	5–10	7.0–5.5	25	10	10	25	30	1
Grower (pellet)	10–15	6.0–4.5	25	10	10	25	30	1
Grower (pellet)	15–20	5.0–3.5	25	10	10	25	30	1
Grower (pellet)	20–25	4.0–3.0	25	10	10	25	30	1
Finisher (pellet)	25–30	3.5–2.5	25	10	10	25	30	1
Finisher (pellet)	30–35	3.0–2.0	25	10	10	25	30	1
Finisher (pellet)	35 and up	2.5–1.5	25	10	10	25	30	1

[a]Percentage of feed ration placed in feeding trays; [b]DOC – days of culture; [c]Feed is given at fixed ration of 1-2 kg/100 000 shrimps

Source: San Miguel Foods, Inc (B-MEG); Santeh Feeds Corp. (Tateh)

TABLE 26
National nutrient standard for aquaculture feeds

Type of feed	Crude protein % (min)	Crude lipid % (min)	Crude fibre % (max)	Moisture % (max)	Ash % (max)
Prawn					
Pre-starter, pellet/crumble	38	4	4	12	16
Starter, pellet/crumble	37	4	4	12	16
Grower, pellet/crumble	35	4	4	12	17
Finisher, pellet/crumble	30	4	5	12	17
Omnivore fishes					
Pre-start mash, pellet/crumble	35	4	4	12	15
Starter mash, pellet/crumble	29	4	6	12	15
Grower mash, pellet/crumble	27	4	9	12	16
Finisher mash, pellet/crumble	35	4	9	12	16
Carnivore fishes					
Pre-start mash, pellet/crumble	45	4	4	12	15
Starter mash, pellet/crumble	40	4	6	12	15
Grower mash, pellet/crumble	35	4	9	12	16
Finisher mash, pellet/crumble	30	4	9	12	16

Source: Department of Agriculture (1996)

TABLE 27
Distribution of commercial feed millers in the Philippines and production capacity of feedmills in tonnes per 8-hour shift

Region	Total registered feed mills		Registered aquafeed mills	
	No.	Total rated capacity	No.	Total rated capacity
NCR	53	4 665	11	3 034
I	9	1 496	3	885
II	8	938	0	0
III	115	8 051	28	4 247
IV	93	4 037	15	1 271
V	14	505	0	0
VI	13	469	6	272
VII	32	1 461	9	295
VIII	3	110	0	0
IX	6	96	0	0
X	11	533	1	10
XI	14	488	1	108
XII	21	613	3	326
XIII	3	8	1	3
Total	**395**	**23 470**	**78**	**10 451**

Source: AFSD-BAI (2005)

capacity is 3.8 million tonnes/year. Given the estimated production of 204 396 tonnes of aquafeed in 2003 suggests that only 5.4 percent of the installed capacity is effectively used. Never the less, in recent years the aquafeed industry has improved enormously in manufacturing processes, quality control, feed formulation and in keeping costs as low as possible.

Distribution and storage capacity. The national distribution of feedmillers is presented in Table 27. Luzon (including NCR, Region III, Region IV) contributes 90.3 percent (3 444 505 tonnes/year) to total animal feed production in the country. The demand for compounded and or mixed animal feeds is regionally unequal and the concentration of feedmill capacity in Luzon has had negative impact on marketing, distribution and feed cost.

Because of the seasonal nature of domestic raw material supply millers have found it more economical to channel the procurement of raw materials to dealers and thus, free themselves of maintaining large year-round storage facilities. However, the shortage and rising prices of raw materials in recent years has forced the industry to expand its storage facilities (AFSD-BAI, 2005). Some companies forward buy in expectation of low supply and high price. There seems to be no problem with the storage capacity to warehouse the finished products.

3.5 Consumption of aquafeeds

Of the 204 396 tonnes of aquafeed produced, 144 356 tonnes were unspecified feeds (AFSD-BAI, 2003) (see Table 30). Based on several assumptions, it was possible to calculate a breakdown of the consumption of domestically produced aquafeeds by species groups (Table 28).

From these data it is clear that the aquafeed industry only provides a fraction of the total feed requirements of the aquaculture industry in the Philippines. The difference is made up by the use of single ingredient feeds such as rice bran, trash fish, other farm-made feeds and imports (Table 12) of manufactured feeds.

TABLE 28
Consumption of domestically produced commercial aquafeeds by major species groups

Feed	Quantity (tonnes)	Actual or calculated
Total aquafeed production	**204 396**	**Actual**
Shrimp feed	11 472	Actual
Catfish feed	1 685	Actual
Tilapia feed	96 066	Calculated
Total milkfish feed	95 173	Calculated
Milkfish in cages and pens	54 543	Calculated
Milkfish and other species in ponds (e.g. grouper)	40 630	Calculated

Assumptions:
Tilapia feed = 47% of total aquafeeds (ADB, 2002)
Shrimp = 5.6% of total aquaculture feed
Catfish = 0.8% of total aquaculture feed
Total Milkfish (Total feed – Tilapia feed – Shrimp feed – Catfish feed) = 46.6%
Milkfish in cages and pens (production in 2003 at FCR = 2.5:1)

3.6 Economics of feeding

The cost of production varies with the level of intensification. The cost of production is lowest in extensive system (US$0.47/kg) and highest in intensive systems (US$0.84/kg) and this is related to high feed inputs and installation of life support systems (Table 29). Profits can still be made intensive milkfish culture as long as the higher production costs are compensated for by high yields and a high fish price. However, if the cost of fish is low then extensive systems, without feeding, are more profitable. This implies that farming practices may change periodically (e.g. extensive to semi-intensive, feeding to no feeding) to maximise income and profits depending on environmental factors (e.g., season, natural food production) and fish price (affected by supply and demand and price of other commodities).

4. PROBLEMS AND CONSTRAINTS

The increasing cost of raw material is the main problem that impacts on aquaculture and its associated feed industry. Because of the high cost of raw materials the Philippines is currently uncompetitive with respect to fish and shrimp production.

Availability of feed ingredients. The perennial shortage of key raw materials, such as fishmeal and soybean meal is highly problematic to feed manufacturers and feedmills that are unable to cope with the problem are forced to shutdown (AFSD-BAI, 2005). However, procurement is a greater problem for the smaller rather than the larger manufacturers in that they are better able to benefit from the National Food Authority procurement system, because of their bulk purchasing power. Clearly, there is a need for the smaller producers to cooperate such that they can also benefit from the NFA system.

High cost of feed. Feed prices are highly dependent on availability of local ingredients (rice bran, copra) and the cost of imported materials (especially fishmeal). Depreciation of the Philippine peso against foreign currencies has increased the domestic cost of imported ingredients. For example, the average cost of producing tilapia feed in 2003 was US$236–309/tonne, of which 70–90 percent of the cost was attributed to imported feed ingredients such as fishmeal, wheat, soybean meal, vitamins and minerals. The price of local ingredients is also volatile because of the seasonal nature of supply.

Low price of fish and a reduced demand for feed. The price of fish is largely dictated by the price of other market commodities and not necessarily related to the cost of production. Aquaculture products must compete with other meat and food. Intensive farmers are sometimes pressured to accept low prices due to large volume that have to be sold at harvest. If the profit margins are too low then farmers are discouraged to use feed and may revert to the more traditional culture methods. The effect of this is drop in the demand for manufactured feeds.

TABLE 29
Comparison of production costs (US$) under different culture conditions

Inputs	Culture Systems		
	Extensive	Semi-intensive	Intensive
Cost (US$/ha)			
Fertilizer	185.84	83.83	3.36
Feed	-	1 134.00	3 402.00
Other expenses	165.45	560.18	1 217.27
Total	**351.30**	**1 788.01**	**4 622.64**
Cost (US$/fish)			
Fertilizer	0.07	0.01	-
Feed	-	0.14	0.17
Other expenses	0.07	0.07	0.06
Total	**0.14**	**0.22**	**0.23**
Cost (US$/kg fish)			
Fertilizer	0.25	0.04	-
Feed	-	0.51	0.62
Other expenses	0.22	0.25	0.22
Total	**0.47**	**0.80**	**0.84**

Stocking density (fish/ha): extensive, 2 500; semi-intensive, 8 000; intensive, 20 000
Fertilizer includes chicken manure and inorganic fertilizers (21-0-0, 46-0-0, 16-20-0)
Cost of feed, US$0.38/lkg; assumed FCR: semi-intensive, 1.6, intensive, 1.8
Other expenses include cost of lime, fish seed/fry, labour, salaries, electricity, and diesel in semi-intensive and intensive systems
US$1.00 = 55.00 Pesos

Delay or non-payment of feed purchases. Because of low profits farmers will often delay payment for feed or not pay at all. This has a cascading effect back to the manufacturer, which in turn may lead to higher feed prices or may result in the closure of feedmills.

Underutilized feedmilling capacity. The animal feedmilling capacity in the Philippines is underutilized and yet many livestock and poultry feed manufacturers are switching to aquafeed production. This may lead to the demise of many small-scale manufacturers. The under-utilised capacity may be attributed to the price of feed, which forces the farmers to use other feeds such as trash fish and / or rice bran.

Preparation of farm-made feeds. The use of farm-made feeds and single-feed ingredients is an alternative way by which to reduce feed cost. However, on-farm feed manufacturing has not developed substantially in most areas because of the high capital requirements and the high cost and erratic supply of raw materials. Small farmers cannot compete with large feedmillers in the purchase of raw materials when these are in short supply. Large millers may receive 20–30 percent discounts for bulk purchase of ingredients

Nutritive value of feeds. The currently observed FCRs need to be reduced to improve income and profits.

Distribution and use of inorganic fertilizer. Fertilizers are frequently used in pond preparation but are not routinely used during the production cycle. Adequate fertilization protocols must be promoted to maximize the benefits of natural food. The cost of fertilizer distribution is high due to transport and inefficient port handling facilities (Aristorenas, 2000). There are malpractices in fertilizer trading such as under-weighing and adulteration, which the Fertilizer and Pesticide Authority cannot continuously monitor due to lack of funding.

Use of organic fertilizers and manure. Collection of manure from poultry and livestock in small-scale farms is seldom feasible because the animals are not usually confined. The use of compost in ponds could reduce production costs, though farmers are unenthusiastic about using compost because of high labour input requirements.

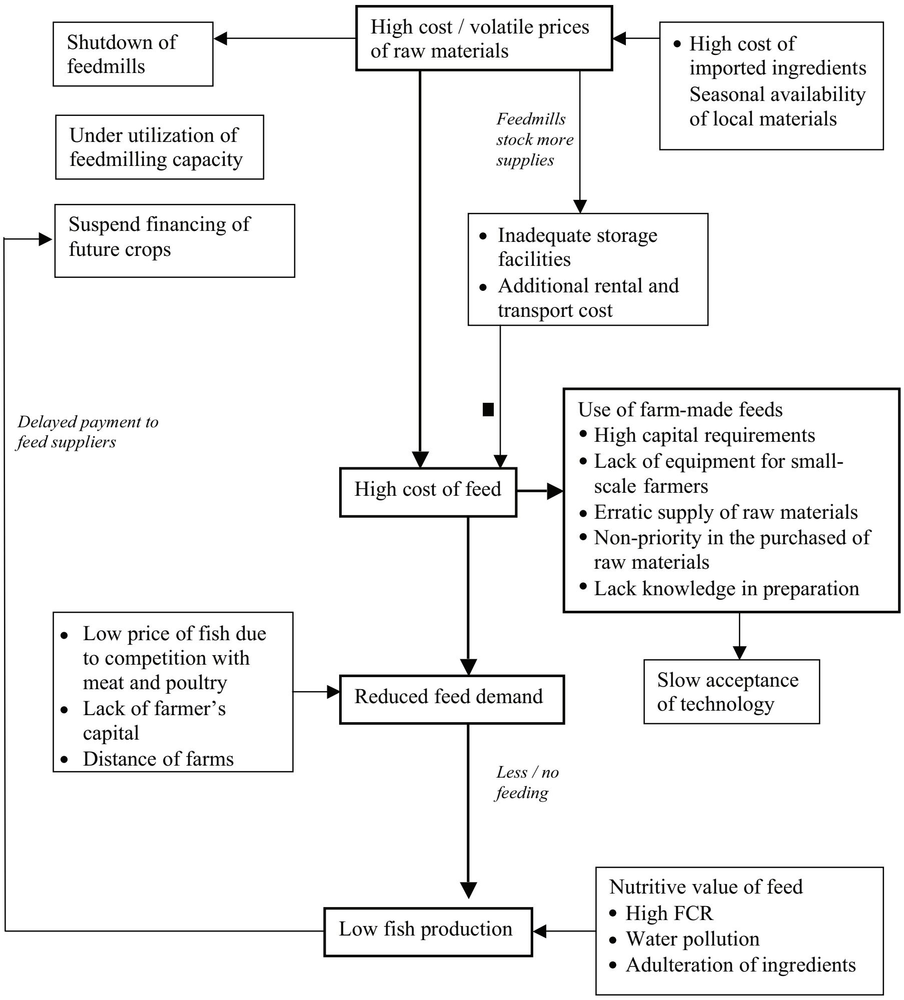
Other problems. The government does not have a national inventory of aquaculture systems and this precludes appropriate planning.

The problems and constraints that face the sector in the Philippines are schematically summarized in Figure 6.

5. RESOURCE AVAILABILITY AND THE EXPANSION OF THE AQUACULTURE INDUSTRY

Aquaculture production increased at an average of 7.2 percent per year during the period 1994 to 2004 with the highest growth registered in 2003-2004. Further expansion of the industry will depend on the availability of feed and fertilizer resources, allocation of suitable areas for expansion and technological advances in feed manufacturing and life support systems. The future requirements for feed and fertilizer are presented below

FIGURE 6
Problems and constraints of the aquaculture sector in the Philippines



Source: FPA (unpublished report)

and are based on projected fish production and FCRs. Fertilizer requirements were predicted based on pond area and recommended application rates.

5.1 Feed requirements

The projected feed requirements are based on available commercial feed consumption data. The average increase in the rate of production of various species over the past four to ten years in different culture systems was used to predict fish production and consequently the feed requirement of the industry (Table 30). It is predicted that milkfish pond culture will show the highest demand. Tilapia in ponds and cages will rank second, followed by milkfish in marine cages and pens, followed by tiger shrimp. Other species like catfish, grouper and mudcrab will eventually require substantial amounts of artificial feeds because of increasing production. Trash fish, as elsewhere in SE Asia, is becoming a limiting resource and every effort must be made to replace its use by artificial feeds in coming years. Assuming a linear increase in production of all species, the total feed requirement in 2014 is projected to be in the range of 1.34 million tonnes. This estimate could be the upper maximum as not all fish farmers will use manufactured feeds and FCRs will decrease.

TABLE 30
Current aquafeed production and future requirements (tonnes)

Species	Average growth during 1994-2004 (%/year)	Aquaculture production		Estimated feed production in 2003[b]	FCR	Feed requirement in 2014[c]
		2004	2014[a]			
Milkfish						
Brackish-water & freshwater pond	6.0	200 531	320 850	-	2.0	641 699
Brackish-water fish cage	6.0	4 056	6 490	-	2.0	12 979
Marine fish cage	6.0	23 179	37 086	-	2.5	92 716
Marine fish pen	6.0	14 173	22 677	-	2.5	56 692
Sub-total				16 974		804 086
Tilapia						
Brackish-water and freshwater pond	6.0	80 877	129 403	-	2.0	258 806
Freshwater cage and pen	6.0	64 779	103 646	-	2.0	207 293
Sub-total				29 908		466 099
Catfish	13.4	1 930	4 516	1 685	2.3	10 387
Grouper	5.5	170	264	-	2.3	606
Tiger shrimp	-0.8	35 916	33 043	11 472	1.8	59 477
Unspecified feed				114 356		
Total				**204 396**		**1 340 656**

[a] Predicted based on average growth rate of all species per year from 1994-2004, except for shrimp (1998-2004); [b] No available data for 2004; [c] Projected production x FCR

To establish whether the raw material supply can meet the demand of future aquafeed requirements an analysis was undertaken in which the requirements (Table 31) where juxtaposed with the projected available resources (Table 15). Energy sources like rice bran, corn bran and cornstarch are the most abundant feedstuffs. If the requirement for energy sources in 2014 will amount to some 717 000 tonnes (Table 31) then the projected available energy sources (10 158 171 tonnes, Table 15) will be adequate to cater for the needs of aquaculture. Coconut oil is the next most available resource but its use in aquafeeds is minimal. The total coconut oil requirement is only 3.6 percent of the projected total amount available. Other sources of oils such as soybean and fish oil must be developed to supply the need for n-3 and n-6 fatty acids in combination with coconut oil. The availability of copra meal and cake is adequate for all animal feed requirements. This commodity is only used in tilapia feeds such that the total aquaculture requirement for this material is low (4.2 percent of the total animal feed requirement). Because of the abundance of copra meal there is a real and urgent need for research and development to increase its use in aquafeeds. Domestic production of meat and bone meal can satisfy the needs of aquaculture. However, because of the requirements for swine feed the total supply will not be able to meet the demands of the animal feed industry as a whole. Soybean meal, which is the second most commonly used ingredient in aquafeeds (36 percent of total feed inputs), must be partially replaced by other legumes. All crustacean meal products are imported and this will not change. Some locally abundant ingredients are still underutilized and these are poultry by-product meal, feather meal and blood meal. These materials, if properly processed, could replace other feedstuffs that are in short supply and would assure the availability of feed ingredients for the future expansion of the aquaculture industry.

5.2 Fertilizer requirement

Fertilizers are needed in extensive and semi-intensive pond culture to promote natural productivity. The requirement for fertilizer depends on fishpond area. Given that the expansion of aquaculture in brackish waters is now prohibited this variable will be assumed to remain stable for the next 10 years. The medium term Philippine Development Plan 2004-2010, however, has allocated new areas for agribusiness that provides an additional 11 390 ha for milkfish and tilapia culture (NEDA, 2004). At an

TABLE 31

Estimated future requirements of feed ingredients for aquafeed production in the Philippines (tonnes)

Species	Feed requirement	Energy sources (rice bran/corn bran/wheat flour)	Copra meal/cake	Soybean meal	Fishmeal	Oils (fish/soybean/coconut)	Shrimp meal/ shrimp head meal	Blood meal
2003*								
Omnivore								
Milkfish	95 173	51 393	-	28 552	10 469	3 807	-	-
Tilapia	96 067	40 348	9 607	24 017	17 292	-	-	-
Catfish	1 685	-	-	-	-	-	-	-
Carnivore								
Grouper	minimal	-	-	-	-	-	-	-
Crustaceans								
Tiger shrimp	11 472	2 294	-	2 868	2 868	574	1 721	-
Total	204 397	94 036	9 607	55 437	30 629	4 381	1 721	-
2014								
Omnivore								
Milkfish	804 086	434 207	-	241 226	88 449	32 163	-	-
Tilapia	466 099	195 762	46 610	116 525	83 898	-	-	-
Catfish	10 387	4 155		3 116	234	519	-	-
Carnivore								
Grouper	606	133	-	36	121	36	61	121
Crustaceans								
Tiger shrimp	59 477	11 895	-	14 869	14 869	2 974	8 921	-
Total	1 340 656	646 152	46 610	375 773	187 572	35 693	8 982	121
% of total feed requirement		48.2	3.5	28.0	14.0	2.7	0.7	< 0.1

*No available data for 2004

Total inclusion levels (%): Energy sources - milkfish, 54; tilapia, 42; catfish, 40; grouper, 22; tiger shrimp, 20; mud crab, 27; copra meal/cake - tilapia, 10; soybean meal - milkfish, 30; tilapia, 25; catfish, 30; grouper, 6; tiger shrimp, 25; mud crab, 11; fishmeal - milkfish, 11; tilapia, 18; catfish, 20; grouper, 20; tiger shrimp, 25; mud crab, 25; oils - milkfish, 4; catfish, 5; grouper, 6; tiger shrimp, 5; mud crab, 5; shrimp meals - grouper, 10; tiger shrimp 15; meat and bone meal and blood meal - grouper, 20 (Based on standard formulations, in: Alava, 2002)

TABLE 32
Estimated fertilizer requirement for extensive and semi-intensive brackish-water pond culture in the Philippines

Region	Fishpond area (ha)[a]	Organic fertilizer requirement (tonnes)[b]	Inorganic fertilizer requirement (tonnes)[c]			
			16-20-0	18-46-0	46-0-0	21-0-0
CAR	-					
I	21 550	43 100	10 775	4 310	3 233	431
II	100	200	50	20	15	2
III	48 980	97 960	24 490	9 796	7 347	980
NCR	2 900	5 800	1 450	580	435	58
IV-A	5 850	11 700	2 925	1 170	878	117
IV-B	7 690	15 380	3 845	1 538	1 154	154
V	15 870	31 740	7 935	3 174	2 381	317
VI	58 720	117 440	29 360	11 744	8 808	1 174
VII	9 030	18 060	4 515	1 806	1 355	181
VIII	2 340	4 680	1-1 70	468	351	47
IX	25 010	50 020	12 505	5 002	3 752	500
X	4 150	8 300	2 075	830	623	83
XI	6 710	13 420	3 355	1 342	1 007	134
XI	3 260	6 520	1 630	652	489	65
XIII	5 830	11 660	2 915	1 166	875	117
ARRM	1 470	2 940	735	294	221	29
Total	219 460	489 998	109 730	43 892	32 919	4 389
Total production/ import (2003/2004)		52 388 734[d]	266 925	229 731	733 683	515 276
% of total production/import		0.9[e]	41.1	19.1	4.5	0.9

[a]Assuming no expansion in fishpond area; area for each region was determined by Landsat Image (NAMRIA, 2005) while total area is from Philippines Fisheries Statistics 2001-2003 (BAS, 2005a) and Philippines Fisheries Profile (BFAR, 2005).
[b]Assumed application rate: 1.5 tonne/ha in first cropping and 0.5 tonne/ha in second cropping.
[c]Assumed application rate: 50 kg/ha 16-0-0 or 20 kg/ha 18-46-0, 15 kg/ha 46-0-0, and 10 kg 21-0-0 applied during pond preparation and 1/2 of these rates every 15 days during four-month culture period; 21-0-0 is applied only during pond preparation; 2 crops/year (total inorganic fertilizer/year, 500 kg 16-20-0 or 200 kg 18-46-0, 150 kg 46-0-0, 20 kg 21-0-0).
[d]Production of chicken manure at 268g/day/2.3 kg animal (Whetsone 1974 in: Nash and Brown 1980)
[e](Total requirement / Total production and import) x 100.

application rate of 1.5 tonnes manure/ha for the first annual crop and 0.5 tonnes manure/ha for the second crop, the total aquaculture manure requirement in the Philippines is estimated to be 489 998 tonnes in 2003 and in the next 10 years (Table 32). A comparison of the data in Table 7 and 32 suggest that future manure supply will be adequate to meet the demands of pond aquaculture. The calculated requirement of inorganic fertilizers in 2004 based on recommended application rates and pond surface area is shown in Table 32. Most of the fertilizer requirements of the country will be imported.

6. RECOMMENDATIONS

On the basis of this review the following recommendations can be made for the future sustainable development of the sector in the Philippines. Several of the recommendations are considered to be of a general nature, while others specifically pertain to the more effective implementation of government programmes.

6.1 General

1. National research and development programmes on the use of other readily available raw materials for use in aquafeeds such as copra oilseed cake, legumes (e.g. cowpeas) and the promotion of soybean production should be established.
2. Strategies should be developed to monitor the quality and composition of available feed ingredients such as local fishmeal, rice bran, copra meals and oils such that farmers get better value for money.

3. The manufacture and use of farm-made feeds using locally available materials is recommended for small-scale fish farmers especially in remote areas and extension services and training programmes on feed preparation should be intensified in areas needing assistance.
4. Reducing feed costs through efficient feed conversion is the key to increasing returns. This requires further research on the nutrient requirements of aquaculture species.
5. There is a need to shift from using trash fish to cost-effective formulated feed.
6. Greater emphasis has to be given to the environmental impact of aquaculture. It is recommended that the environmental carrying capacity of major receiving waters in the country be established and that this should guide the expansion of the sector.
7. Nutrient discharge from shrimp farms should be minimized. Some shrimp farms already practice low-discharge techniques. There is a need to further refine and disseminate this technology to fish farmers.
8. According to the regional guidelines (SEAFDEC, 2005), a research-based quality standard for feeds and feed additives and guidelines for their proper selection and use should be established.

The recommendations made above offer significant opportunities for public/private partnerships involving farmers, feed manufacturers, private research institutes, universities and statutory institutions.

6.2 Effective implementation of government programmes

9. The further clustering of fish and shrimp farms and feedmills should be strongly promoted. The Department of Science and Technology (DOST), BFAR and the Department of Trade and Industry (DTI) have initiated such a program in some parts of the country.
10. The Balanced Fertilization Strategy (BFS) is an innovative and cost efficient approach for the use and management of location-specific combinations of inorganic and organic fertilizers. The BFS likewise aims to correct the declining rice production caused by fertilizer misuse and impact of urea overuse. This programme requires active support by all aquaculture stakeholders. The Department of Agriculture through the FPA has agreed to establish regional bulk blending facilities in strategic regional sites in the Philippines. This strategy is also applicable to and must be developed for the aquaculture sector.
11. The manufacture and use of compost must be promoted. The National Rapid Composting Programme should be strongly supported by all stakeholders and extension services must promote the programme among fish and shrimp farmers. Government should establish and disseminate guidelines for the appropriate selection and use of organic compost.

ACKNOWLEDGEMENTS

The author wishes to thank the following institutions and individuals for providing valuable information without which this report could not have been produced.

Aquaculture Department, Southeast Asian Fisheries Development Center
Animal Feed Standard Division, Bureau of Animal Industry, Department of Agriculture
Bureau of Agricultural Statistics
Bureau of Customs
Bureau of Fisheries and Aquatic Resources (Region III, IV-B, VI, VII, XIII, CAR)
Department of Environment and Natural Resources
Fertilizer and Pesticide Authority
National Mapping and Resource Information Authority

National Meat Inspection Service
National Statistics Office
Feed manufacturers and distributors
Ms Emerald Corpuz-Uy
Mr Philip Cruz
Mr Teodoro Cruz
Ms Arlene de la Vega
Mr Nelson Jardeleza
Mr Philip Ong
Mr Jun Toreda

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