Milkfish culture in cages at SEAFDEC/AQD, Igang marine station, Guimaras, Philippines. Photo by J.A. Ragaza.

A Fish Farmer's Role in Sustainable Aquaculture: An Overview of Philippine Aquaculture

Jonni Fay C. Teves and Janice A. Ragaza

The expansion of Philippine aquaculture is essential to addressing poverty and food insecurity in the midst of a seemingly irreversible decline in national capture fisheries. Concomitant with its rise, however, are compounding environmental problems caused by climate change, lackluster governance and irresponsible farming practices. It is equally important to ensure aquaculture sustainability so that fish demand from a rapidly growing population is continually met and that fish farmers' socioeconomic well-being is secured. As such, programs have been developed that aim to enjoin the government and private sectors with fishing communities to realize this goal.

Contribution of the Fishery Sector to the Philippine Economy

The Philippines is a tropical, archipelagic country comprised of 7,107 islands located in Southeast Asia. Surrounded by the Pacific Ocean on the east, the Celebes Sea and Bornean waters on the south and the South China Sea on the west and north (Bautista 2009), it has a total territorial water area of 2,200,00 km^2 while the total land area covers only about 300,000 km^2. Its 17,460 km coastline spans marine areas that include coral reefs, seagrass and algal beds. In the interior of landmasses are freshwater and brackishwater

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Fish pens using bamboo poles for enclosure at SEAFDEC/AQD, Binangonan Freshwater station, Rizal, Philippines. Photo by J.A. Ragaza.

Lake-based cages at SEAFDEC/AQD, Binangonan Freshwater station, Rizal, Philippines. Photo by J.A. Ragaza.

swamplands, fishponds, lakes, rivers and reservoirs (Yap 1999, BFAR 2011).

With its extensive aquatic resources, the country was the fifth top fish producer in the world in 2010. However, total production has decreased at a rate of 3.6 percent, from 5.16 million t in 2010 to 4.97 million t in 2011. Nonetheless, total export value was US$ 871 million while import value was US $217 million, leaving a positive trade balance of US$ 654 million. Overall, the fishery sector contributed 1.9 percent (US$ 4.23 billion) and 2.2 percent (US$ 3.02 billion) at current and constant prices respectively of the country's GDP (US$ 224.79 billion at current prices and US$ 136.79 billion at constant prices) (BFAR 2010a, BFAR 2011).

Annual performance of Philippine fisheries is attributed to three subsectors: municipal (small-scale) fisheries, commercial fisheries and aquaculture. Municipal and commercial sectors are distinguished by fishing location and vessel capacity—the municipal sector involves capture operations in inland and coastal areas with or without the use of a vessel not exceeding 3 gross t, while commercial fisheries is done in offshore waters using vessels of at least 3 gross t. Aquaculture is defined as the cultivation and farming of aquatic plants and animals in inland, coastal and marine areas (FAO 2001).

Among the three subsectors, aquaculture made the greatest contribution to fish production in 2011, with 52.4 percent (2.61 million t), followed by the municipal sector with 26.8 percent (1.33 million t) and commercial sector with 20.8 percent (1.03 million t) (BFAR 2011).

Status of Philippine Aquaculture

Philippine aquaculture can be traced to the fourteenth century, starting with the use of traditional, low-density pond culture of milkfish (Lopez 2006). Only in the 1940s was aquaculture recognized as an important industry, with 20,000 t of production, and since then has grown rapidly (Yap 1999). Total aquaculture production has increased from 0.29 million t in 1980 to 2.54 million t in 2012 (CountrySTAT Philippines 2012), comprising 42.5 percent of total fisheries output in 2013. Its steady growth, together with increased commercial fishery production, allowed the fishery sector to recover from a contraction in growth the previous year (BAS 2014). It has had an average annual growth rate in production volume of 8.6 percent from 1997 to 2008, and the production value is now nearly triple the amount in 1996 (BAS 2014, CountrySTAT Philippines 2012).

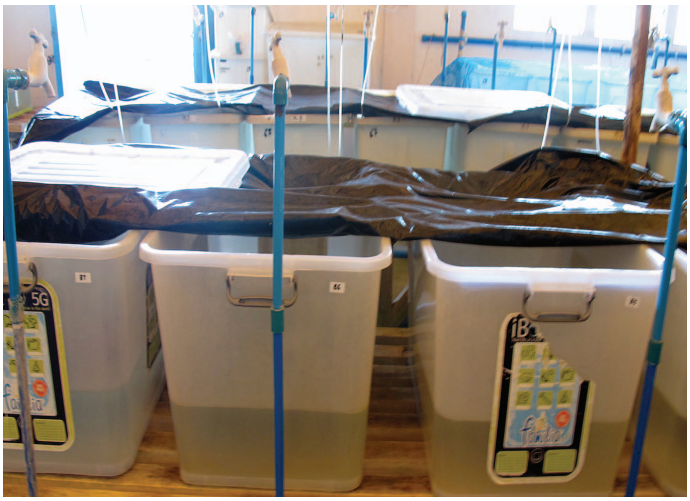
Philippine aquaculture involves many species and farming systems. As of 2007, there are 16 reported aquaculture species, among which four are considered most important: seaweeds, milkfish *Chanos chanos*, Nile tilapia *Oreochromis niloticus* and tiger shrimp *Penaeus monodon* (BFAR 2011, Sumagsay-Chavoso 2007). In 2011, seaweed was the greatest contributor to production at 70.6 percent (1.84 million t); followed by milkfish, 14.3 percent (372,580 t); tilapia, 9.9 percent (257,385 t); shrimps and prawns, 1.9 percent (50,159 t); and others, 3.3 percent (87,162 t) (BFAR 2011).

Seaweeds. There are two groups of farmed seaweeds in the Philippines, those which are extracted for industrial chemicals, such as *Eucheuma* spp., and edible species, mainly *Caulerpa* spp. Research on new seaweed strains (*Kappaphycus* spp.) has been undertaken in 2008 to generate fast-growing, disease-resistant seaweeds for commercial farming (SEAFDEC/AQD 2008). The Philippines is the world's largest producer of farmed *Eucheuma* (BFAR-PHILMINAQ 2007).

Milkfish. Locally known as bangus, milkfish is the country's national fish, having a high level of consumer acceptance and the largest share of farmed foodfish production. In 2001-2005, the Philippines was consistently the top milkfish producer in the world, and has increased growth rate over the recent years (BFAR 2008). Meanwhile, milkfish processing is a growing industry in the country. Fish are deboned before they undergo marinating or smoking to make them more palatable to the current younger generation, who are often deterred by its bony features. "Boneless bangus," as it is called, is a uniquely popular Philippine product (Yap *et al*. 2007).

Tilapia. Tilapia (*Oreochromis mossambicus*) was first introduced to the Philippines from Thailand in 1950. Nile tilapia (*O. niloticus*) was first introduced in 1972 and has since gained wide acceptance among farmers and consumers (Yap 1999). It is the main tilapia species cultured in the Philippines and in 2013 the country

Seahorse hatchery at SEAFDEC/AQD, Tigbauan, Iloilo, Philippines. Photo by J.A. Ragaza.



Rearing tanks for giant freshwater prawn at SEAFDEC/AQD, Binangonan Freshwater station, Rizal, Philippines. Photo by J.A. Ragaza.

maintained its rank as the fourth top tilapia producer, contributing 8 percent to global tilapia production (SunStar 2013).

Shrimp/prawns. In the early 1990s, the Philippines ranked as the third top shrimp producing country in the world, specifically based on the culture of the black tiger shrimp *P. monodon*, locally known as sugpo. However, high stocking densities in pursuit of high production have led to the spread of bacteria diseases. Although initially mitigated by antibiotics, the causative bacteria developed resistance, causing the collapse of shrimp farms (Yap 1999). Culture of black tiger shrimp then waned, clearing the way for the culture of Pacific white shrimp *P. vannamei*, the species of current interest. Despite opposition by local NGOs and producers fearful of another disease outbreak, Pacific white shrimp are preferred for ease of culture, better survival and lower protein requirement in feeds, together leading to cheaper shrimp in the market (Sulit *et al*. 2005).

Culture environments. Species are cultivated in fish pens, cages and ponds in marine, brackishwater, and freshwater environments. Open coastal water is the largest culture environment, mainly as a result of the seaweed industry. Mariculture began in the 1930s with oysters, followed by the culture of mussels 20 years later. However, it progressed only with the start of carrageenophyte seaweed farming in the 1970s (Yap 1999).

Brackishwater areas, such as mangrove swamps and estuarine areas, is the second largest culture environment. The two main brackishwater species cultured are milkfish and black tiger shrimp; others include mudcrabs *Scylla serrata*, grouper *Epinephelus* spp., seabass *Lates calcarifer* and other penaeid shrimps.

Freshwater aquaculture started with the introduction of Mozambique tilapia in 1950 and the subsequent spread of backyard tilapia culture throughout the country. Freshwater aquaculture came to prominence in the mid-1970s with the discovery that milkfish could be reared without feeding at commercial levels in Laguna de Bay fish pens. Thereafter, tilapia were successfully cultured in cages, initially in Laguna de Bay and then in other lakes, dams and reservoirs. Commonly cultured freshwater species aside from tilapia are bighead carp *Aristichthys nobilis* and common carp *Cyprinus carpio*, African catfish *Clarias gariepinus*, snakehead *Channa striata*, euryhaline milkfish and most recently the freshwater prawn *Macrobrachium rosenbergii* (Garcia and Sumalde 2013, BFAR-PHILMINAQ 2007, Lopez 2006).

Aquaculture, Food Security and Poverty Alleviation

Aquaculture has steadily contributed to the fish supply, a panacea for dwindling fish stocks from overfishing and habitat degradation. The importance of aquaculture is underscored inasmuch as fish remains the major essential protein source for the poor majority, with a 42.5 percent share of total animal protein consumption (Kawarazuka and Béné 2011) as well as the greater food insecurity experienced in rural compared to urban areas (Ravanera and Emata 2012). Pressure on the fish supply has been intensified by the impacts of climate change, as evinced by erratic weather patterns and the increasingly powerful and frequent typhoons that ravage the country. Fish farmers are highly vulnerable to loss of food and income. This was keenly felt when Typhoon Haiyan (known locally as Yolanda) wreaked havoc in the major aquaculture and fisheries producing regions in the Visayas in November 2013, leaving most small-scale fish and seaweed farmers displaced. Dependence of poor fish farmers on the fish supply is augmented by the fact that families in the lowest income groups spend more on fish products for food compared to the average Filipino household (Worldfish Center 2008).

Sustainability in Aquaculture

The rise of aquaculture has negatively impacted ecosystems. Proliferation of fish pens and cages has led to fish kills because of oxygen depletion, accumulation of pollutant toxins and diseases. Species have become threatened and endangered. Mangrove areas were converted to fishponds, a practice that has compromised natural filtration and has added up to water pollution (Bergquist 2007, BFAR-PHILMINAQ 2007).

The Philippine government's Mid Term Development Program (2004-2010) has identified aquaculture as a subsector that will generate new jobs and ensure food security geared toward the country's goal of economic development (Nagothu and Ortiz 2007).

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Mud crab rearing tanks at Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of the Philippines-Visayas, Miagao, Iloilo, Philippines. Photo by J.A. Ragaza.

Rotifer culture, as feed for fish larvae at Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of the Philippines-Visayas, Miagao, Iloilo, Philippines. Photo by J.A. Ragaza.

If aquaculture is aimed toward positive development, sustainability programs must integrate the following factors: technical (feeding practices, aeration, broodstock quality); physical (temperature, salinity); institutional (legislation, externalities); and socioeconomic (poverty, farmers' management abilities) (Bergquist 2007).

Technical factors. The search for potential plant-based proteins, including water hyacinth and white cowpea as alternatives for fishmeal in aquafeeds, has gained importance to reduce dependence on depleted marine fish stocks (SEAFDEC/AQD 2008). This also calls for a shift toward cultivating herbivorous and omnivorous fishes, such as milkfish, tilapia and catfish.

Studies have also been conducted that aim to improve the living standards of fish farmers and consumers, provide avenues for employment and ensure food security throughout the country. These include the genetic improvement of tilapia and, more recently, the project of identifying tilapia "super strains" (Worldfish 2013), improving technologies for breeding new aquaculture species of high economic value, such as snubnose pompano *Trachinotus blochii*, scat *Scatophagus argus* and Napoleon wrasse *Cheilinus undulatus*, among others (SEAFDEC/AQD 2010).

Innovative studies for resource enhancement to increase species stocks also have helped sustain the aquaculture industry. Low survival of seahorses *Hippocampus comes* in hatcheries has been a problem until the recent discovery of disinfecting its live food (copepods) with low doses of disinfecting chemicals in Guimaras, West Central Visayas. This technique has increased seahorse survival, which could enable mass production and consequently rehabilitation of depleted stocks (SEAFDEC/AQD 2014).

Physical factors. Studies on how climate change can affect the aquaculture industry have been conducted to aid fish farmers in adapting to this change. For example, effects of elevated water temperatures and acidity on performance of important cultured fishes, such as milkfish and seabass, have been assessed. Search and identification of species that can be used for integrated multi-trophic aquaculture (IMTA), an approach that promotes waste management and minimizes environmental impacts of aquaculture, is also being examined (SEAFDFEC/AQD 2011).

Recently completed research in Dagupan on saline tilapia called "mollibicus," which can be reared in coastal areas, proves to be promising in the face of increasingly frequent fishkills in brackishwater environments (The Fish Site 2014a). These studies can help provide preparatory and mitigation measures that can ultimately cushion the impacts of climate change on food supply and livelihood of fisherfolk communities.

Institutional factors. The Bureau of Fisheries and Aquatic Resources (BFAR) is the leading fishery organization in the Philippine government that has a mandate under the Republic Act (RA) 8550 of 1998 to conserve, protect and use fishery and aquatic resources sustainably, alleviate poverty and provide supplementary livelihoods for Filipinos (Lopez 2006). Other research organizations include the Aquaculture Department of Southeast Asian Fisheries Development Center (SEAFDEC/AQD), Worldfish Center, Food and Agriculture Organization (FAO) and the Asian Development Bank (ADB), among others (Lopez 2006).

At present, fisheries researchers have been collaborating with private sector fish farmers and policy makers from the national and local government through forums on enforcing limits on aquaculture operations and other environmental concerns (BFAR 2010b). This is to ensure the fair allocation of coastal resources; otherwise externalities (indirect costs to aquaculture) are incurred. Externalities include reduction in natural fish productivity and increased vulnerability to natural disasters, such as typhoons and tsunamis, resulting in loss of natural coastal protection (as provided by mangroves).

Government institutions are also strongly encouraged to mobilize funds for the benefit of fish farmers. For example, the Quezon provincial state government has been providing free materials for milkfish cage construction, such as bamboo poles, nets, ropes and fingerlings to fishermen, thereby paving the way for aquaculture development in the region (The Fish Site 2013b). Similarly, BFAR has allocated US$ 737,000 to the local government of Cebu to help rehabilitate fish cages, seaweed farms, fish pens and coral reefs damaged by Typhoon Yolanda (The Fish Site 2014b). As the country has been facing shortages in the supply of seaweed, the

Checking water quality in milkfish culture ponds at Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of the Philippines-Visayas, Miagao, Iloilo, Philippines. Photo by J.A. Ragaza.

Outdoor circular fish tanks at Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of the Philippines-Visayas, Miagao, Iloilo, Philippines. Photo by J.A. Ragaza.

government also increased the budget from US$ 924,000 in 2011 to US$ 6.275 million in 2012 to develop the seaweed industry. This could help farmers supply more seaweeds to avoid importing from Indonesia, and eventually retrieve the country's position as the top seaweed industry in the world (Dagooc 2012).

Socioeconomic factors. The capacity of fish farmers to run aquaculture operations sustainably depends on their economic standing, education and empowerment, inasmuch as these can provide farmers with access to the latest aquaculture information and technologies. Access to this information is normally limited to local elites, who are more capable of acquiring institutional and natural resources, thus placing poor and unskilled laborers at a great disadvantage (Bergquist 2007). To address this, the Philippine government has adopted a shift in its policy program from aquaculture development to aquaculture for rural development, a 'pro-poor' program that promotes livelihood projects in rural communities (Lopez 2006). Government and private sectors also have been conducting a series of workshops and skills training throughout the country. These aim to educate fishing communities on the importance of aquaculture resources, impacts of climate change and adoption of the latest environment-friendly technologies (SEAFDEC/AQD 2011). For example, the Misamis Occidental Project has trained fishers on improved grouper cage culture technology so they can operate cage farms in the province (SEAFDEC/AQD 2010). Skills training for farm operations is positively correlated with income, emphasizing how the lack of proper skills and access to technology remain among the main constraints to aquaculture development in the country (Nagothu and Ortiz 2007).

Outlook

The Philippines is endowed with a tropical climate and vast aquatic resources conducive for aquaculture expansion. However, it also faces an overarching problem—climate change—parried only by an equally potent solution through integrated sustainability programs. While anchored in research and development of new environment-friendly technologies, government and private sectors alike must take on the task of bringing these to the industry's real major stakeholders, the poor majority. Given a substantial dependence on aquaculture for food and income, their wide and active participation would provide for their needs and also sustain the fast-paced growth of aquaculture in the Philippines.

Notes

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References

Bautista, L.B. 2009. The Philippine treaty limits and territorial waters claim in international law. Social Science Diliman 5(1-2):102-127.

Bergquist, D.A. 2007. Sustainability and local people's participation in coastal aquaculture: regional differences and historical experiences in Sri Lanka and the Philippines. Environmental Management 40:787-802.

BAS (Bureau of Agricultural Statistics). 2014. Fisheries situation. Philippine Statistics Authority. www.bas.gov.ph/?ids=fisheriessituation

BFAR-PHILMINAQ (Bureau of Fisheries and Aquatic Resources (BFAR)-PHILMINAQ Project). 2007. Managing aquaculture and its impacts: a guidebook for local governments. Bureau of Fisheries and Aquatic Resources (BFAR)-PHILMINAQ Project, Diliman, Quezon City. Philippines.

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Concrete tanks for tilapia culture at SEAFDEC/AQD, Binangonan Freshwater station, Rizal, Philippines. Photo by J.A. Ragaza.

BFAR (Bureau of Fisheries and Aquatic Resources). 2008. Fisheries commodity roadmap: milkfish. Fisheries Policy and Economics Division, Bureau of Fisheries and Aquatic Resources, Diliman, Quezon City. Philippines.

BFAR (Bureau of Fisheries and Aquatic Resources). 2010a. Philippine fisheries profile 2010. Department of Agriculture, Bureau of Fisheries and Aquatic Resources, Diliman, Quezon City. Philippines.

BFAR (Bureau of Fisheries and Aquatic Resources). 2010b. Stakeholders meet to mitigate negative impacts of aquaculture. Bureau of Fisheries and Aquatic Resources, Diliman, Quezon City. Philippines. www.bfar.da.gov.ph/pages/publications/managing percent20aquaculture.htm

BFAR (Bureau of Fisheries and Aquatic Resources). 2011. Philippine fisheries profile 2011. Department of Agriculture, Bureau of Fisheries and Aquatic Resources, Diliman, Quezon City. Philippines.

CountrySTAT Philippines. 2012. Aquaculture: value of production by type/ environment/ species by region, by region, by province and by period. Philippine Statistics Authority. countrystat.bas.gov.ph

Dagooc, E.M. 2012. Phl out to regain lead as top seaweed source. Philstar. www.philstar.com/cebu-business/2012/11/17/867767/phl-out-regain-lead-top-seaweed-source

FAO (Food and Agriculture Organization of the United Nations). 2001. Aquaculture topics and activities. Aquaculture Resources. *In*: FAO Fisheries and Aquaculture Department [online], Rome, Italy. www.fao.org/fishery/topic/13530/en

Garcia, Y.T. and Z.M. Sumalde. 2013. Productivity growth in Philippine agriculture: growth of aquaculture productivity in the Philippines. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA); Bureau of Agricultural Research (BAR); Philippine Rice Research Institute (PhilRice). Philippines.

Kawarazuka, N. and C. Béné. 2011. The potential role of small fish species in improving micronutrient deficiencies in developing countries: building evidence. Public Health Nutrition 14(11):1927-1938.

Lopez, N.A. 2006. Sustainable development and trends in the Philippine Aquaculture. Bureau of Fisheries and Aquatic Resources, Diliman, Quezon City. Philippines.

Nagothu, U.S. and I. Ortiz. 2007. Review and assessment of socio-economic issues of aquaculture in the Philippines: mitigating impact of aquaculture in the Philippines.Norweigan Institute for Water Research and PHILMINAQ.

Ravanera, R.R and C.H.B. Emata. 2012. Food and nutrition security in the Philippines: an overview. Xavier Science Foundation, Inc (XSF). Philippines.

SEAFDEC/AQD. 2008. Highlights 2008. Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Iloilo. Philippines.

SEAFDEC/AQD. 2010. Highlights 2010. Aquaculture Department, Southeast Asian Fisheries Development Center.

SEAFDEC/AQD. 2011. Highlights 2011. Aquaculture Department, Southeast Asian Fisheries Development Center.

SEAFDEC/AQD. 2014. Two innovations in aquaculture. Aquaculture Department, Southeast Asian Fisheries Development Center. www.seafdec.org.ph/2012/two-innovations-in-aquaculture

Sulit, V.T., M.E.T. Aldon, I.T. Tendencia, A.M.J. Ortiz, S.B. Alayon and A.S. Ledesma. 2005. Regional technical consultation on the aquaculture of *Penaeus vannamei* and other exotic shrimps in Southeast Asia. Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Iloilo. Philippines.

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

SunStar. 2013. PH 4th top producer of tilapia across the globe. SunStar Pampanga. www.sunstar.com.ph/pampanga/local-news/2013/10/17/ph-4th-top-producer-tilapia-across-globe-309123

The Fish Site. 2013a. Aquaculture and fishing operations destroyed in the Philippines. The FishSite News Desk. www.thefishsite.com/fishnews/22004/aquaculture-and-fishing-operations-destroyed-in-the-philippines

The Fish Site. 2013b. Fish hatchery developing aquaculture in Quezon State. www.thefishsite.com/fishnews/21359/fish-hatchery-developing-aquaculture-in-quezon-state

The Fish Site. 2014a. Saline tilapia research completed in Dagupan. The FishSite News Desk. www.thefishsite.com/fishnews/22782/saline-tilapia-research-completed-in-dagupan

The Fish Site. 2014b. Government gives P33 million to rehabilitate damaged farms and fish cages. The FishSite News Desk. www.thefishsite.com/fishnews/22770/government-gives-p33-million-to-rehabilitate-damaged-farms-and-fish-cages

The WorldFish Center. 2008. Supply and demand issues affecting fisheries and aquaculture in the Philippines. The WorldFish Center, Penang, Malaysia.

Worldfish 2013.Nile tilapia 'super strains' to help Philippines. Worldfish. worldfishcenter.org/press-release/nile-tilapia-super-strains-to-help-philippines

Yap, W.G. 1999. Rural aquaculture in the Philippines. RAP Publication 1999/20. Regional Office for Asia and the Pacific, Food and Agriculture Organization of the United Nations, Bangkok.

Yap, W.G., A.C. Villaluz, M.G.G. Soriano and M.N. Santos. 2007. Milkfish production and processing technologies in the Philippines. Milkfish Project Publication Series No. 2.