HOLISTICA Vol 11, Issue 3, 2020, pp.25-45 DOI:10.2478/hjbpa-2020-0030

COMMERCIALIZING THE MILKFISH HATCHERY-BRED FRY INDUSTRY IN THE PHILIPPINES: A WELFARE ANALYSIS

Yolanda T. GARCIA[1]*
Maria Esperanza T. GARCIA[2]
Arnulfo G. GARCIA[3]

Received: August 2020 | Accepted: November 2020 | Published: December 2020
Please cite this paper as: Garcia, Y.T., Garcia, M.E.T., Garcia, A.G (2020) Commercializing The Milkfish Hatchery-Bred Fry Industry In The Philippines: A Welfare Analysis, *Holistica Journal of Business and Public Administration*, Vol. 11, Iss. 3, pp.25-45

Abstract

This study aims to estimate the welfare gains of the Philippine milkfish industry in establishing local fry hatcheries to reduce imports from Indonesia and Taiwan. It also seeks to identify the industry stakeholders who gain from this import substitution endeavour. The economic surplus model was used to estimate the welfare gains from the commercialization of the hatchery-bred milkfish fry in the fishery sector. Specifically, the changes in consumer and/or producer surplus per stakeholder were compared to determine who the biggest gainers are. Results of the study showed that the consumer surplus from the milkfish fry industry was larger than its producer surplus. On the other hand, the reverse was true for the grow-out industry. It is interesting to note that the consumers in the fry industry and the producer in the grow-out industry were the same set of stakeholders, i.e., the milkfish grow-out operators, who gained the most from this development. The study also showed that commercializing the local milkfish hatchery technologies can bring about more benefits to the country than importing fry and fingerlings. Hence, the development of local hatcheries for other aquaculture species can be expected to bring similar welfare gains. More importantly, the technical and financial assistance that were extended by the government's fishery institutions through the GAINEX project as pioneered by DOST-PCAARRD can serve as an effective catalyst to prospective hatchery operators in reducing the risks, especially when setting-up a new enterprise like the hatchery-bred fry for an emerging aquaculture species in the country.

Keywords: Commercialization; import substitution; welfare gain; consumer surplus; producer surplus; milkfish; hatchery technology; hatchery-bred fry.

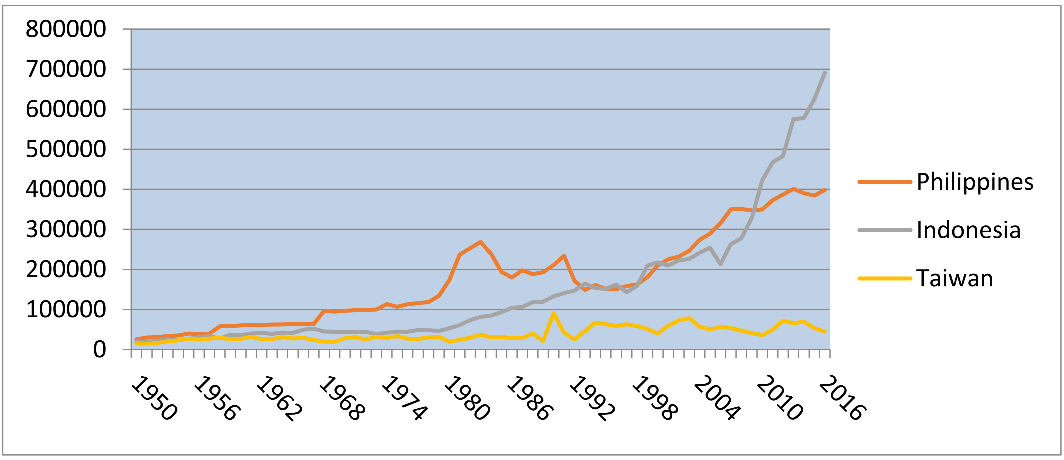
[1]* *Corresponding author. Professor, Department of Economics, College of Economics and Management, University of the Philippines Los Banos, Philippines, ytgarcia@up.edu.ph*
[2] *Former Research Assistant, Milkfish Impact Assessment Project, PCAARRD-World Fish Collaborative Project, Philippines, aggarcia006@gmail.com.*
[3] *Former Technical Consultant, Milkfish Impact Assessment Project, PCAARRD-World Fish and Retired Scientist, International Rice Research Institute, Philippines, met9garcia@gmail.com*

1. Introduction

Milkfish or Chanos chanos is the largest farmed fish species in the Philippines, contributing 50% to total food fish aquaculture in 2017 (PSA, 2018). Early records of milkfish farming in the country revealed 400 years of culture history (Bagarinao, 1999). Interestingly, milkfish is geographically confined only in the Asia-Pacific regions due to its intolerance to extremely low temperatures. Hence, aside from the Philippines, commercial aquaculture of milkfish occurs only in Indonesia, Taiwan and some parts of the Pacific Islands.

Up to 2009, the Philippines was the largest world producer of milkfish (Figure 1). By 2010 onwards, Indonesia had claimed the world production record. In 2016, Indonesia's milkfish production had reached 690,720 mt with the Philippines trailing behind at 398,088 mt. Taiwan ranks third with production of only 44,548 mt. To date, most of the world supply of milkfish came from aquaculture, i.e., Indonesia's supply of milkfish is 100% from aquaculture. On the other hand, about 98.8% of milkfish supply from the Philippines was contributed by aquaculture with only 1.2% coming from coastal fishing. Taiwan likewise reported wild capture of milkfish, but with negligible amount of only 0.01% of their total production. These data imply that supply of milkfish from major producing countries is generally sourced from aquaculture production.

Figure 1 Trend in milkfish production (mt) in the Philippines, Indonesia and Taiwan, 1950-2016

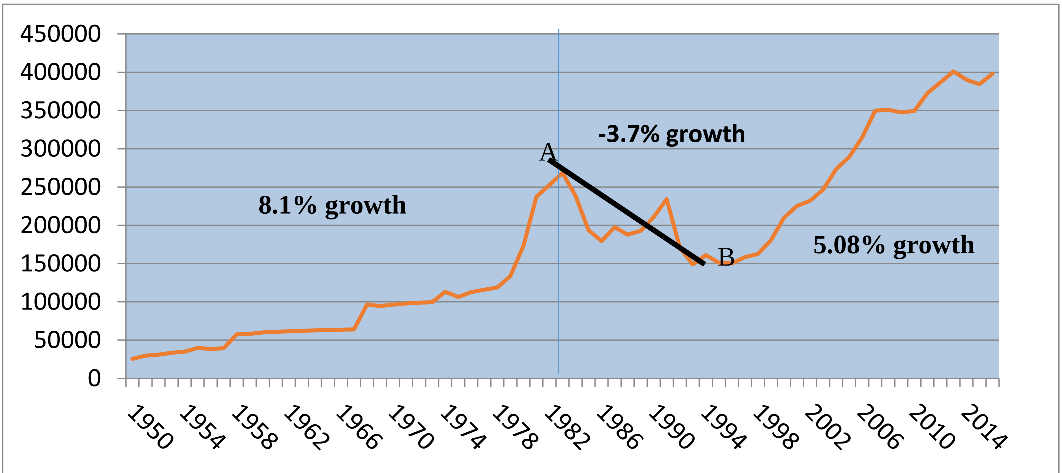


Source: FAOSTAT, 2018

Since 1950 to 1983, the Philippine milkfish production was steadily rising with an average growth rate of 8.1% (Figure 2). However, not all was rosy in the milkfish industry, since the production between the period 1984-1996 started to decline at an average growth rate of -3.7%. The deteriorating performance of the milkfish industry for more than a decade caused serious concern among the milkfish stakeholders, i.e., grow-out operators, traders and consumers including the country's policymakers in the fishery sector.

Incidentally, since the early days of milkfish farming in the country, grow-out operators had been largely dependent on wild-caught and imported fry as seed stock. However, as early as the 1980s, supply of wild milkfish fry rapidly declined due to several reasons, i.e., a) decrease in the number of wild sabalo or breeder stock; b) degradation of traditional fry grounds due to over fishing and c) pollution of coastal waters due to industrialization (Ahmed et.al., 1987). Imported fry, on the other hand, was on the rise during this period, which increased the cost of inputs in milkfish grow-out operation.

Figure 2 Trend in Philippine aquaculture production of milkfish, 1950-2016



Source: FAOSTAT, 2018

In 1997, the Philippine Council for Aquatic and Marine Research and Development (PCAMRD) initiated the project entitled "GAINEX[4] Milkfish Broodstock Development and Fry Production in Ponds and Tanks" with funding from the United Nations Development Programme (UNDP) and the Department of Science and Technology (DOST). This project (hereinafter referred to as the GAINEX project) sought to launch the commercialization of the technology for hatchery-bred fry in the Philippines. Specifically, it aimed to augment the dwindling supply of wild-caught fry in the country and reduce dependence on imported fry from Taiwan and Indonesia.

In 2017, the milkfish industry in the country is approximately worth Php50B, based on the aquaculture production of 411.1 M mt at the retail price of Php124.07 per kg (PSA, 2018). The relative share of the fry industry in the milkfish sector was around 2% amounting to Php750M. This value was computed based on the estimated fry demand in the country

[4] GAINEX is a coined word referring to a UNDP project whose aim is increased agricultural production to "gain export".

totalling to 2.5B valued at the average price of Php 0.30 per fry. In the last two decades ago, the country has no hatchery-bred fry industry; hence this value is the potential cost saving in the milkfish industry if local hatchery-bred fry can be made available to the grow-out operators. Only after 2001, the Philippines was able to successfully commercialize the milkfish hatchery technology, which ushered the local fry industry in the country. From only two milkfish hatcheries in 1997, which were ran by the Aquaculture Department of the Southeast Asian Fishery Development Centre (SEAFDEC-AQD) and the hatchery giant FinFish Hatchery Inc of the Alcantara Group of Companies in Sarangani province, there are now more than 34 commercial hatcheries in the country. More than half of these hatcheries are run privately while the rest are operated under the mandate of the Bureau of Fisheries and Aquatic Resources.

This study sought to estimate the welfare gains of the Philippine milkfish industry in establishing local fry hatcheries to reduce imports from Indonesia and Taiwan. It also seeks to establish the industry stakeholder, i.e., either the hatchery operators, grow-out operators or milkfish consumers, who gain the most from this import substitution industrialization. This concept was applied in this study in the context of commercializing a local milkfish hatchery to reduce dependence on imported fry and fingerlings.

By using the economic surplus model, the welfare gains from commercializing the local hatchery-bred fry was estimated. Specifically, the total economic surplus which is derived from adding the consumer surplus and producer surplus per stakeholder were compared to determine who the biggest gainers are. The results of this study can be useful to policy makers from the fishery sector to target the group of stakeholders who urgently need strategic support and public interventions to boost the milkfish aquaculture sector in the country.

2. Review of the Development of Milkfish R&D in the Philippines

This section presents the previous R&D initiatives and the continuing researches that supported and strengthened the milkfish industry in the Philippines up to the present. Historically, the milkfish hatchery technology was chronologically developed in the 1970s by SEAFDEC-AQD in Iloilo, Philippines; Kaoshiung, Taiwan; and Gondol, Indonesia. However, commercialization of hatchery-bred fry was first initiated in Taiwan in the 1990s followed by Indonesia and lastly by the Philippines. In 1975, SEAFDEC-AQD pioneered the research on milkfish broodstock management and larval rearing techniques in collaboration with scientists from Philippines, Canada, Taiwan, Japan and India with funding from the International Development Research Centre (IDRC). By 1980, SEAFDEC-AQD had succeeded in the maturation and spontaneous spawning of captive milkfish broodstock in marine cages. The objective of this initiative was to produce sea-based hatchery-bred fry.

One year later, the newly developed milkfish broodstock and hatchery technology was replicated by the National Bangus[5] Breeding Program (NBBP) of the Bureau of Fishery and Aquatic Resources (BFAR) in 12 milkfish broodstock stations across the country. In turn, this program aimed to mass produce milkfish fry to augment the declining supply of wild-caught fry and address the rising demand of grow-out operators for imported seed stock.

By 1990s, R&D on milkfish broodstock and hatchery operations continued simultaneously at SEAFDEC-AQD and BFAR-NBBP with the intention of refining the existing milkfish hatchery operations. Unfortunately, the BFAR-NBBP project failed to accomplish its goal of mass-producing milkfish fry due to insufficient funding from the government and lack of interest from the private sector to venture into the milkfish hatchery business. However, the NBBP project resulted to considerable supply of milkfish broodstock that can sufficiently support the milkfish fry industry in the country.

Due to the alarming decline in the supply of wild-caught milkfish fry, the importation of fry from Indonesia and Taiwan ballooned from 20M fry in 1994 to 150M fry in 1995 (GAINEX Project, 2001). At that time, the milkfish industry was in dire need for local source of milkfish fry. In 1998, SEAFDEC/AQD established the Integrated Fish Broodstock and Hatchery Demonstration Complex in Tigbauan, Iloilo which supplied some hatchery-bred fry to grow-out operators from neighbouring provinces. In the same year, The UNDP-DOST GAINEX project on Milkfish Broodstock and Fry Hatchery was initiated by the Philippine Council for Aquatic and Marine Research Development (PCAMRD) and the University of the Philippines Visayas (UPV). The project piloted the land-based milkfish hatchery technology with four hatchery collaborators, of which three were privately owned while the last one was a BFAR national centre located in the Ilocos Region. At the completion of the GAINEX project in 2001, the commercialization of the local milkfish hatchery industry in the country was initiated.

To support the new hatchery-bred fry industry, BFAR though the National Integrated Fisheries Technology Development Centre (NIFTDC) launched the Phil-Bangus Development Program in 2002. It is important to note that during the GAINEX project, BFAR-NIFTDC (one of its hatchery collaborators) was tasked to conduct all technology dissemination activities of the project through hands-on trainings and seminars to prospective business operators. Even after the GAINEX project was finished, BFAR-NIFTDC continued to conduct similar trainings on larval rearing and natural food production for milkfish fry and fingerlings to all interested parties. To date, BFAR-NIFTDC was able to establish nine central hatcheries and eight satellite hatcheries all over the country.

At present, milkfish R&D from different concerned institutions continue to be refined and perfected. In 2012, The Philippine Council for Agriculture and Aquatic Resources Research and Development (PCAARRD) launched the Milkfish Industry Strategic Plan which funded 21 projects spanning across genomic researches, broodstock and hatchery enhancement, new feed formulation, mechanization of feeding operation, prediction of fishkill and control of off-flavour in milkfish (PCAARRD, 2012). Similarly, BFAR had updated its Milkfish

[5] Bangus is the common name of Milkfish in the Philippines.

Roadmap which was publicly released in 2015. Recent research and policy initiatives of BFAR and PCAARRD for the milkfish sector are focused on increasing the pond and cage yields of milkfish aquaculture; reduce feed-conversion ratio for more cost-effective production and boost the production of fry and table-sized milkfish in the country.

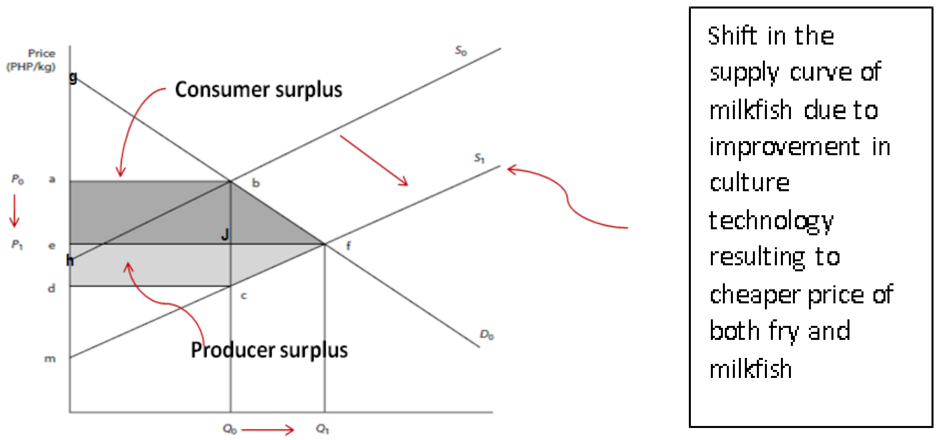
3. Methodology

3.1. Estimation of Welfare Gains through Economic Surplus Model

The estimation of economic surplus in this study rests on the assumption that the supply curve of milkfish in the market will shift to the right due to increase production brought about by the adoption of a new technology which reduces the cost of production. Specifically, there are two levels of industries that were affected by the commercialization of the milkfish hatchery technology, i.e., the fry industry which was benefitted by the increase production of milkfish fry; and the milkfish industry, which gained economically from increase production of table-size milkfish due to lower cost of seedstock, i.e., fry and fingerlings.

Theoretically, the total economic surplus can be decomposed into the consumer surplus (CS) and producer surplus (PS). The area ABEF in Figure 3 corresponds to the consumer surplus while the area EFCD pertains to the producer surplus. For the milkfish fry industry, the consumers are represented by the grow-out operators who use milkfish fry as seed stock. Generally, they are benefitted by the commercialization of the hatchery technology through increased access to milkfish fry and lower fry price in the market. On the other hand, the hatchery operators who are represented by the producers in the fry industry are also benefitted by this initiative through increase revenues due to mass production of milkfish fry and reduction in unit cost per fry.

Figure 3 Consumer and producer surplus generated from the commercialization of the hatchery-bred milkfish fry



Source: Alston et. al, 1995

The consumer surplus and producer surplus are expected to change due to the shift in the supply of table-sized milkfish brought about by the introduction of the cheaper hatchery-bred fry. The size of the vertical shift in the supply curve due to the price decrease in the fry input is generally referred to as the K-shift in the welfare literature. The respective change in the consumer surplus (ΔCS) and producer surplus (ΔPS) were estimated using the formula given below. Note that their sum is the change in the total economic surplus (ΔTS) brought about by the commercialization of the hatchery-bred fry in milkfish aquaculture.

Consumer Surplus $\Delta CS = P_0Q_0 Z (1 + 0.5Z\eta)$……………………..(1)

Producer Surplus $\Delta PS = P_0Q_0 (K - Z) (1 + 0.5Z\eta)$ …………….(2)

Total Economic Surplus $\Delta TS = \Delta CS + \Delta PS = P_0Q_0 K (1 + 0.5Z\eta)$...(3)

Where:

P_o - real price of the wild fry in Php at year zero

Q_o - quantity of local hatchery-bred fry produced in pieces at year zero

η - own price elasticity of demand for milkfish fry by grow-out operators

ξ - supply elasticity for milkfish fry

Z - value of the K shift weighted by the relative size of supply elasticity (ξ) with respect to the sum of demand and supply elasticities of milkfish fry ($\eta+\xi$). The formula of the Z[6] is given as follows:

$$Z = \frac{K\xi}{\xi + \eta} \quad \text{…………(4)}$$

In the case of milkfish industry, the estimation of the change in consumer (ΔCS) and producer surplus (ΔPS) uses the same formula except that the definitions of the parameters were changed as follows:

P_o - real price of table-sized milkfish in Php at year zero

Q_o - quantity of table-sized milkfish produced in kgs at year zero

η - own price elasticity of demand for table-sized milkfish by consumers

ξ - supply elasticity for table-sized milkfish

[6] The value of the Z was found to follow the behavior of the K shift since it was weighted by the ratio of the supply elasticity with the sum of the demand and supply elasticities (x/x+ η), which is actually a constant value.

Since there are no existing literature that provides demand and supply estimates for milkfish fry, the study estimated the respective demand and supply elasticities by running double logarithmic regressions on the total production/demand of milkfish fry in the country against its real price. Given the double log specification of the demand and supply equations below, the slope parameters, β1 and δ1, are automatically interpreted as demand and supply elasticities, respectively (Leftwich, 1970).

Demand: $\ln(\text{Total Fry Demand}) = \beta o + \beta 1 \ln(\text{Fry Price}) + \varepsilon 1$ ……………………………………(5)

Supply: $\ln(\text{Hatchery Supply}) = \delta o + \delta 1 \ln(\text{Fry Price}) + \varepsilon 2$ ……………….................(6)

On the other hand, in the case of table-sized milkfish, there is an existing study that estimated the demand elasticity for milkfish as food fish at different income levels, i.e., extremely poor, poor, lower middle, upper middle- and high-income group (Garcia, Dey and Navarez., 2005). The average demand elasticity for all income groups was used in this study. In the case of the supply elasticity for milkfish as food fish, it was estimated using a similar double logarithmic regression on total production of milkfish against its real retail price and is represented by the parameter λ1 in the equation below:

Supply: $\ln(\text{Milkfish Production}) = \lambda o + \lambda 1 \ln(\text{Real Retail Price}) + \varepsilon 3$ …………………..(7)

The estimated changes in consumer and producer surplus in both components of the milkfish industry were aggregated to represent the total welfare gain of the respective stakeholders. These welfare gains were compared to establish who among the industry stakeholders gained the most from the commercialization of the milkfish hatchery technology.

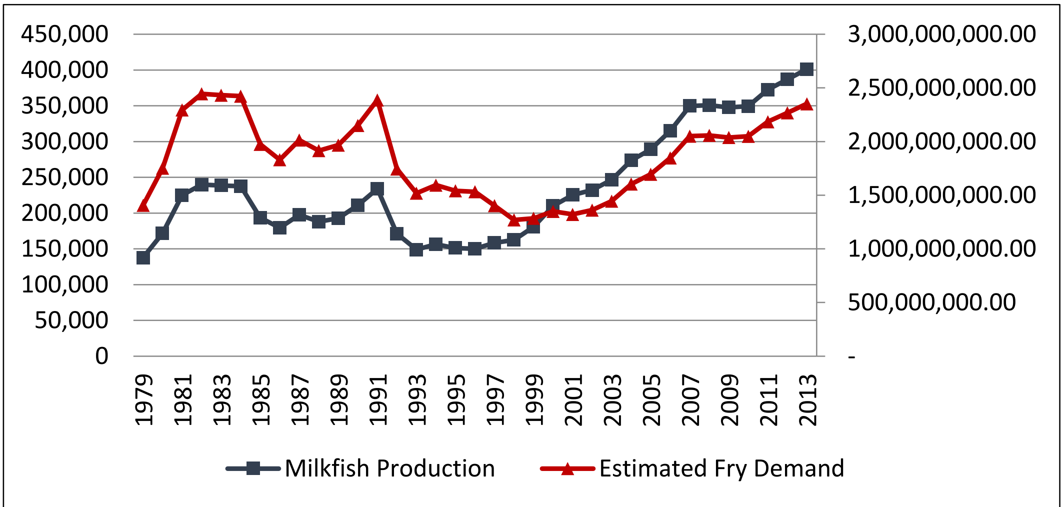
3.2. Sources of Data

Data used in this study were generated from the existing documents of the DOST-PCAARRD GAINEX project, Philippine Statistics Authority (PSA) for milkfish production and price data and FAOSTAT of the Food and Agriculture Organization (FAO) for global production data. Key informant interviews (KIIs) of hatchery collaborators were conducted and focused group discussions (FGDs) were organized to solicit the opinions of other stakeholders in the milkfish industry. Since there are no published data for milkfish fry demand (nor supply) in the country, the annual milkfish fry production was estimated in this study by employing the backward estimation procedure using technical production parameters that were universally accepted by milkfish scientists on fry survival rates during various stages of rearing, transport and storage. The estimation procedure was adopted from the study of Israel (2000) and Ahmed et. al. (2001). This impact assessment study was conducted in the same project sites of the milkfish GAINEX project, i.e., Pangasinan (Region 1); Iloilo, Cebu and Aklan (Region 6) and Bohol (Region 7).

4. Discussion of Results

To estimate the welfare gains in the milkfish fry industry, the total demand for local hatchery-bred fry needs to be estimated first based on the total production of milkfish in the country. The total fry demand was placed at 1.4B in 1979. It exhibited an unstable trend until 1998, which was similar to the performance of total milkfish production (Figure 4). After the commercialization of milkfish fry hatchery in the country, milkfish aquaculture production and fry demand both exhibited increasing trend. In 2012, total fry demand was placed at 2.4B.

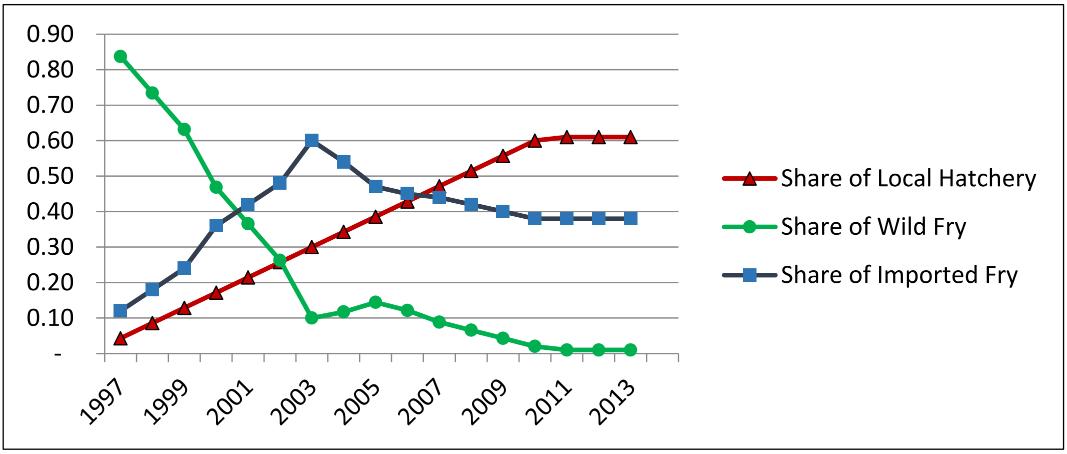
Figure 4 Trends in milkfish production and estimated fry demand, 1979-2013, Philippines



Source: BAS, 2014

Based on the estimated fry demand, the local production of hatchery-bred fry was in turn estimated by deducting the percentage shares of wild and imported milkfish fry. The remaining fry supply was then allocated as the production of local hatcheries. The distribution of these three sources of fry supply (i.e., wild fry, imported fry and locally produced fry) from 1997-2013 is shown in Figure 5. It is important to note that before the commercialization of the milkfish hatcheries in the country, milkfish fry supply was largely sourced from the wild or imported from Taiwan and Indonesia.

Figure 5 Trend in the share of wild, imported and local hatchery-bred milkfish fry, Philippines, 1997-2013



Source: BAS, 2013; NFRDI, 2013; GAINEX project documents; and KII with milkfish experts

Records from the GAINEX project documents showed that imported fry in 1994 was placed at 20M which increased to 150M in 1995. Given the estimated fry demand in the country, the shares of fry imports were calculated to be 1% and 10% in the respective years. Over time, the share of imported fry continued to increase reaching 60% in 2003 (PRIMEX, 2005). On the other hand, the share of wild caught fry had diminished from a high of 99% in 1994 to less than 1% at present. Since 2001, the supply of local hatchery-bred fry in the country started to pick up and was estimated to be 61% by 2010.

4.1. Computation of Economic Gains for Milkfish Fry Industry

To estimate the total welfare gains from the commercialization of the milkfish hatchery, the reduction in the cost of producing milkfish fry needs to be established. In the case of the milkfish fry industry, the lower price of hatchery-bred fry compared to the price of wild-caught fry was identified as the source of the shift in the supply of milkfish fry in the country. Due to the lower price of local hatchery-bred fry, the cost of production decreased for the grow-out operators, which brought about welfare gains for both the producers and consumers in the milkfish fry industry. Therefore, the total welfare gains can be derived by combining the changes in consumer and producer surplus brought about by the vertical shift of the fry supply curve due to cheaper fry supply from local hatcheries.

4.2. Estimation of the K Shift for the computation of Welfare Gain in the Fry Industry

The K shift in the milkfish fry supply curve is estimated using the equation below:

$$K = \frac{\Delta Price\ of\ milkfish\ fry}{Price\ of\ milkfish} \quad \text{.......(8)}$$

where:

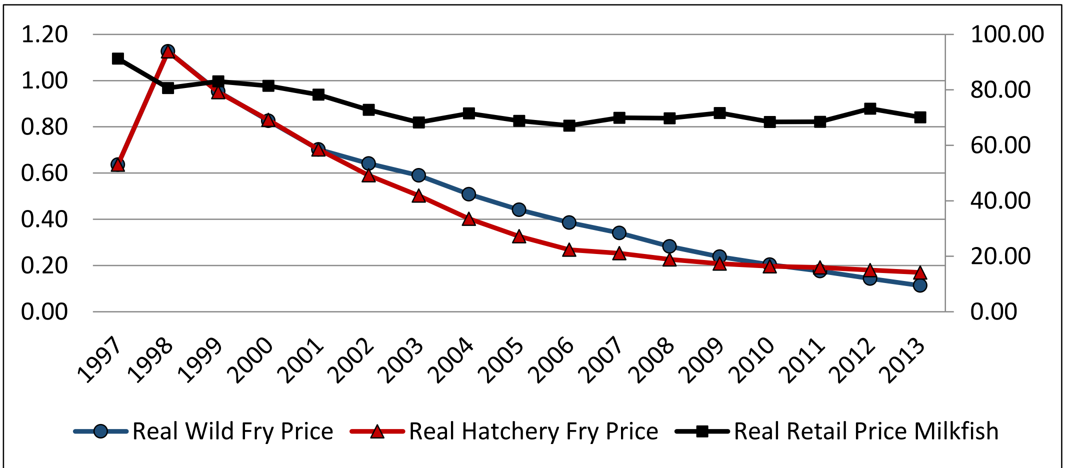
ΔPrice of milkfish fry – the difference in the real price of wild-caught fry and the hatchery-bred fry per piece

Price of milkfish – the real price of table-sized milkfish per kilo

To compute for the value of the K shift, the real prices of milkfish, hatchery-bred fry and wild-caught fry were computed by deflating their respective nominal prices using the fish consumer price index (PSA, 2014). The difference in the fry price from the wild and local hatchery in 2002 was Php 0.05. This means that the real price of hatchery-bred fry was 5 centavos cheaper than the wild-caught fry. In turn, this price reduction was computed to be 0.07% of the real price of milkfish, which actually is the measure of the K shift. This value suggests that the percent reduction in production cost of milkfish grow-out operators per fish was 0.07% lower in 2002 due to cheaper price of fry in the market.

Up to 2001, there was no price difference between the hatchery-bred fry and wild-caught fry since there was very little supply of the former in the market (Figure 6). Starting 2002 up to 2010, the wild-caught fry proved to be more expensive than the hatchery-bred fry, which encouraged continuous harvesting of wild fry from the country's fry grounds. However, since 2011, the reverse was true, which eventually diminished the interest of coastal communities in gathering wild fry. At the same time, the real retail price of table-sized milkfish showed a declining trend up to 2003. However, from 2004-2013, real price of milkfish stabilized to an average value of about 70 Php per kg.

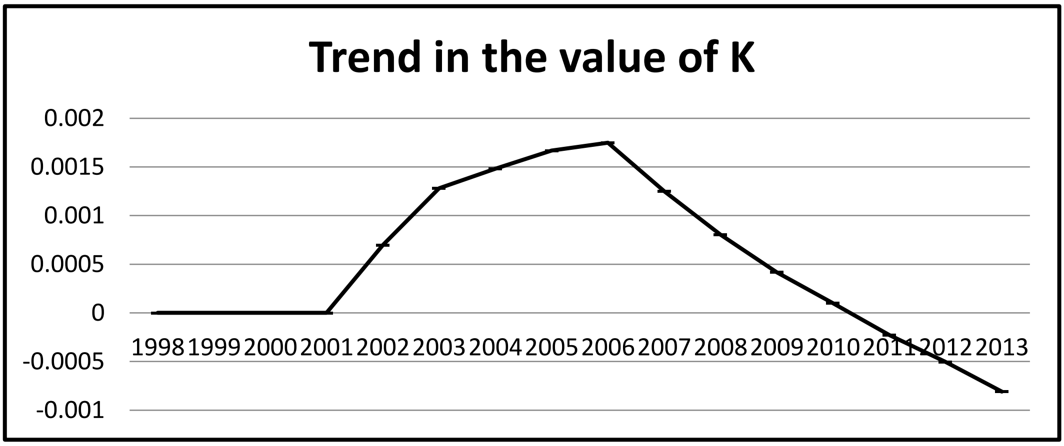
Figure 6 Trend in the real price of milkfish, wild fry and local hatchery-bred fry, Philippines, 1997-2013



Source: PSA, 1997-2013 (Fish CPI and Milkfish Price); Ahmed et. al., 1997 (Prices of wild fry) and BFAR, 2013 (Prices of hatchery-bred fry)

Given the behaviour of the real retail price of milkfish and the respective trends in the prices of hatchery-bred and wild-caught fry, the K shift was computed to exhibit a pattern found in Figure 7. Initially, the value of the K was zero up to 2001 when the prices of hatchery-bred and wild-caught fry were the same. Then it showed an increasing trend up to 2007 which eventually declined reaching negative values since 2011. Generally, the values of the K shift were positive suggesting welfare gain in using hatchery-bred fry. This benefit stems from the cost reduction in the procurement of seed stock since the price of the hatchery-bred fry was lower than the wild-caught fry. The value of the K shift ranged from 0.01% to 0.17% and was highest during the period of 2005 to 2006.

Figure 7 Trend in the value of the K shift for the milkfish fry industry, Philippines, 1997-2013



Source: Author's synthesis

However, since 2011, the values of K shift became negative showing that the wild caught fry was now cheaper than the hatchery-bred fry. This is the reason why the welfare gain computation of the study was carried out only up to 2010. The negative K values after 2011 suggest that the welfare gain from using hatchery-bred fry had already dissipated since the price of the wild-caught fry had declined to the level of the price of the imported fry, which was way lower than the local hatchery-bred fry. The low price of fry imports from Indonesia and Taiwan was one of the reasons for the continuous decline in the supply of wild-caught fry since it reduced the incentive for fry gatherers to participate in this activity. At present, the use of wild-caught fry as seed stock is no longer sustainable since supply of wild-caught fry in the country had become too limited, i.e., less than 1% of the national supply of milkfish fry. On the other hand, the imported fry continues to compete with the local hatchery-bred fry. Despite the lower price of imported fry, the local grow-out operators preferred to use the local hatchery-bred fry due to two reasons, namely: a) same sizes of the fry stock during stocking; and b) higher survival rate of fry and fingerlings due to less fish stress compared to imported fry that needs to be transported internationally.

The estimation of the total economic gains in the fry industry requires the computation of the changes in the consumer (ΔCS) and producer surplus (ΔPS) associated to the shift in the supply of milkfish fry. As mentioned earlier, the shift in the supply of milkfish fry was due to the commercialization of the milkfish hatchery technology, which eventually led to a decrease in the price of milkfish fry in the country. To compute for ΔCS and ΔPS defined in equations 1 and 2, the demand and supply elasticities for milkfish fry was first estimated. The demand and supply elasticities were derived from the estimated slope coefficients of equations 5 and 6, respectively. Table 1 presents the estimates for these parameters from the respective regression runs.

Based on the values of $\beta 1$ and $\delta 1$, the elasticity of fry demand is η = -0.31, while the elasticity of fry supply is ξ = 0.72. It is important to note that the values of both elasticity estimates were less than one indicating that the demand and supply for milkfish fry were both inelastic. This suggests that the demand and supply for milkfish fry have low responsiveness to price changes. These results reiterate the importance of milkfish fry in the grow-out production of milkfish. Although supply elasticity was also estimated to be inelastic, its magnitude was found to be twice the size of the demand elasticity. This further suggests that the hatchery supplier of milkfish fry tended to respond more to price changes compared to the grow-out operators.

Table 1 Estimated parameters of demand and supply functions for milkfish fry, Philippines, 1997-2013

Regression Parameters	Estimated Parameters	Standard Error	t-value
Demand			
β_o	20.97**	0.025	824.02
β_1	-0.31**	0.022	-13.87
Supply			
δ_o	19.86**	0.171	116.21
δ_1	0.72**	0.147	4.89

** significant at α=1%

Source: Author's synthesis

Table 2 presents the estimated changes in consumer, producers and total economic gain for the milkfish fry industry. Based on the results, the estimated consumer surplus was found to be greater than the producer surplus, i.e., ΔCS=36.1 M Php > ΔPS=15.5 M Php. Furthermore, the relative size of the consumer surplus was more than twice (i.e., 2.3X) compared to the size of the producer surplus (Figure 8). Since the consumers in the fry industry are the grow-out operators, this means that welfare gain derived by the grow-out operators from the cheaper price of hatchery-bred fry was 2.3 times higher than hatchery operators who are producing them.

Interestingly, prior to 2002 and after 2011, the ΔCS and ΔPS have values equal to zero due to the similarity of the price for wild and hatchery-bred fry. Note that only between 2002 to 2010 were the periods where the ΔCS and ΔPS generated positive values due to the cheaper price of hatchery-bred fry compared to wild-caught fry. Also note that after the commercialization of the hatchery-bred fry, the price of the wild-caught fry had declined drastically hence the advantage of cheaper hatchery-bred fry had disappeared. This means that the benefits of cheaper fry price can continue to generate welfare gains only when the price of hatchery-bred fry is lower than the wild-caught fry. It is also important to note that before the commercialization of the local milkfish hatchery, the fry price in the market was dominated by the supply of wild-caught and imported fry since there was very limited quantity of fry coming from local hatcheries during that period.

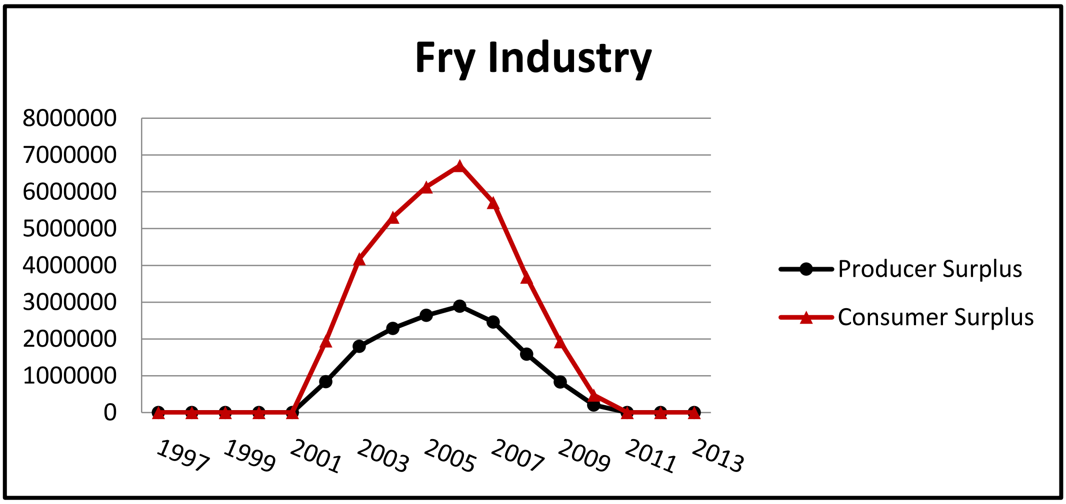
Table 2 Estimated producer, consumer and total economic surplus associated to the commercialization of milkfish fry hatcheries in the Philippines, 1997-2013

Year	**Adoption Rate of Hatchery-bred fry**	**Change in Producer Surplus**	**Change in Consumer Surplus**	**Total Economic Surplus**	**Discount Factor at 6%**	**Discounted ΔPS**	**Discounted ΔCS**	**Discounted Total Economic Gain**
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
2002	0.26	1,121,265	2,604,229	3,725,495	1.3	837,875	1,946,032	2,783,906.4
2003	0.30	2,552,983	5,929,509	8,482,491	1.4	1,799,752	4,180,070	5,979,821.8
2004	0.34	3,437,198	7,983,170	11,420,368	1.5	2,285,933	5,309,264	7,595,196.8
2005	0.39	4,208,557	9,774,712	13,983,269	1.6	2,640,501	6,132,775	8,773,275.9
2006	0.43	4,884,033	11,343,560	16,227,592	1.7	2,890,851	6,714,235	9,605,086.9
2007	0.47	4,404,209	10,229,131	14,633,341	1.8	2,459,288	5,711,894	8,171,181.1
2008	0.51	3,007,206	6,984,478	9,991,683	1.9	1,584,158	3,679,336	5,263,494.1

2009	0.56	1,665,868	3,869,112	5,534,980	2.0	827,885	1,922,830	2,750,715.4
2010	0.60	433,836	1,007,620	1,441,456	2.1	203,399	472,411	675,810.7
2011	-	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	15,529,642	36,068,847	51,598,489

Source: Author's synthesis

Figure 8 Trend in the estimated change in consumer and producer surplus in the fry industry due to the commercialization of hatchery-bred fry, Philippines, 1997-2013



Source: Author's synthesis

4.3. Estimation of Economic Gains for the Table-sized Milkfish Industry

Similar to the case of the fry industry, the supply curve of table-sized milkfish was expected to shift rightwards due to the reduction in the price of fry which is one of the key inputs in milkfish aquaculture. This shift generates welfare gains for the producers and consumers of milkfish as food fish. Specifically, the producer surplus pertains to welfare benefits of milkfish grow-out operators due to lower cost of production brought about by cheaper price of input, i.e., reduction in the price of milkfish fry due to more supply from local hatcheries. On the other hand, the consumer surplus is expected to emanate from welfare benefits of milkfish consumers due to the lower price of table-sized milkfish in the market brought about by cheaper production cost.

In the estimation of the change in consumer and producer surplus for the table-sized milkfish industry, the same values of the K shift in the fry industry was used, i.e., the reduction in fry cost as proportion of the milkfish price. However, different values of the demand (η) and supply (ξ) elasticities were used since the analysis now pertains to a different market, i.e., milkfish as food fish.

In the case of demand elasticity, the study used the existing estimates of Garcia, Dey and Navarez (2005) for milkfish consumption of different income groups with an average value of $\eta=-2.14$ (Table 3). The demand elasticity was found to be elastic, i.e., $\eta>-1.0$ with decreasing absolute values as income increases. This implies that milkfish demand tends to be more price responsive for lower income groups compared to higher income groups. Intuitively, this means that milkfish as food fish is considered as a luxury fish by the poorer households while the more affluent households considered it as an ordinary fish commodity.

Table 3 Demand elasticities for milkfish by income groups, Philippines, 2005

Consumer Groups	Demand Elasticity
Lowest income group	-3.61
Low income group	-2.26
Middle income group	-1.79
Upper middle-income group	-1.57
Highest income group	-1.46
Average	-2.14

Source: Garcia et. al, 2005

On the other hand, the supply elasticity was estimated using the model defined in equation 7. Results showed that the slope parameter of the model $\lambda 1$, which is interpreted as the supply elasticity, was equal to 1.08 (Table 4). This implies that although the supply elasticity was found to be elastic, i.e., $\xi>1.0$, it was very close to one, hence deemed to be almost unitary elastic. This suggests that the supply of milkfish had a one-to-one correspondence with the increase in the real price, i.e., if the real price of milkfish will increase by one percent, production of milkfish will likewise increase by one percent.

Table 4 Estimated parameters for the milkfish supply function, Philippines, 1997-2013

Regression Parameters	Estimated Parameters	Standard Error	t-value
λ_o	7.62**	0.791	9.63
λ_1	1.08**	0.179	6.03
** significant at α=1%			

Source: Author's synthesis

The estimated demand elasticity for milkfish was found to be twice that of the supply elasticity, i.e., η=-2.14 vs. ξ= 1.08. These results suggest that the consumers of milkfish were more responsive to price changes than the producers. This has important implications on the welfare gains from the consumer and producer surplus that can be derived from the lower cost of production brought about by cheaper fry cost.

Table 5 presents the estimated changes in consumer, producers and total economic surplus for the table-sized milkfish industry. Based on the results, the estimated producer surplus was found to be greater than the consumer surplus, i.e., ΔPS=31.8 M Php > ΔCS=16.0 M Php. Specifically, the producer surplus was about twice (i.e., 1.98X) the size of the consumer surplus. Note that in the table-sized milkfish industry, the producers are the grow-out operators while the consumers are the households who consume milkfish as food fish. Therefore, these results suggest that welfare gain derived by grow-out operators from lower price of hatchery-bred fry was higher than the consumers who buy them as food fish. Since the same values for the K shift were used in the estimation of the ΔCS and ΔPS in this industry, they exhibited the same pattern as in the case of the fry industry (Figure 9). The ΔCS and ΔPS were also found to be increasing until 2006 and then declined to zero by 2010.

To identify the stakeholder that reaped the most benefits from the commercialization of the local hatchery-bred fry, the estimated total economic gains of the respective stakeholders from the two industries were compared. Basically, there were three beneficiaries from this initiative, namely: a) hatchery operators; b) grow-out operators; and c) household consumers of milkfish. It is important to note that the consumers in the fry industry and the producer in the milkfish industry are the same set of stakeholders, i.e., the grow-out operators. Hence, to obtain the total economic gains of the grow-out operators, i.e., the ΔCS from the fry industry and ΔPS from the milkfish industry were aggregated to represent their total welfare gains. Figure 10 shows the relative distribution of benefits for these three stakeholders. Based on the graph, the grow-out operators gained the most from this initiative of the government. The figure also shows that the benefit shares of the hatchery operators and milkfish consumers were relatively the same. Although, they were smaller than the share of the grow-out operators, their welfare gains were nevertheless positive which indicate that these stakeholders also benefitted from this intervention.

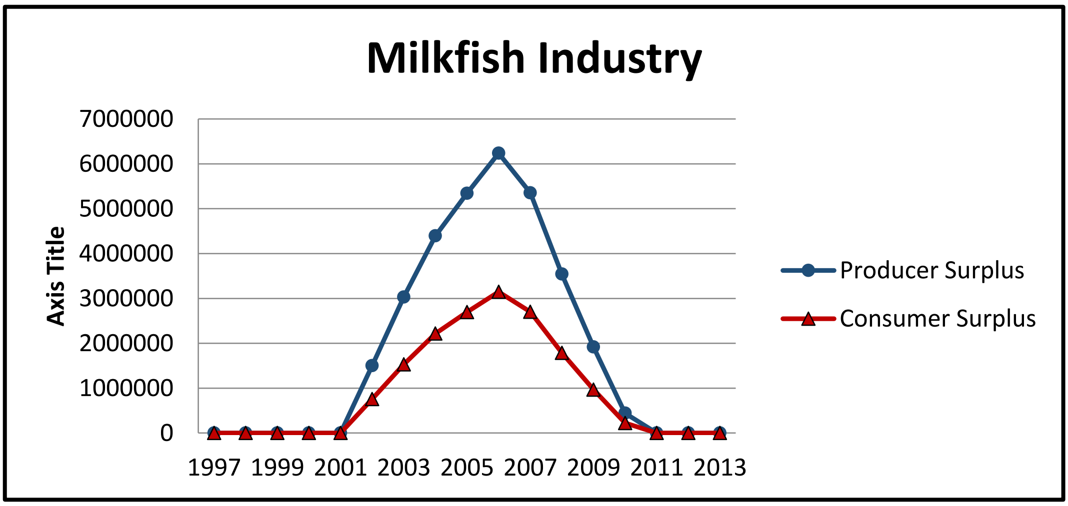
Table 5 Estimated producer, consumer and total economic surplus for the milkfish industry associated to lower cost of milkfish production due to cheaper fry price in the Philippines, 1997-2013

Year	**Adoption Rate of Hatchery-bred fry**	**Change in Producer Surplus**	**Change in Consumer Surplus**	**Total Economic Surplus**	**Discount Factor at 6%**	**Discounted ΔPS**	**Discounted ΔCS**	**Discounted Total Economic Gain**

2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
2002	0.26	2,010,025	1,014,405	3,024,430	1.3	1,502,007	758,022	2,260,030
2003	0.30	4,297,441	2,168,802	6,466,243	1.4	3,029,526	1,528,920	4,558,446
2004	0.34	6,607,562	3,334,657	9,942,219	1.5	4,394,406	2,217,738	6,612,144
2005	0.39	8,516,204	4,297,897	12,814,101	1.6	5,343,172	2,696,554	8,039,725
2006	0.43	10,536,722	5,317,598	15,854,321	1.7	6,236,670	3,147,478	9,384,148
2007	0.47	9,587,700	4,838,652	14,426,353	1.8	5,353,722	2,701,878	8,055,600
2008	0.51	6,726,318	3,394,590	10,120,908	1.9	3,543,340	1,788,228	5,331,568
2009	0.56	3,860,484	1,948,282	5,808,765	2.0	1,918,542	968,236	2,886,778
2010	0.60	945,493	477,164	1,422,657	2.1	443,284	223,713	666,997
2011	-	-	-	-	-	-	-	-
2012	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	31,764,669	16,030,768	47,795,437

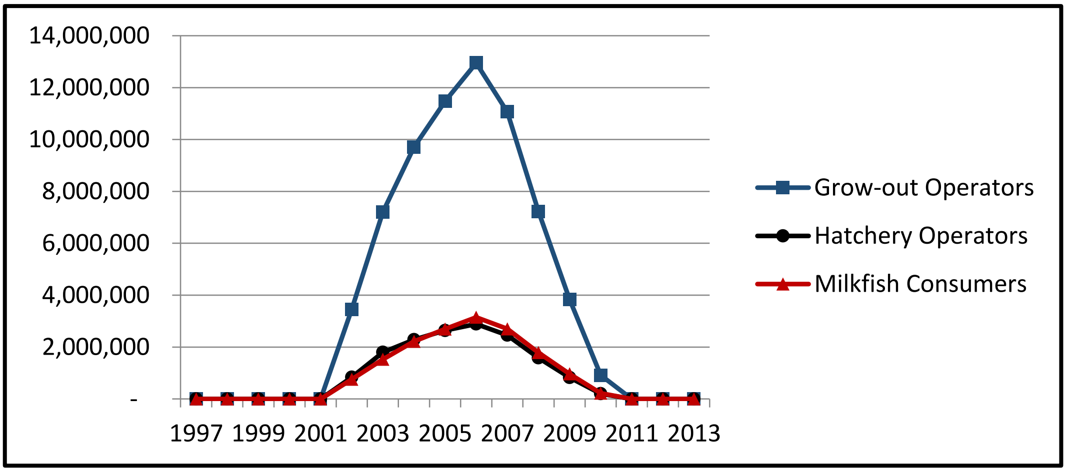
Source: Author’s synthesis

Figure 9 Trend in the estimated consumer and producer surplus in the milkfish industry due to cheaper price of hatchery-bred fry, Philippines, 1997-2013



Source: Author's synthesis

Figure 10 Trend in the estimated economic surplus of different stakeholders in the milkfish and fry industries due to cheaper price of hatchery-bred fry, Philippines, 1997-2013



Source: Author's synthesis

5. Conclusion and Recommendation

This study concluded that the commercialization of the milkfish hatchery technology in the Philippines proved to be beneficial to the milkfish industry as a whole, with the grow-out operators reaping the most welfare gains. This initiative can be emulated for other aquaculture species in the country where hatchery operation is not yet fully commercialized, hence are still import dependent on seed stock supply. For example, there is strong demand for grouper, seabass, pomfret, mudcrab, sea cucumber and abalone fry among the local grow-out operators. All of these high-value species have strong aquaculture potential but there is lack of private interest to set up local hatcheries to produce the seed stocks at commercial scale. Therefore, what is needed is a sound commercialization strategy, similar to the GAINEX experience provided by PCAARRD-DOST project, to encourage the private sector to enter into the hatchery business. Specifically, the subsidy and close technical assistance that was extended to both the private and public hatchery operators proved to be an efficient catalyst that helped in reducing the risks of venturing into a new enterprise like the hatchery business for new aquaculture species.

Finally, to further boost the milkfish fry industry in the country, the ban on fry export should be lifted to allow the local hatchery operators to compete in the world market for milkfish fry. During peak season (April to June), the Philippines has excess capacity in fry production. According to the KIIs with hatchery operators, excess production of eggs and fry were often released at sea due to insufficient demand from grow-out operators. Ideally, the excess production of milkfish fry can be exported. However, the current

Philippine Fishery Law banned any exportation of live fish, either in the form of fry or broodstock (Fisheries Code of the Philippines, 1998). The ban originated at the time when the supply of milkfish fry was only sourced from the wild, hence it became a sensitive trade item for the country. Now that milkfish fry can be easily produced from local hatcheries, there are clamors from the local hatchery operators to allow the exportation of excess fry production especially during peak season. This will not only bring in additional foreign exchange for the country but can also help to increase the industry's competitiveness in milkfish fry production. Given the opportunity to export the local hatchery-bred fry, the hatchery operators need to find ways and means to raise their productivity in order to sell the fry at competitive prices. The lower price of hatchery-bred fry will not only encourage export but it can further generate economic benefits for all the stakeholders in the milkfish industry as was shown in the comparative welfare analysis of this study.

Acknowledgement

The authors are grateful to the institutions and individuals who have supported and helped in the preparation of this study. First, special thanks are extended to the Philippine Council for Agriculture and Aquatic Resources Research and Development (PCAARRD) for funding this project and WorldFish under the leadership of Dr. Maripaz L. Perez for their technical and financial backstopping of the operations of the project. Second, the authors wish to recognize all the hatchery operators, BFAR staff and officers of the local government units of Pangasinan, Cebu, Iloilo, Bohol and Panay, who generously shared their time and experiences with the milkfish GAINEX project. Also, the authors wish to express heartfelt thanks to the technical guidance of Dr. Albert P. Aquino, Dr. Ernesto O. Brown, Dr. Adelaida T. Calpe and Engr. Eduardo V. Manalili for their precious comments during the in-house reviews of the project. Finally, special thanks are extended to Dr. Reynaldo L. Tan for painstakingly editing the full technical report of the project to come up with this present short version. All your help is truly appreciated

References

Ahmed, M., Magnayon-Umali, G.A.,Valmonte-Santos, R.A., Toledo, J., Lopez, N., & Torres, Jr.F., (2001). Bangus Fry Assessment in the Philippines, *ICLARM Technical Report*, Vol. 58.

Alston, J.M., Norton, G.W., & Pardey, P.G., (1995). *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. USA: Cornell University Press.

Philippine Statistics Authority Fishery Statistics. Accessed 2016. http://openstat.psa.gov.ph/.

Bagarinao, T., (1999). Ecology and Farming of Milkfish, SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines.

Corre, V.L.Jr., Janeo, R.L., Dureza, V.A., & Edra, R.B., (2001). Milkfish Broodstock Management and Fry Production in Tanks, PCAMRD, Los Banos and UPV, Miag-ao Iloilo.

FAOSTAT. http://data.fao.org/database?entryId=262b79ca-279c-4517-93de-ee3b7c7cb553. Fisheries Code of the Philippines,1998, Department of Agriculture Republic Act 8550.

Garcia, Y.T., & Garcia, M.E.T., (2014). Impact Assessment of the DOST-UNDP GAINEX Project on Milkfish Broodstock Development and Fry Production in Ponds and Tanks, Technical report submitted to Socio-economic Division, PCAARRD.

Garcia, Y.T., Madan, D., Navarez., S.M., (2005). Demand for Fish in the Philippines: A Disaggregated Analysis, *Aquaculture Economics and Management Journal*, Vol. 9, No. 1-2.

Garcia, Y.T., Rodriguez, U.P.E., (2011). Trade Reforms and Policies in Philippine Fishery, UPLB-CEM Policy Paper Series, No. 12, University of the Philippines Los Banos, College of Economics and Management (UPLB-CEM).

Garcia, Y.T., Piadoso. M.E.S., Rodriguez, U.P.E., Paris, T.B.Jr., & Ramirez, P.J.B., (2013). Effects of Trade Reforms on Philippine Agriculture and Fishery, Challenges and Agenda for Action for the Philippine Agricultural Sector, Lantican FA and Aragon CT (eds), published by UPLB-CEM, SEARCA and PCAARRD.

Israel, D.C., (2000). The Milkfish Broodstock-Hatchery Research and Development Program and Industry: A Policy Study. PIDS Discussion Paper Series N0. 2000-05, Makati, Philippines.

Leftwich, R.H., (1955). *The Price System and Resource Allocation*. Hinsdale, Illinois, USA: The Dryden Press.

PRIMEX, (2005). Preliminary Survey for the Comprehensive Outreach and Fish Breeding Project, Philippines, Pacific Rim Innovation and Management Exponents, Inc, Manila, Philippines.

SEAFDEC AQD, (1991). Development in Southeast Asia and Prospects for Seafarming and Searanching; Iloilo City, Philippines. (pp. 145-151).

STRIVE Foundation, (1997). Impact of Macropolicies on Fisheries Export Winners, Domestic Needs and Coastal Resource Management, Final Report: 1-104.

Tidon, A.G., Aquino, A.P., Brown, E.O., & Bandoles, G.G. (eds), (2013). Impact Assessment of Research Development and Extension Projects in Agrciulture: A Simplified Approach, Book Series No. 5/2013, PCAARRD-DOST, 155.

Werner, B., (1972). Import Substitution and Industrialization in Latin America: Experiences and Interpretations, *Latin American Research Review*, Vol. 7, No. 1 (Spring, 1972): 95-122.

Yap, W.G., (2006). Philippine Aquaculture: Historical Overview and Present Situation with Focus on the Marine and Brackishwater Aquaculture, SEAFDEC discussion paper: 1-62.