DOI: 10.31398/tpjf/28.2.2020A0018

RESEARCH ARTICLE

Assessment of Postharvest Losses Due to Catching Undersized Fishery Commodities and Size-Dependent Pricing in the Philippines

Riza Jane S. Banicod[1], Ulysses M. Montojo*[1], Gezelle C. Tadifa[1], Deserie M. Peralta[1], Charlotte Ann M. Ramos[1], Jessica C. Esmao[2]

[1]*Fisheries Postharvest Research and Development Division - Fish Handling and Processing Section, National Fisheries Research and Development Institute, 101 Mother Ignacia Avenue, Quezon City, 1103 Philippines*
[2]*Postharvest and Marketing Section, Bureau of Fisheries and Aquatic Resources Regional Office 6, Iloilo City, 5000 Philippines*

ABSTRACT

The continuing decline in catch rates instigates various fishing adjustments to keep up with the demands of a growing population. Fishery resources are being caught before they can attain their optimum harvestable size. Undersized catch elicits lower economic value; thus, considered as losses in postharvest fisheries. The present study focused on generating actual data on the volume of undersized catches in selected landing sites in the Philippines. It aims to quantify the magnitude of postharvest and financial losses incurred from catching fishery commodities below their marketable sizes. The estimated loss at 0.97% and 4.02% for capture and aquaculture commodities, respectively, was equivalent to PHP 15,235,290 financial loss. Estimation of losses by commodity showed that squid recorded the highest at 20.14%, followed by tilapia (9.61%), blue swimming crab (4.48%), shrimp (2.75%), small pelagics (1.98%), mussel (1.46%), oceanic tuna (0.91%), by-catch (0.79%), milkfish (0.09%), and oyster (0.02%). Excessive catching of undersized BSC and squid in Western Visayas may lead to overexploitation of resources and may adversely affect subsequent recruitment in the long run. The study's results indicate that catching undersized species could lead to substantial postharvest losses and subsequent loss of potential revenue to the industry players. Allowing the stocks to attain their maximum biomass level will minimize postharvest losses; thus, maximizing utilization of resources and benefits derived from the sector. Unrestrained catching of undersized fishery commodities undermines resource sustainability, economic potential, and food security. The strengthening of regulatory frameworks is, therefore, necessary to address both economic and ecological impacts.

*Corresponding Author: *ulyssesmontojo@gmail.com*
Received: *July 17, 2020*
Accepted: *July 14, 2021*
Keywords: *Postharvest Losses,Financial Loss,Undersized Fishery Commodities, Physical Loss, Quality Loss*

1. INTRODUCTION

The Philippines has vast fisheries and aquatic resources that contribute significantly to the economy (Luna et al. 2004; FAO 2014). According to BFAR (2019), the country ranked 9th among the top fish producing countries in the world in 2017. The total volume of production was recorded at 4.31 million metric tons (MT), amounting to PHP 243.9 billion. However, the annual production has reportedly dropped by 11.8% from 4.7 million MT in 2013 (BFAR 2017). As a developing country, the continuing decline in fisheries production poses a major challenge given the requirements for a fast-growing population (Green et al. 2003).

Various fishing adjustments have been made to grapple with the dwindling resources in eminently exploited fishing grounds, such as increasing fishing effort and becoming less selective in target species. Fishery commodities are reportedly caught before they can attain their optimum harvestable sizes. Unrestrained catching of undersized fish has a negative impact on fisheries production and subsequent economic yield in the long run. Growth overfishing occurs when there is massive removal of immature fish, which impedes the ability of fish stocks to replenish themselves. It is regarded as detrimental because it may further aggravate the current problem of resource depletion (Green et al. 2003; Kamei et al. 2013; Dar et al. 2015). Moreover, the capture of fish below its marketable size induces a potential loss of revenue due to its lower market value. Allowing the cohort to reach their maximum biomass level optimizes the yield derived from the fisheries sector (Pauly 1984; Kamei et al. 2013).

In the Philippines, an increasing incidence of undersized fish landings has been reported despite the enactment of various management measures such as mesh size regulation, hook size control, and gear ban (DA-BFAR 2004; FAO 2014; Soliman and Yamaoka 2010; PEMSEA 2018). Landed catch is often traded at a reduced price; thus, it should be considered losses in postharvest fisheries. Ward and Jeffries (2000) defined postharvest losses (PHL) as the reduction in quantity and monetary value of fish and fishery resources owing to discards, quality deterioration, and market dynamics. It occurs at different stages of the distribution chain to varying extents. Postharvest losses are a serious socio-economic problem as these equate to loss of valuable food sources for consumers and loss of potential revenue for industry players.

While the ecological impacts of catching immature fish have been broadly studied, the extent of economic damage is constrained by the scarcity of data on the losses incurred. Therefore, managing postharvest losses begins with a quantitative assessment of the problem. The present study focused on generating actual data on the volume of undersized catch landings in major producing regions in the Philippines. Classification of sizes was primarily based on market preference. It aims to assess the magnitude of postharvest and financial losses obtained from unrestrained catching of fishery commodities below their marketable size. Akande and Diei-Ouadi (2010) underlined that information gathered from this assessment could be used as a benchmark to formulate appropriate policies and management interventions to address the losses and maximize resource utilization.

2. MATERIALS AND METHODS

2.1. Data Collection

The assessment method was based on the Manual for Assessing Postharvest Fisheries Losses by Ward and Jeffries (2000). The Exploratory Fish Loss Assessment Method (EFLAM) was used during inception for initial data gathering. Data regarding the types and variables affecting losses were obtained from fisherfolk. The Questionnaire Loss Assessment Method (QLAM) was used during the actual assessment, based on a formal survey approach. Questionnaires for QLAM were structured following the initial data gathered from EFLAM.

Technical enumerators carried out data collection five times a week in selected landing sites in major producing regions in the Philippines (Figure 1). They were assigned to interview boat operators, crew members, fishers, fish farmers, brokers, and traders to

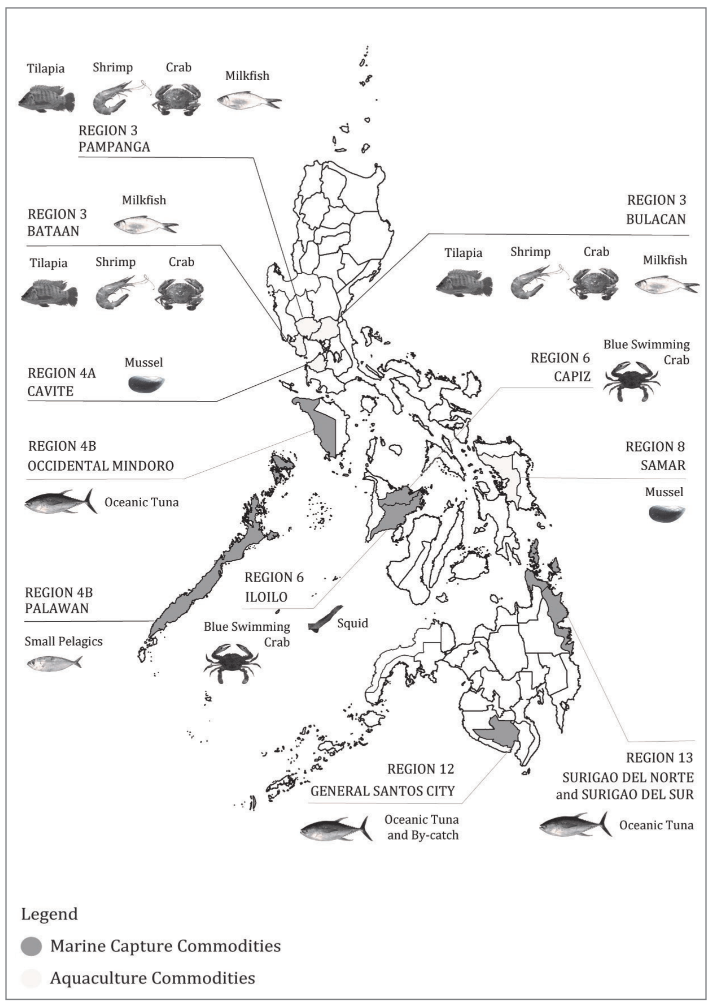

Figure 1: Assessed commodities in major producing regions in the Philippines

collect pertinent information regarding fishing and postharvest handling practices, type of gear used, actual volume, value, and breakdown of catch, and losses incurred during their most recent fishing or trading activities. The monthly number of respondents was set but not limited to 30% of the actual landings per area (Ward and Jeffries 2000).

2.2. Target Commodities and Study Areas

This study focused on economically important capture and aquaculture commodities. The assessment was conducted in major producing regions of the target commodities (Figure 1). Study areas were determined based on the production data of the Bureau of Fisheries and Aquatic Resources (BFAR). Selected landing sites per region were based on the area's accessibility for the enumerators and the respondents' willingness. Capture commodities such as small pelagics, blue swimming crab (BSC), and squid were assessed from February 2017 to January 2018. Data collection for oceanic tuna and by-catch started from October 2017 until September 2018. For aquaculture commodities, including milkfish, tilapia, shrimp, and mangrove crab, the assessment was carried out from January to December 2017, while data gathering for mussel and oyster was conducted from January to December 2018.

2.3. Computation of Losses

Physical and quality losses were computed based on the collated raw data. Physical loss is defined as the production that is either discarded or lost. Quality loss refers to the total monetary difference between the potential value of the commodity if no deterioration had occurred (best quality) and the reduced price of the commodity if it had undergone quality deterioration due to the changes, brought about by spoilage, presence of defects, impurities, and undesirable sizes. For this study, only quality loss due to undersized catch was considered by determining the difference between the potential value of fish species at their optimum sizes and the actual price of the undersized catch. Both physical and quality losses were computed and expressed in terms of monetary value and volume using the following equations:

(Eq. 1) $$TPL = \sum_{i=1}^{n} PL_i$$

(Eq. 2) $$V_{TPL} = TPL \times BPr$$

(Eq. 3) $$TQL = \sum_{i=1}^{n} \frac{(BPr_i - RPr_i)}{BPr_i} \times SQL_i$$

(Eq. 4) $$V_{TQL} = \sum_{i=1}^{n} (BPr_i - RPr_i) \times SQL_i$$

Where:

TPL is the total physical loss (kg);
PL is the volume of physical losses per respondent (kg);
n is the number of respondents;
V_{TPL} is the total value of physical loss (PHP);
BPr is the best price of the commodity per kg (PHP);

Table 1. Study areas and number of recorded landings per commodity

Commodity	Regions	Total No. of Landing Sites Assessed	Total No. of Recorded Landings
Small Pelagics[1]	Region IV-B	12	2210
Blue Swimming Crab[1]	Region VI	13	3876
Squid[1]	Region VI	5	1026
Oceanic Tuna[1]	Region IV-B, XII, and XIII	5	2984
By-catch[1]	Region XII	1	610
Milkfish[2]	Region III	8	1922
Shrimp[2]	Region III	8	1914
Tilapia[2]	Region III	8	2189
Mangrove Crab[2]	Region III	8	1275
Oyster[2]	Region VI	2	1144
Mussel[2]	Region IV-A and VIII	2	1311

[1]*Capture Fisheries Commodities*
[2]*Aquaculture Commodities*

RPr is the reduced price of the commodity per kg (PHP);
SQL is the volume subjected to quality loss per respondent (kg);
TQL is the total quality loss (kg);
V_{TQL} is the total value of quality loss (PHP);

Total loss:

(Eq. 5) $$TL = TPL + TQL$$

Where:

TL is the total loss (kg);
TPL is the total physical loss (kg); and
TQL is the total quality loss (kg)

Percentage loss:

(Eq. 6) $$\% \, Loss = \frac{TL}{TCA} \times 100$$

Where:

TL is the total loss (kg);
TCA is the total catch assessed (kg)

The financial loss was computed based on the best price of the commodities assessed. For this study, the best price was based on the weekly modal price of the commodity in the area. However, in instances where the best price was not given, the interpolation formula (Eq. 7) was used.

Interpolation Formula for Best Price Computation

(Eq. 7) $$\frac{S_1}{BPr} = \frac{S_2}{P_2} \longrightarrow BPr = \frac{S_1 P_2}{S_2}$$

Where:

BPr is the best price of the commodity per kg (PHP);
S_1 is the size of commodity with the unknown potential or best price in kg;
S_2 is the size of commodity with the known price in kg;
P_2 is the price of the commodity with size S_2 per kg (PHP)

2.4. Data Analysis

Microsoft Excel was used to tabulate the values obtained from the assessment. These include physical, quality, and financial losses. Data analysis was carried-out using the Statistical Package for the Social Sciences (SPSS) software version 20.0. Descriptive statistics quantitatively described and summarized the features of the collected data. The Paired T-test was used to determine significant difference in the means of market prices for undersized and optimum size fishery commodities. The significance was set at a 95% confidence level (p<0.05).

3. RESULTS AND DISCUSSION

3.1 Overall Loss

Out of 9,280 MT of capture commodities assessed in selected landing sites in the Philippines, 442 MT or 4.76% was recorded as undersized (Table 2). The overall loss in volume was estimated at 90 MT or 0.97% of the total volume of catch assessed. Key players incurred an estimated financial loss amounting to PHP 10,444,808. Losses per commodity ranged

Table 2. Estimated loss of undersized capture commodities

Commodity	Vol. Assessed (MT)	Vol. of Undersized Catch (MT)	TPL (MT)	TQL (MT)	Total Loss (MT)	% Loss	Financial Loss (PHP)
Small pelagics	378.29	23.67	0.00	7.50	7.50	1.98	196,959.90
Blue swimming crab (BSC)	24.13	1.80	0.00	1.08	1.08	4.48	256,469.28
Squid	11.56	4.65	0.00	2.33	2.33	20.14	459,846.10
Oceanic Tuna	7,568.26	370.35	0.00	68.84	68.84	0.91	8,519,065.60
By-catch	1,298.20	41.27	0.00	10.26	10.26	0.79	1,012,467.50
TOTAL	**9280.44**	**441.74**	**0.00**	**90.01**	**90.01**	**0.97**	**10,444,808.38**

Computation for total % loss was based on the total catch assessed and its corresponding loss
TPL-Total Physical Loss
TQL-Total Quality Loss

from 0.79% to 20.14%, with maximum loss recorded in squid. It was followed by BSC at 4.48%, small pelagics at 1.98%, oceanic tuna at 0.91%, and by-catch at 0.79%. The highest loss in value was obtained in oceanic tuna, which constituted 82% of the total financial loss. Being a high-value commodity, Tuna acquired an estimated PHP 8,519,066 financial loss despite its minimal loss in volume. Capture commodities were all subjected to quality loss.

Roughly 135 MT (7.54%) out of 1,789 MT of aquaculture commodities assessed was documented as undersized (Table 3). Loss incurred was estimated at 72 MT or 4.02% of the total production. Farmers suffered monetary loss amounting to PHP 4,790,481. Estimation of losses by commodity showed that tilapia obtained the highest loss at 9.61%. Shrimp followed it at 2.75%, mussel at 1.46%, milkfish at 0.09%, and oyster at 0.02%. Postharvest losses due to undersized catch were not prevalent in mangrove crab. Small-sized tilapia is either discarded during harvest or sold at a reduced price; thus, subjected to both physical and quality losses. Cases of physical loss due to discarded milkfish were rarely observed; however, it was mainly due to undersized fish included during partial harvest when such cases happen. Traded shrimps, mussels, and oysters below the marketable size undergone a quality loss.

The average market value for optimum and undersized fishery commodities, including the range of prices, is shown in Table 4. Market prices were noticeably dispersed, resulting in a significant difference ($p < 0.05$) between sizes for all commodities. Size has been considered one of the dominant factors affecting the market price of the fish (Sjoberg 2015). Tsikliras and Polymeros' (2014) findings showed that larger fishes were consistently attaining higher market value than their small and medium counterparts. In a study conducted by Dar et al. (2015), the capture of juvenile fish elicited enormous economic loss in selected landing centers in India. Zimmerman and Heino (2013) accentuated that change in catch composition greatly influences size-dependent pricing. The scarcity of large-sized fish makes it more desirable and valuable in the market.

In the Philippines, the continuing decline in catch rates since the 1970s instigates various fishing adjustments to keep up with the demands of a growing population. Fishers, faced with appalling poverty due to dwindling catch, have to come up with various strategies to augment their income. These include increasing fishing effort and becoming less selective in target species. The latter resulted in indiscriminate catching of undersized, immature, and low-value fishery resources (Green et al. 2003; Muallil et al. 2013). According to Delos Angeles et al. (1990), changes in the catch composition towards younger fish stocks were recorded as early as the 1980s in the country. Thus, it indicates that resources are being fished down the food chain (Staples and Funge-Smith 2005). The DA-BFAR (2004) reported that assessments conducted during the 1980s showed that capture of undersized fish aggravated the problem of overfishing, ensuing 25% and 35% losses in volume and value of catches, respectively.

In the present study, prices of undersized fishery commodities fluctuate depending on various factors such as species, seasonality, and abundance of other fishery resources. Limited landings, particularly during the wet season, along with higher consumer demands, could potentially lead to higher market prices regardless of the size. Nonetheless, most recorded landings with undersized catches were

Table 3. Estimated loss of undersized aquaculture commodities

Commodity	Vol. Assessed (MT)	Vol. of Undersized Catch (MT)	TPL (MT)	TQL (MT)	Total Loss (MT)	% Loss	Financial Loss (PHP)
Tilapia	667.40	102.53	3.68	60.43	64.11	9.61	3,389,616.06
Milkfish	515.69	0.46	0.46	0.00	0.46	0.09	36,515.00
Mussel	209.16	15.53	0.00	3.05	3.05	1.46	78,789.88
Oyster	142.71	0.11	0.00	0.03	0.03	0.02	2,122.00
Shrimp	154.08	16.26	0.00	4.23	4.23	2.75	1,283,438.45
Mangrove crab	100.12	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**1789.16**	**134.89**	**4.14**	**67.74**	**71.88**	**4.02**	**4,790,481.39**

Computation for total % loss was based on the total catch assessed and its corresponding loss
TPL-Total Physical Loss
TQL-Total Quality Loss

Table 4. Market price for optimum and undersized fishery commodities

	N	Mean± SD	Min	Max	*p*-value
Oceanic Tuna[1]					
Optimum Size	515	146.00±64.34	43.00	330.00	0.0000
Undersized		102.00±48.73	25.00	250.00	
By-catch[1]					
Optimum Size	126	100.00±27.80	53.00	167.00	0.0000
Undersized		68.00±34.67	30.00	143.00	
Small Pelagics[1]					
Optimum Size	55	45.00±25.70	8.60	130.00	0.0000
Undersized		32.00±20.60	4.30	90.00	
Blue Swimming Crab[1]					
Optimum Size	612	195.00±43.46	120.00	320.00	0.0000
Undersized		87.00±59.25	30.00	300.00	
Squid[1]					
Optimum Size	721	202.00±36.94	104.00	280.00	0.0000
Undersized		102.00±20.37	50.00	180.00	
Tilapia[2]					
Optimum Size	662	54.00±13.77	20.00	90.00	0.0000
Undersized		26.00±11.85	4.00	70.00	
Milkfish[2]					
Optimum Size	-	-	-	-	-
Undersized		-	-	-	
Mussel[2]					
Optimum Size	264	23.00±7.14	12.00	64.00	0.0000
Undersized		18.00±6.41	7.00	54.00	
Oyster[2]					
Optimum Size	-	-	-	-	-
Undersized		-	-	-	
Shrimp[2]					
Optimum Size	344	305.00±44.78	220.00	620.00	0.0000
Undersized		221.00±40.48	100.00	350.00	
Mangrove Crab[2]					
Optimum Size	-	-	-	-	-
Undersized		-	-	-	

[1]Capture Fisheries Commodities
[2]Aquaculture Commodities
p-value, significant at $p \leq 0.05$
-Negligible or no documented quality loss due to undersized catch

marketed at a reduced price, thereby inducing potential revenue loss to the key players. Allowing the species to grow to a larger size would result in a better yield in terms of volume and value (Staples and Funge-Smith 2005). This will maximize the utilization of resources and benefits derived from the fisheries sector.

3.2 Small Pelagics

Target species assessed include scads, mackerels, sardines, anchovies, neritic tunas, and fusiliers. These were the top species of small pelagics caught in Region IV-B (Candelario et al. 2017). Out of 378 MT catch assessed, 6.26% or 23.67 MT was undersized. Approximately 1.98% of the total volume valued at PHP 196,960 was recorded as loss (Table 2). Monthly loss ranged from 0% to 5.96%, with the maximum loss recorded in May (Figure 2). Roundscad or locally known as "galunggong," accounts for 94% of the losses incurred in small pelagics. The capture of undersized fish typically between 6 cm to 13 cm resulted in quality losses since larger fish yield higher prices in the market. According to Rada et al. (2019), the lengths at 50% maturity of female and male scads were estimated at 15.29 cm and 17.22 cm, respectively. The market price for optimum sizes ranged from PHP 8 to 130 per kg, while undersized was usually sold at PHP 4-90 per kg. Undersized small pelagics are commonly traded to small-scale fishers and processors at a lower price to be used as bait, feeds, or processed into dried fish. A higher percentage of undersized catch and subsequent losses were observed from March to June. This is because the three-month closed season in northern Palawan was just lifted during these months. According to Dalzell et al. (1991), the peak season for roundscad occurs throughout dry and declines during wet seasons. Reproductive biology studies on roundscad in Palawan show that the peak spawning period is from November to March. Hence, the catch from January to March is mostly juveniles (DA-DILG 2015).

Estimation of losses per gear showed that 7.60% of fish caught using bag net was undersized, resulting in a 2.55% loss in volume. Bag net or "basnig," a fine-meshed net similar to an inverted mosquito net, is classified as an active gear that operates through lifting motion. It is commonly used in Quezon and Narra, Palawan, targeting small pelagic species such as scads, anchovies, and mackerel (Balisco et al. 2019). Based on the community-based fish catch monitoring in Quezon, Palawan, bag net has the highest catch per unit effort (CPUE) and accounted for 80% of the total catch in the municipality (WWF-Philippines 2010). The said fishing gear is highly efficient and extractive; even small and juvenile fish can be captured because of the fine-meshed net and the method of operation (Dugan et al. 2003).

Like bag net, ring net is also an active gear that exploits more of the juveniles of pelagic species (Olaño et al. 2018). Approximately 5.27% of the total catch from ring net was undersized, leading to a 1.35% volume loss. Based on the assessment conducted by Olaño et al. (2018) in Lagonoy Gulf, ring net caught 98% of small-sized pelagic fishes that contributed to the exploitation of juvenile species in the gulf. This also coincides with the findings of Villanueva (2018) and Belga et al. (2018) in Davao Gulf and the Camotes Sea, respectively.

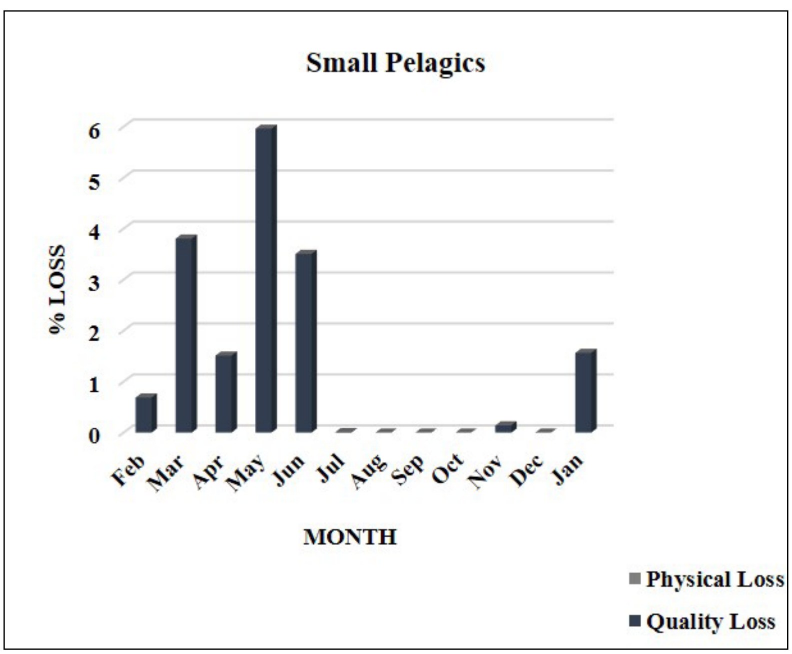

Figure 2. Estimated monthly loss (%) of small pelagics

Fishing gears such as bag net, ring net, and purse seine are limited to 1.9 cm (17 knots) mesh size of the bunt stipulated under the Fisheries Administrative Order (FAO) 155-1, s. 1994. Detailed studies on the catch composition and mesh size selectivity of bag net and ring net should be conducted in Palawan to determine the optimum mesh size corresponding to length at 50% maturity of small pelagic species. Mesh size designated to capture mature individuals of smaller species may still catch immature individuals of a co-occurring larger species; thus, restrictions should be species-specific. Mesh regulation will prevent further degradation of stock levels by allowing young fish to escape and grow, thereby contributing to the biomass of the fish stocks in the subsequent years (DENR, DA-BFAR, DILG, and CRMP 2001). This will also maximize the yield and minimize postharvest losses from the capture fisheries sector.

3.3. Blue Swimming Crab (BSC)

A total of 24 MT of BSC was assessed in Iloilo and Capiz. Undersized BSC accounted for 7.46% of the total landed catch assessed. Blue swimming crab with <10.2 cm carapace width was considered undersized. These were sold at a lower price resulting in quality loss. Based on the recent stock assessment study conducted by Mesa et al. (2018) in the Visayan Sea, the length at first maturity for BSC was estimated at 11.5 cm carapace width. The selling price for larger-sized crabs was between PHP 120 to 320, while undersized can be bought as low as PHP 30-300 per kg. The estimated loss in volume was recorded at 4.48%, amounting to PHP 256,469. Monthly loss ranged from 0.29% to 12.09%, with the highest loss recorded in June (Figure 3). Spawning of BSC occurs all year round. The lean season occurs during the southwest monsoon (June to November), while peak spawning ensues during the northeast monsoon (December to February) (Ingles 1996). The incidence of catching undersized BSC is higher during the lean season.

The majority of undersized BSC was caught using crab pot. Nearly 7% of the total catch in crab pot was recorded undersized. Crab pot and bottom-set gillnet incurred an estimated loss of 1.12% and 0.61%, respectively. Findings of Mesa at el. (2018) revealed that bottom-set gillnets and crab pots had a higher percentage of catching undersized crabs. About 57% and 62% immature sizes were caught by bottom-set gillnets and crab pots, respectively. There are crab pots made of bamboo strips, polyethylene net, or synthetic chicken wires in Western Visayas (Mesa et al. 2018). The majority of crab pots have a one-way entrance point designed to accommodate bigger size crabs. However, even small crabs can enter without the capability to escape (Sara et al. 2016). Therefore, Mesa et al. (2018) recommended increasing the trap entrance diameter to minimize the retention of unwanted BSC sizes. Collapsible crab pots equipped with escape vents will allow smaller sizes to escape and return to the sea to grow and attain maturity (Sara et al. 2016). Crab pots made of bamboo with mesh sizes bigger than 3 inches are also recommended to minimize the catching of juvenile crabs and by-catch (Yap et al. 2020).

Notwithstanding the enactment of an Administrative Order (DA-DILG 2014) that prohibits catching, collecting, and trading of BSC with a carapace width of <10.2 cm, undersized crabs are still caught and marketed. In addition, prior to the issuance of the AO, specific provincial and municipal ordinances are already implemented in several areas in the country. However, these are not fully executed and disseminated to the industry's stakeholders (Yap et al. 2020).

The study of Mesa et al. (2018) corroborated that BSC fishery in Western Visayas is experiencing overfishing in the last several years, as evidenced by decreasing CPUE and intensified fishing pressures. The declining catch of BSC prompted local crab fishers to catch undersized and gravid crabs to increase production and augment their income. The income of crab fishers is generally not enough to meet the ends of their families, especially during the lean season; thus, others resort to using fishing gears such as gillnets and crab pots with smaller mesh sizes which are constrained by a higher incidence of catching juvenile crabs, by-catch, and other species of concern including sharks and sea turtles. This could further

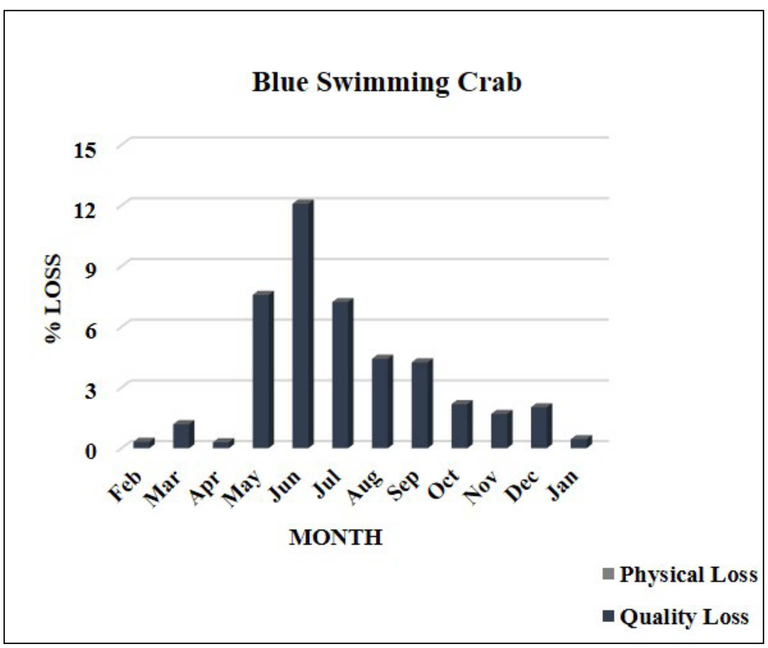

Figure 3. Estimated monthly loss (%) of blue swimming crab

aggravate the current problem of overfishing in the BSC-fishing grounds. The survey revealed that many crab fishers, specifically those who have knowledge on the existing ordinances concerning the BSC fishery, have been practicing the release of undersized crabs back to the sea. However, there are crab fishers who still bring juveniles either for personal consumption or for distribution to local markets, especially during lean months or when the catch rate is low. Restricting the use of crab pots and gillnets will negatively impact the socio-economic conditions of the fisherfolk since the majority of the crab fishers have been using these gears in Western Visayas (Yap et al. 2020).

Despite the enactment of various national and local policies concerning the BSC fishery, the industry is still facing apparent problems on sustainability, which can be explained by the presence of markets for undersized crabs, weak dissemination of relevant initiatives or programs of the government, lack of awareness among the stakeholders on the existence of specific rules on BSC, such as the prohibition on the catching of undersized or gravid crabs, as well as limited assistance or alternative livelihood being given to the crab fishers. For proper and sustainable management of the BSC fishery in the Philippines, strict compliance with pertinent BSC regulations must be enforced. Incentive programs and smart financing schemes may be given to fishers following local ordinances and sustainable fishing practices to increase compliance with BSC-specific rules and regulations (Yap et al. 2020).

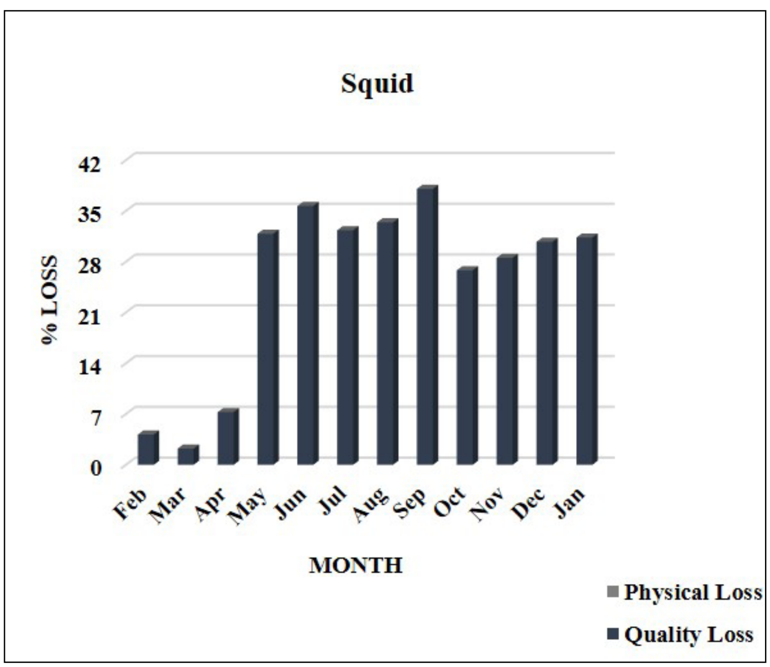

Figure 4. Estimated monthly loss (%) of squid

3.4. Squid

Among the different capture commodities assessed, the highest volume of undersized was documented in squid. Approximately 40.22% out of 11.56 MT catch assessed was classified as undersized. The recorded loss due to squids measuring <7.62 cm in size was estimated at 20.14%. There is no existing policy or regulation about the minimum size limit for catching and trading squids. Classification of squids based on size entirely depends on the brokers, traders, or buyers. In this study, squids measuring <7.62 cm were considered undersized by the industry players. According to Basir (2000), the maturity length of squid ranged from 11 cm to 24 cm. The market price for undersized squid was between PHP 50 to 180, while the optimum size was valued at PHP 104-280. Financial loss sustained amounted to PHP 459,846. Substantial losses were obtained from May 2017 to January 2018, ranging from 26.82% to 38.04% (Figure 4). The majority of squids were caught using portable lift net, bag net, and modified cast net during those months. Analysis of losses per gear revealed that nearly 32% of the total catch in bag net was recorded as loss due to undersized. Modified cast net and portable lift net obtained an estimated loss of 29.73% and 27.35%, respectively. In contrast, the negligible loss was recorded in trawl and squid jig, which comprised most of the catch from February to April. Fishing gears such as portable lift net, bag net, and modified cast net capture undersized squids (≤15 cm), which elicit lower market value than optimum size squid (≥30 cm). Squids are the target species for portable lift net, bag net, and squid jig, while trawls and modified cast net regarded them as by-catch.

Excessive catching of undersized squid is a significant concern because it may lead to overexploitation of the resources and may adversely affect subsequent recruitment in the long run. Aside from the increasing economic importance of cephalopods as evidenced by the substantial rise in recorded landings, they are also regarded as a key component of marine food webs by providing sustenance for myriad marine species (Hunsicker et al. 2010). However, ecological studies on squids and other cephalopods are very sparse; therefore, major producing areas in the country wherein cephalopods are highly exploited as a targeted resource and as an ecological support service should be further evaluated to secure the sustainability of the stocks over the years.

3.5. Oceanic Tuna and By-catch

Out of 7,568 MT oceanic tuna (yellowfin tuna, skipjack, and bigeye tuna) assessed, 370 MT or 4.89% was considered undersized. Tuna weighing less than 35 kg and 500 g for handline fishery and purse seine or ring net, respectively, are classified as undersized. These were sold at reduced prices ranging from PHP 25 to 250 per kg. Average to large-sized tunas were marketed at PHP 43-330 per kg. An estimated PHP 8,519,066 financial loss was incurred despite the minimal loss in volume. Monthly loss ranged from 0.1% to 2.53% (Figure 5-A). Losses per species indicate that 10.48% of the total catch in bigeye was undersized, resulting in a 5.86% loss in volume. The volume of undersized in skipjack and yellowfin was recorded at 5.10% and 4.29%, respectively. The highest volume of undersized was caught by ring net at 5.1%, followed by purse seine at 4.1%, and hook and line at 4.04%.

According to BFAR (2012), all three oceanic tuna species spawn extensively in the Philippine waters. A high proportion of the standing biomass was comprised of juvenile tunas. Yellowfin tuna schools with skipjack as juveniles and inhabits deeper waters as adults. Bigeye tuna has a similar life cycle to yellowfin, while skipjack occupies the surface layers for most of their lives (BFAR 2012). USAID (2017) reported that yellowfin's observed length-frequency distribution in General Santos Fish Port Complex (GSSFPC) is 11 cm to 159 cm with an average of 29 cm. These were mainly juveniles since the average length at maturity for yellowfin is 103.3 cm. Landings of juvenile bigeye tuna with an average length of 28 cm were also observed (USAID 2017).

Catch from purse seine and ring net are of smaller sizes compared to the handline fishery. These gears gather mainly juvenile yellowfin and skipjack near the surface of the water. The minimum size limit for the purse seine sector in the Philippines is 500 g which is unsuitable for export. The export-quality or sashimi-grade tuna should weigh at least 35 kg. Hence, catch from purse seine is usually sold in canneries and local markets at a reduced price. Based on the study of Montojo et al. (2020), 59.42% of the catch of the Philippine purse-seine fleet from High Seas Pocket 1 were distributed in canneries in General Santos City. Setting minimum size requirements corresponding to the maturity of tuna could decrease productivity and therefore compromise employment because significant volume of juvenile tunas is destined for canneries. Domestic purse seine and ring net fisheries are highly dependent on Fish Aggregating Devices (FADs), targeting juvenile yellowfin and bigeye tuna. The use of FADs is allowed throughout the year in the Philippines under certain conditions. These include the setting of nets less than 115 fathoms or 210 meters deep (USAID 2017). The said measure applies only to bigeye tuna without a significant impact on yellowfin.

By-catch is defined as fish or marine species

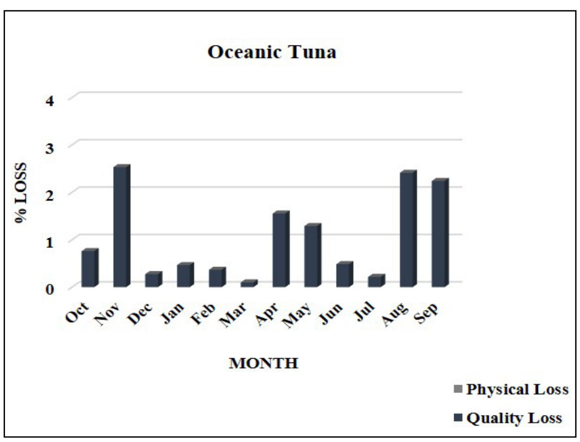

Figure 5-A. Estimated monthly loss (%) of oceanic tuna

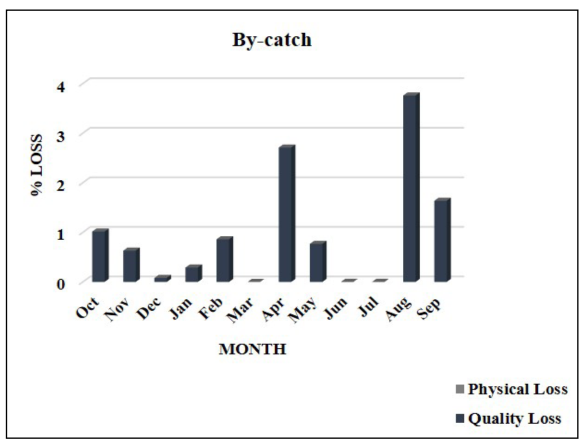

Figure 5-B. Estimated monthly loss (%) of by-catch

caught unintentionally while targeting certain species and sizes (Keledjian et al. 2014). Species of by-catch in tuna fishery include:

- Bigeye scad, longtail scad, and mackerel in the handline fishery;
- Rainbow runner, bigeye scad, and triggerfish in purse seine;
- Roundscad, bigeye scad, rainbow runner, and mackerel scad in ring net; and
- Flying fish, needlefish, halfbeak, and bigeye scad in gill net or drift gill net.

Out of 1,298 MT catch assessed, 41.27 MT or 3.18% was undersized. Around 0.79% of the total volume amounting to PHP 1,012,468 was documented as loss.

3.6. Tilapia

Estimation of losses in farmed tilapia showed that approximately 15.36% out of 667 MT catch assessed was classified as undersized. These were either discarded during total harvest or traded at a lower price; thus, resulting in physical and quality losses. The total percentage loss recorded at 9.61% was equivalent to PHP 3,389,616 monetary loss. Monthly loss ranged from 2.48% to 13.31%, with the highest loss obtained in January (Figure 6). Based on the interview with local fish farmers, there were instances wherein cultured tilapia did not grow into the desired harvestable size due to inferior strains of fingerlings. When these incidents happen, farmers tend to harvest the stocks and replenish the pond with good quality fingerlings. Undersized tilapia is sold per plastic tubs or "banyera" at a meager price. One "banyera," which usually weighs between 35 to 40 kg, will only be sold at around PHP 100-200. Small-sized tilapia is commonly processed into dried fish or "tilanggit," particularly popular in Central Luzon. The term "tilanggit" is derived from "tilapiang malinggit," which means small-sized tilapia processed similar to boneless "danggit" or siganid. The production of "tilanggit" not only provides value addition to small-sized tilapia but also opens opportunities for livelihood and additional income for fisherfolk in the area.

The overcrowding of ponds has due to the early maturation of tilapia has always been a challenge to farm owners. The uncontrolled breeding of tilapia in ponds may result in stunted growth and reduced yield. (Kaliba et al. 2006; Forgako 2018). According to Boyd (2004), tilapia quickly proliferates in ponds, leading to overpopulation and dominance of small and unmarketable fish during harvest. The results of Kaliba et al. (2006) suggest that mixed-sex tilapia culture is not economically sustainable. The development of methods to control the rapid proliferation of tilapia is, therefore, necessary to increase the return of investments. In the Philippines, selective breeding and sex control technologies have been employed to improve tilapia production. These include monosex male culture, sex reversal of females through hormone treatment of tilapia fry, and genetically-improved tilapia strains such as GIFT, FaST, YY-male and GMT, GET EXCEL, GSTTM, SST, salt-tolerant strains (Molobicus and BEST), and cold-tolerant developed through various breeding programs (Fortes 2005; Ordoñez et al. 2014). A hormonal sex-reversal technique that emerged in the 1970s is a breakthrough that allowed the male monosex population to grow into uniform, marketable sizes (FAO 2020).

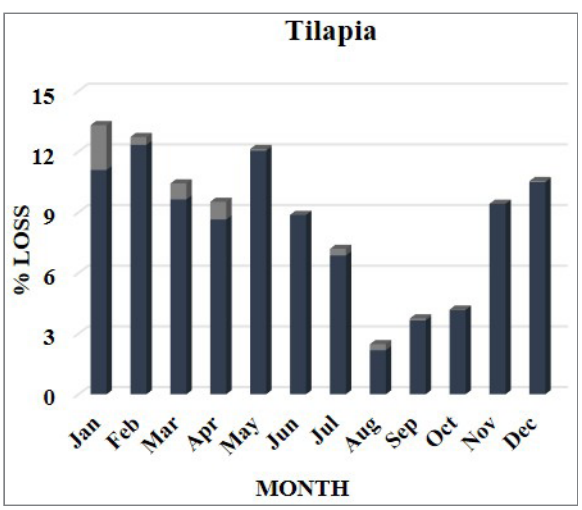

Figure 6. Estimated monthly loss (%) of tilapia

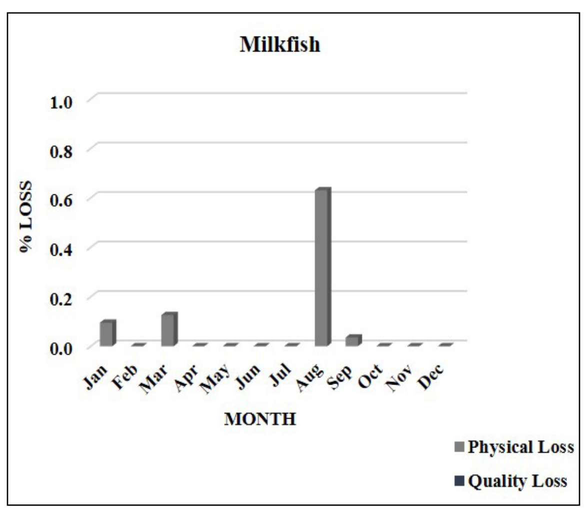

Figure 7. Estimated monthly loss (%) of milkfish

3.7. Milkfish

Minimal loss was recorded in milkfish grown in ponds. Physical loss due to discarded undersized makes up only 0.09% of the total volume assessed. The corresponding financial loss sums up to PHP 36,515. Small-sized milkfish caught and wounded during partial harvest were thrown away by fish farmers. Partial harvest involves selective harvesting of uniformly grown milkfish from grow-out facilities. Commercial-sized stocks with an average of 250 g or larger weight are harvested using seine or gillnets, while undersized fish are retained (FAO 2020). This will allow the remaining fish to attain larger sizes to increase yield and income per crop (Yap et al. 2007). However, uneven sizes during the final harvest will ensue when there is food competition among the cultured fish. Therefore, equitable feed distribution and stocking of uniform size fingerlings are recommended to extenuate the problem (Yap et al. 2007; White et al. 2018). Moreover, Jaspe and Caipang (2011) cited that using nursery ponds before grow-out culture will ensure more size uniformity during the final harvest.

3.8. Oyster and Mussel

Quantity of undersized and subsequent postharvest and financial losses were minimal in oysters. Undersized oysters comprised nearly 0.02% of the total production. Volume loss was estimated at 0.03 MT or amounting to PHP 2,122. According to SEAFDEC-AQD (1994), oysters can be harvested as early as six months or if the size reaches 7-8 cm long and 3 cm wide. However, some farmers in Roxas City and Ivisan, Capiz were reported to harvest as early as four months of culture to meet the volume required by the buyers, who are mostly producers of oyster sauce. Thin and premature shucked oysters are usually sold at PHP 15 per glass (350 ml) as opposed to PHP 20 per glass for optimum sizes.

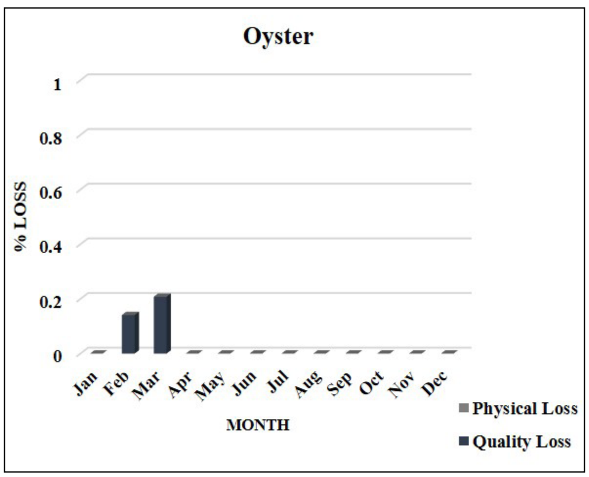

Figure 8-A. Estimated monthly loss (%) of oyster

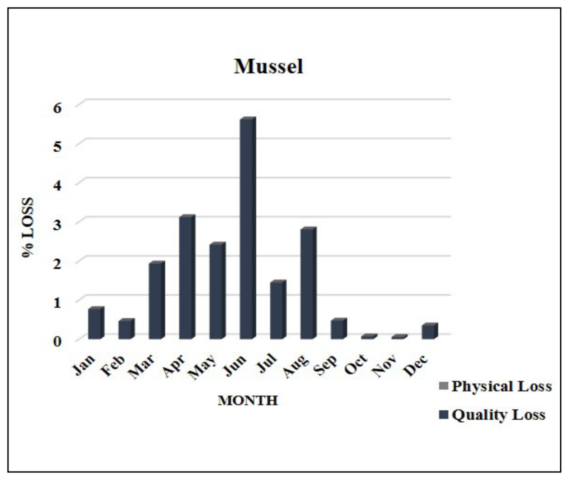

Figure 8-B. Estimated monthly loss (%) of mussel

Undersized mussels constituted 7.42% of the total volume assessed. The magnitude of loss incurred was estimated at 3.05 MT, valued at PHP 78,790. Similar to the case of oysters, undersized mussel was sold at a lower price compared to those that were harvested after complete maturation. Mussels were traded per "canastro" (wooden boxes) with an estimated weight of 40 kg. Optimum size is commonly sold at PHP 700 per "canastro" while undersized ranges from PHP 600 to 650. A higher percentage of quality loss was observed from March to June (Figure 8-B). The majority of the recorded harvest size was 1.5 inches and below. Demand from buyers increases during the Holy Week season (March or April). Farmers tend to harvest more mussels regardless of the size to meet the target volume required by the buyers.

After spat collection, it usually takes 10-12 months before mussels reach the marketable size of 6 cm long (2.5 inch) and 3 m wide. The optimum culture period, on the other hand, is eight months (SEAFDEC-AQD 1994). However, based on the assessment conducted in Cavite and Samar, interviewed farmers opt to harvest farmed mussels after four months of culture.

3.9. Shrimp

Shrimps are graded based on quality and size upon harvest due to high local and international markets demand. Estimation of postharvest losses in shrimps showed that undersized accounted for 10.55% of the total volume assessed. Financial loss

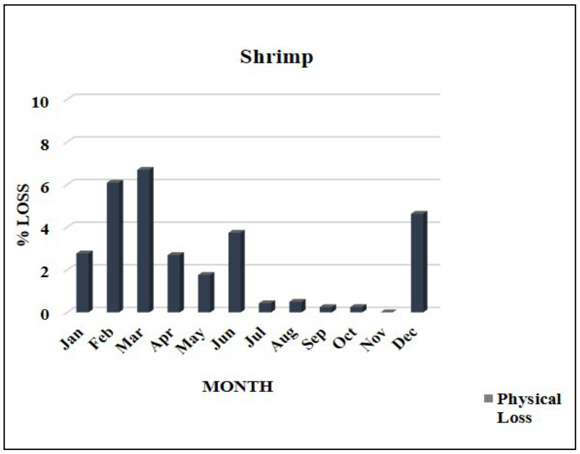

Figure 9. Estimated monthly loss (%) of shrimp

incurred from 2.75% loss in volume amounted to PHP 1,283,438. Monthly loss ranged from 0% to 6.69%, with the maximum loss recorded in March (Figure 9). The marketable size for shrimp ranges from 60 to 100 pieces per kg. However, larger sizes with an average weight of 30 to 35 g per piece are preferred in the export market (Sulit et al. 2005). In this study, the market price per kg ranged from PHP 500 to PHP 1000 for shrimps weighing > 20 g, PHP 250 to PHP 500 for 10-20 g, and PHP 100-200 for <10 g. Harvesting of shrimps below marketable size poses a loss of revenue to farm operators. However, shrimp farmers opt to harvest their stocks regardless of the size after the onset of viral diseases such as the White spot syndrome virus (WSSV). White spot syndrome virus can wipe out the cultured species within 3 to 10 days after the advent of the disease (Sulit et al. 2005). Therefore, emergency harvest is a common practice in Asian shrimp farms to save the remaining stocks once the disease has been diagnosed (Reddy et al. 2013). The findings of this assessment coincide with the study of Sritunyalucksana et al. (2010), wherein traded shrimps below the optimum harvestable size (<10 g) originated from shrimp farms that have undergone emergency harvest.

3.10. Mangrove crab

Losses due to the catching of undersized were not prevalent in mangrove crab. A total of 100 MT was assessed in Central Luzon from January to December 2017. Mangrove crab may be harvested once it reaches the marketable size of more than 200 g (Aldon and Dagoon 1997) or 300-350 g (Santos [date unknown]). Based on the assessment, good-quality mangrove crabs are highly expensive, ranging from PHP 800 to PHP 1000 per kg. The majority of the catch assessed weighed more than 350 g. Mangrove crabs weighing 150 g were also traded but minimal. The latter was not considered a loss because its market price was comparable to bigger crabs. Agbayani (2001) stated that the harvesting of crabs is usually staggered due to multiple sizes in ponds and the limited volume that can be traded in the market

4. CONCLUSION

Undersized capture and aquaculture commodities in selected landing centers in the Philippines recorded an estimated loss of 0.97% and 4.02%, respectively. The total financial loss incurred amounted to PHP 15,235,290. Losses for capture commodities ranged from 0.79% to 20.14%, with the highest loss recorded in squid, followed by BSC at 4.48%, small pelagics at 1.98%, oceanic tuna at 0.91%, and by-catch at 0.79%. Excessive catching of undersized capture commodities may lead to overexploitation of the resources and may adversely affect subsequent recruitment in the long run. Ecological studies must be conducted in areas where squids are highly exploited as a targeted resource to ensure the sustainability of the stocks over the years. For BSC, compliance with pertinent regulations prohibiting the catching, collecting, and trading of undersized crabs must be strictly enforced. The use of crab pots and bottom-set gillnets in Western Visayas must also be regulated. Detailed studies on mesh size selectivity are recommended to determine the optimum mesh size corresponding to length at 50% maturity of target species. These could be used as a benchmark for formulation and revision of existing policies involving fishery regulatory measures to ensure sustainable use and management of resources. For aquaculture commodities, tilapia obtained the maximum loss at 9.61%, followed by shrimp at 2.75%, mussel at 1.46%, milkfish at 0.09%, and oyster at 0.02%. Fish farmers should practice monosex tilapia culture to prevent uncontrolled breeding in ponds. Cultured species should only be harvested once it reaches the marketable size to maximize the yield, except in cases of emergency harvests.

Results of this study showed that indiscriminate catching of undersized fishery commodities could lead to substantial postharvest losses and subsequent loss of potential revenue to the industry players. Allowing the species to grow, attain maturity, and reach maximum biomass level will minimize postharvest and financial losses; thus, maximizing utilization of resources and benefits derived from the fisheries sector. Unrestrained catching of undersized fishery commodities undermines resource sustainability, economic potential, and food security. The strengthening of regulatory frameworks is, therefore, necessary to address both economic and ecological impacts.

5. ACKNOWLEDGMENT

This study was funded by the National Fisheries Research and Development Institute as a sub-component project of the Reduction of Postharvest Losses Program. The authors would like to extend their deepest gratitude to the management of BFAR Regional Field Offices No. III, IV-A, IV-B, VI, VIII, XII, and XIII; Local Government Units (LGUs) of the regions as mentioned earlier for the technical support; and to all industry players comprised of fishers, fish farmers, operators, brokers, traders, and other stakeholders for giving their time and cooperation during the conduct of meetings, focus group discussions, and field surveys.

AUTHOR CONTRIBUTIONS

Montojo UM: Conceptualization, Methodology, Writing-Review and Editing Supervision, Project Administration, Funding Acquisition. **Banicod RJS:** Conceptualization, Methodology, Validation, Formal Analysis, Data Curation, Writing—original draft, Visualization. **Tadifa GC:** Conceptualization, Methodology, Formal analysis, Writing—Review and Editing. **Peralta DM:** Conceptualization, Methodology, Formal Analysis, Investigation. **Ramos CAM:** Conceptualization, Methodology, Formal analysis, Investigation. **Esmao JC:** Resources, Supervision.

CONFLICT OF INTEREST

The authors declare that no known financial and personal relationships with other people or organizations could have appeared to influence the work reported in this paper.

ETHICS STATEMENT

No animal or human studies were carried out by the authors.

REFERENCES

Agbayani RF. 2001. Production economics and marketing of mud crabs in the Philippines. Asian Fisheries Science 14: 201-210.

Akande G, Diei-Ouadi Y. 2010. Postharvest losses in small-scale fisheries: Case studies in five sub-Saharan African countries. FAO Fisheries and Aquaculture Department. Rome: FAO Fisheries Technical Paper 550. [cited 2020 April 24]. http://www.fao.org/3/i1798e/i1798e.pdf.

Aldon ET and Dagoon NJ. 1997. The market for mud crab. SEAFDEC Asian Aquaculture. 19 (3): 11-13. http://hdl.handle.net/10862/2909

Balisco RA, Tahajudjin CJ, Vigonte AC. 2019. Fishing gears and their common catch in two coastal areas of Palawan, Philippines: Implications to fisheries management. International Journal of Fisheries and Aquatic Studies 7(2): 216-222.

Basir S. 2000. Biological feature of an oceanic squid, *Sthenoteuthis oualaniensis* in the South China Sea, Area III: Western Philippines. In Proceedings of the Third Technical Seminar on Marine Fishery Resources Survey in the South China Sea, Area III: Western Philippines, 13-15 July 1999 (pp. 135-147). Bangkok, Thailand: Secretariat, Southeast Asian Fisheries Development Center.

Belga P, Abrenica B, Paran J, Bacalso RT. 2018. Stock Assessment of Small Pelagic Fishes Caught by Ring Net Fishery in the Camotes Sea, Central Visayas, Philippines (2003-2012). Phil J Fish. 25(1): 95-106. https://doi.org/10.31398/tpjf/25.1.2017C0009

[BFAR] Bureau of Fisheries and Aquatic Resources. 2012. National tuna management plan of the Philippines. [cited 2020 May 28]. https://www.wcpfc.int/doc/ntmp-2012-05/national-tuna-management-plan-philippines.

[BFAR] Bureau of Fisheries and Aquatic Resources. 2017. Philippine Fisheries Profile 2017. Bureau of Fisheries and Aquatic Resources. PCA Compound, Elliptical Road, Quezon City. [cited 2020 April 20]. https://www.bfar.da.gov.ph/publication.jsp?id=2365#post.

[BFAR] Bureau of Fisheries and Aquatic Resources. 2019. Philippine Fisheries Profile 2018. Bureau of Fisheries and Aquatic Resources. PCA Compound, Elliptical Road, Quezon City. [cited 2020 April 20]. https://www.bfar.da.gov.ph/publication.jsp?id=2369#post.

Boyd CE. 2004. Farm-Level Issues in Aquaculture Certification: Tilapia. Report Commissioned by WWF. [cited 2020 May 28]. Available from http://fisheries.tamu.edu/files/2013/09/Farm-Level-Issues-in-Aquaculture-Certification-Tilapia.pdf

Calvelo R, Ganaden S, Tuazon L. 1991. Relative abundance of fishes caught by bag net around Calagua Island (Lamon Bay) with notes on their biology. Phil J Fish. 22: 49-67.

Candelario M, Villaflor E, Landrito J. 2017. Status of Marine Fisheries in Region IVB-MIMAROPA. In: Santos M, Barut N, Bayate DE, editors. National Stock Assessment Program: The Philippine Capture Fisheries Atlas. Bureau of Fisheries and Aquatic Resources-National Fisheries Research and Development Institute. Quezon City, Philippines. 220 p.

[DA-BFAR] Department of Agriculture - Bureau of Fisheries and Aquatic Resources. 2004. In turbulent seas: The status of Philippine marine fisheries. Coastal Resource Management Project of the Department of Environment and Natural Resources. Cebu City, Philippines, 378 p.

[DA-DILG] Department of Agriculture – Department of Interior and Local Government Unit. 2015. Establishment of a closed season for the management of galunggong (roundscad; Decapterus spp.) in Northern Palawan. Department of Agriculture-Department of the Interior and Local Government. Joint DA-DILG Administrative Order No. 01 series of 2015. [cited 2020 May 26]. https://www.bfar.da.gov.ph/files/img/photos/doc01561920160306220202.pdf.

[DA-DILG] Department of Agriculture – Department of Interior and Local Government Unit. 2014. Regulation for the conservation of the blue swimming crab (Portunus pelagicus). Department of Agriculture-Department of the Interior and Local Government. Joint DA-DILG Administrative Order No. 01 series of 2014. [cited 2020 May 26]. https://www.bfar.da.gov.ph/2017/institutional.pdf.

Dalzell P, Corpuz P, Ganaden R. 1991. The characteristics of Philippine small pelagic fisheries and options for management. Phil J Fish 22: 1-28. http://www.nfrdi.da.gov.ph/tpjf/vol22/

Dar S, Thomas S, Chakraborty SK, Sreekanth GB, Balkhi MH. 2015. Economic loss assessment on juvenile fish catch due to forced non-selectivity in a selective fishing gear, gillnet along Mumbai coast, India. Journal of Applied and Natural Science. 7(2): 916-921. https://doi.org/10.31018/jans.v7i2.707

De Los Angeles M, Gonzales E, Pelayo R, Ygrubay L. 1990. Economics of Philippine fisheries and aquatic resources: a literature survey. Working paper series, 9017. Manila: PIDS.

[DENR, DA-BFAR, DILG, and CRMP] Department of Environment and Natural Resources, Bureau of Fisheries and Aquatic Resources, Department of the Interior and Local Government Unit, and Coastal Resource Management Project. 2001. Philippine Coastal Management Guidebook No. 6: Managing Municipal Fisheries. Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines, 122p.

Dugan C, Jr. Bernarte A, Vera CA. 2003. Guide to Fishing Gears in the Philippines. Quezon City: Sentro para sa Ikauunlad ng Katutubong Agham at Teknolohiya, Inc. (SIKAT, Inc.), 328 p.

[FAO] Food and Agriculture Organization. 2014. Fishery and Aquaculture Country Profiles: The Republic of the Philippines. FAO Fisheries and Aquaculture Department. [cited 2020 April 20]. http://www.fao.org/fishery/facp/PHL/en

[FAO] Food and Agriculture Organization. 2020. Cultured Aquatic Species Information Programme: Oreochromis niloticus (Linnaeus, 1758). Fisheries and Aquaculture Department.

Rome. [cited 28 June 2020]. http://www.fao.org/fishery/culturedspecies/Oreochromis_niloticus/en.

Forgako E. 2018. Techniques of controlling mixed sex tilapia and the practicability of hormonal reversal in Cameroone. Nations University Fisheries Training Programme, Iceland [final project]. [cited 2020 May 28] http://www.unuftp.is/static/fellows/document/elizabeth16prf.pdf.

Fortes DR. 2005. Review of techniques and practice in controlling tilapia population and identification of methods that may have practical applications in Nauru including a national tilapia plan. Agdex Pacific Islands 492/679, New Caledonia, France.

Green SJ, White A, Flores J, Carreon III MF, Sia, A. 2003. Philippine fisheries in crisis: A framework for management. Coastal Resource Management Project of the Department of Environment and Natural Resources. Cebu City, Philippines. 77 p.

Hunsicker M, Essington T, Watson R, Sumaila R. 2010. The contribution of cephalopods to global marine fisheries: can we have our squid and eat them too? Fish and Fisheries 11(4): 421-438. https://doi.org/10.1111/j.1467-2979.2010.00369.x

Ingles JA. 1996. The crab fishery off Bantayan, Cebu, Philippines. Report submitted to the Philippine Council for Marine and Aquatic Resources Research and Development. Institute of Marine Fisheries and Oceanology, University of the Philippines Visayas, Iloilo, Philippines. 34 p.

Jaspe C, Caipang CM. 2011. Nursery production of hatchery-reared milkfish, Chanos chanos in earthen ponds. AACL Bioflux. 4(5): 627-634.

Kaliba A, Osewe K, Senkondo E, Mnembuka B, Quagrainie K. 2006. Economic analysis of Nile Tilapia (Oreochromis niloticus) production in Tanzania. J World Aquac Soc. 37(4): 464-473. https://doi.org/10.1111/j.1749-7345.2006.00059.x

Kamei G, Chakraborty SK, Deshmukhe G, Jaiswar AK, Mandakini-Devi H, Kumari S, Sreekanth GB. 2013. Assessment of economic impact of juvenile fishing of sciaenids along Mumbai Coast, India. Indian J Geomarine Sci. 42(5): 617-62.

Keledjian A, Brogan G, Lowell B, Warrenchuk J, Enticknap B, Shester G, Hirshfield M, Cano-Stocco D. 2014. Wasted Catch: Unsolved Problems in U.S. Fisheries. Oceana. [cited 2020 May 28]. https://oceana.org/sites/default/files/reports/Bycatch_Report_FINAL.pdf.

Luna CZ, Silvestre GT, Green SJ, Carreon III MF, White AT. 2004. Profiling the status of Philippine marine fisheries: A general introduction and overview, p. 3-11. In Department of Agriculture- Bureau of Fisheries and Aquatic Resources (DA-BFAR): In turbulent seas: The status of Philippine marine fisheries. Coastal Resource Management Project. Cebu City, Philippines, 378 p.

Mesa S, Bayate DE, Guanco M. 2018. Blue swimming crab stock assessment in the Western Visayan Sea. Phil J Fish. 25(1): 77-94. https://doi.org/10.31398/tpjf/25.1.2017C0008

Montojo U, Delos Santos V, Narida C, Febreo Y, Peralta D, Banicod RJ, Sabal O. 2020. Estimation of Post-Harvest Losses of Fish Transported Using Ice-chilled Carrier Boats from High Seas Pocket 1. Phil J Fish. 27(1): 82-91. https://doi.org/10.31398/tpjf/27.1.2019A0018.

Muallil R, Mamauag S, Cababaro J, Arceo H, Aliño P. 2013. Catch trends in Philippine small-scale fisheries over the last five decades. The fisher's prospect. Mar Pol. 47:110-117. https://doi.org/10.1016/j.marpol.2014.02.008

Olaño V, Lanzuela N, Paredes KSM. 2018. Assessment of Fishery Resources in Lagonoy Gulf, Philippines. Phil J Fish. 25(1): 62-76. https://doi.org/10.31398/tpjf/25.1.2017C0007

Ordoñez J, Santos M, Tayamen M. 2014. Tilapia genetic R&D in the Philippines: Challenges and prospects for future development. Fish for the People 12: 31-43. http://hdl.handle.net/20.500.12066/942

Pauly D. 1984. Some simple methods for the 1983 assessment of tropical fish stocks. FAO Fisheries Technical Paper No. 234; Rome, Italy. 52 p. [cited 2020 April 20]. http://www.fao.org/3/X6845E/X6845E00.htm.

[PEMSEA] Partnerships in Environmental Management for the Seas of East Asia. 2018. Sustainable tuna fisheries for blue economy. GEF/UNDPWCPFC Project: Sustainable management of highly migratory fish stocks in the West Pacific and East Asian Seas. Global Environment Facility/ United Nations Development Programme/ Partnerships in Environmental Management for the Seas of East Asia (PEMSEA). Quezon City, Philippines. 68 p.

Rada B, Ramos E, Riva C, Royo N. 2019. Preliminary study on spawning period and length at maturity of shortfin scad, Decapterus macrosoma, (Bleeker, 1851, Perciformes: Carangidae) from the coastal waters of San Fernando, Romblon. Phil J Fish. 26(1): 35-43. https://doi.org/10.31398/tpjf/26.1.2018-0014

Reddy A, Jeyasekaran G, Shakila R. 2013. Morphogenesis, Pathogenesis, Detection, and Transmission Risks of white Spot Syndrome Virus in Shrimps. Fisheries and Aquaculture Journal. 3:1-13. https://doi.org/10.4172/2150-3508.1000066

Santos F. [date unknown]. Mudcrab Industry Profile and Trends. [cited 2020 June 29]. Available from https://www.bfar.da.gov.ph/services?id=4.

Sara L, Halili, Mustafa A, Bahtiar. 2016. Appropriate escape vent sizes on collapsible crab pot for blue swimming crab (Portunus pelagicus) fishery in Southeast Sulawesi waters, Indonesia. J Fish Aquat Sci. 11(6): 402-410. https://doi.org/10.3923/jfas.2016.402.410

[SEAFDEC-AQD] Southeast Asian Fisheries Development Center-Aquaculture Department. 1994. Oyster and mussel farming. Aqua Farm News. 12(1):14.

Sjöberg E. 2015. Pricing on the fish market - Does size matter? Marine Resource Economics. 30(3): 277-296. https://doi.org/10.1086/680445

Soliman VS, Yamaoka K. 2010. Assessment of the fishery of siganid juveniles caught by bagnet in Lagonoy Gulf, Southeastern Luzon, Philippines. J Appl Ichthyol. 26(4): 561-567. https://doi.org/10.1111/j.1439-0426.2010.01477.x

Sritunyalucksana K, Srisala J, Wangnai W, Flegel TW. 2010. Yellow head virus (YHV) transmission risk from commodity shrimp is reduced to negligible levels by normal processing. Aquaculture. 300 (1-4): 32-36. https://doi.org/10.1016/j.aquaculture.2010.01.014

Staples D, Funge-Smith S. 2005. Prized commodity: Low value/trash fish from marine fisheries in the Asia-pacific region. Fish for the People 3(2): 2-15. http://hdl.handle.net/20.500.12066/707

Sulit V, Aldon MA, Tendencia I, Ortiz AMJ, Alayon S, Ledesma A. 2005. Regional technical consultation on the aquaculture of Penaeus vannamei and other exotic shrimps in Southeast Asia. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department. http://hdl.handle.net/10862/1717.

Tsikliras A, Polymeros K. 2014. Fish market prices drive overfishing of the 'big ones'. Peer J 2:e638. https://doi.org/10.7717/peerj.638

[USAID] United States Agency for International Development. 2017. Oceans and Fisheries Partnership. Output 3: Customer requirement for Philippine tuna products in General Santos City, Philippines. [cited 2020 May 28]. https://www.seafdec-oceanspartnership.org/wp-content/uploads/USAID-Oceans_Philippines_Output-3_Customer-Report_final.pdf.

Villanueva J. 2018. Assessment of Commercially Important Pelagic Fishes in Davao Gulf CY 2004-2013. Phil J Fish. 25(1): 163-182. https://doi.org/10.31398/tpjf/25.1.2017C0013

Ward AR, Jeffries DZ. 2000. A manual for assessing postharvest fisheries losses. Chatman, UK: Natural Resources Institute. 140 pp.

White P, Shipton T, Bueno P, Hasan M. 2018. Better management practices for feed production and management of Nile Tilapia and milkfish in the

Philippines. FAO Fisheries and Aquaculture Technical Paper 614. [cited 2020 June 29]. http://www.fao.org/3/i9073en/I9073EN.pdf.

[WWF-Philippines] World Wide Fund for Nature-Philippines. 2010. Annual Report-2010. [cited 2021 June 15]. Available from https://pkp.pcsd.gov.ph/images/pdf/coastal%20marine%20and%20island%20biodiversity/WWF%20LRF%20Compilation%20of%20reports%202010.pdf.

Yap WG, Villaluz AC, Soriano MGG, Santos MN. 2007. Milkfish production and processing technologies in the Philippines. Milkfish Project Publication Series No. 2. 96 pp.

Yap EE, Mesa S, Napata R, Ledesma A. B. 2020. The Philippines' Blue Swimming Crab (Portunus pelagicus) Fishery Root Cause Analysis Report. United Nations Development Programme and Bureau of Fisheries and Aquatic Resources, Philippines.

Zimmermann F, Heino M. 2013. Is size-dependent pricing prevalent in fisheries? The case of Norwegian demersal and pelagic fisheries. ICES J Mar Sci. 70 (7): 1389–1395. https://doi.org/10.1093/icesjms/fst121