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RESEARCH ARTICLE

A Study on Postharvest Losses in Fisheries Owing to Changes in Market Supply and Demand in the Philippines

Gezelle C. Tadifa, Riza Jane S. Banicod, Deserie M. Peralta, Charlotte Ann M. Ramos, Ulysses M. Montojo*

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

ABSTRACT

Market patterns and conditions can affect the economic value of fishery commodities; hence, they can contribute to postharvest losses. This paper primarily aims to provide information on the magnitude of losses incurred from changes in market supply and demand of economically important fishery commodities. Assessed capture commodities in selected landing sites and wet markets recorded an estimated loss of 3.98% and 0.44%, respectively. The total financial loss incurred in both supply chains amounted to PHP 480,160. Estimation of losses per commodity showed that landed sardines obtained the highest loss at 6.86%. This can be attributed to the oversupply of catch at the end of the closure period, leading to a drastic decrease in market prices. Minimal losses were documented in aquaculture at 0.33% and 0.23% for landing and trading, respectively, amounting to PHP 26,541. While lower retail prices could be beneficial to consumers, it could lead to a loss of revenue for fisherfolk. The government should, therefore, take measures to curb price collapses associated with market dynamics through Value Chain Analysis, the establishment of market linkages between producers and consumers, price regulating mechanisms such as the suggested retail price that should be area and species-specific, the establishment of cold storage and commercial-scale ice production facilities in strategic places, utilization of fish and fishery resources through the application of low-cost processing technologies, and provision of livelihood support to small-scale fisherfolk. These initiatives will ensure equitable benefit sharing from the fisheries industry and reduce postharvest losses and wastes across the supply chain in pursuit of food security.

*Corresponding Author: *ulyssesmontojo@gmail.com*
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1. INTRODUCTION

The Philippines, as an archipelagic state, is known to have vast fisheries and aquatic resources. The fisheries sector contributes significantly to the national economy by generating direct revenues and employment opportunities (FAO 2014). According to PSA (2020), the total volume of fisheries production in 2017 was estimated at 4.31 million metric tons (MT), amounting to PHP 243.9 billion. The majority of fish and fishery products are consumed locally in either fresh, chilled, or processed form, while the export volume accounted for 11% of the total production in the same year. According to the Department of Science and Technology - Food and Nutrition Research Institute (DOST-FNRI), the mean per capita consumption of fish and fishery products is 36.8 kg/year (DA-BFAR 2017). Moreover, Garcia et al. (2005) reported that the annual national consumption of fish and fishery products in the Philippines is nearly 2 million MT, with an average yearly increase of 2.20% from 1997 to 2001.

Fishery commodities are known to be highly perishable; thus, they are susceptible to postharvest losses (PHL) if intervention measures are not put in place (Tesfay and Teferi 2017). Ward and Jeffries (2000) defined PHL as the reduction in quantity or monetary value of fishery resources throughout the distribution chains owing to discards, quality deterioration, or market dynamics. Market patterns and conditions such as oversupply of fish catch during peak season, limited access to or lack of marketing information, or merely consumer willingness and purchasing power are common factors that contribute to PHL. Market force loss (MFL) is one of the three types of PHL dictated by the market's reaction rather than the quality of the fish. This type of loss is incurred when the price of the commodity falls because of the changes in market supply and demand, particularly during peak fishing season. Postharvest losses are a serious socio-economic concern as these equate to loss of potential revenue to the industry players with negative implications for food security. (Ward and Jeffries 2000; Akande and Diei-Ouadi 2010).

The Philippine government has imposed a closed fishing season on principal fishing grounds as one of the fisheries management approaches to address the declining fish stocks by allowing a productive spawning season (Rola et al. 2018). During glut season, which usually occurs following the lifting of the fishing ban, supply exceeds demand, thus, leading to a drastic decrease in fish prices regardless of the quality (RFLP 2013; Assefa et al. 2018). Bagsit et al. (2021) reported that fisherfolk tend to overfish the resources during the said period because of the abundant supply of fish and to compensate for their inactivity during the closed fishing season. However, with the absence of cold chain facilities, fishers may incur a massive loss on a daily basis, as large volumes of fish are thrown away or left to rot due to their high perishability (RFLP 2013). Furthermore, little to no access to market information infuses challenging struggles in marketing fish, especially to small-scale fishers, as niche markets tend to be highly competitive (Bukenya and Hyuha 2016). The occurrence of oversupply can substantially lower fish quality due to lengthy sales and improper handling (Figure 1), which can incite forced reduction of the market price or complete discard of fish and fishery products (Getu et al. 2015).

Fisheries supply and value chains are affected by various factors such as product demand, available processing technologies, regulations, market access, and competition (FAO 2015). MFL not only constitutes the loss of income to the industry players but also contributes to food insecurity (Akande and Diei-Ouadi 2010). The effort to reduce MFL in local trade begins with a quantitative assessment of the problem. As a pioneering study in the Philippines, this paper primarily aims to provide information on the magnitude of losses incurred from changes in market supply and demand of fishery commodities. The assessment in major fish-producing regions was species-specific to highlight various occurrences or local postharvest practices contributing to MFL in a given area. This would merit more attention and drive urgent policy recommendations and management interventions to address the losses due to fluctuations in fish supply and changing marketing environments.

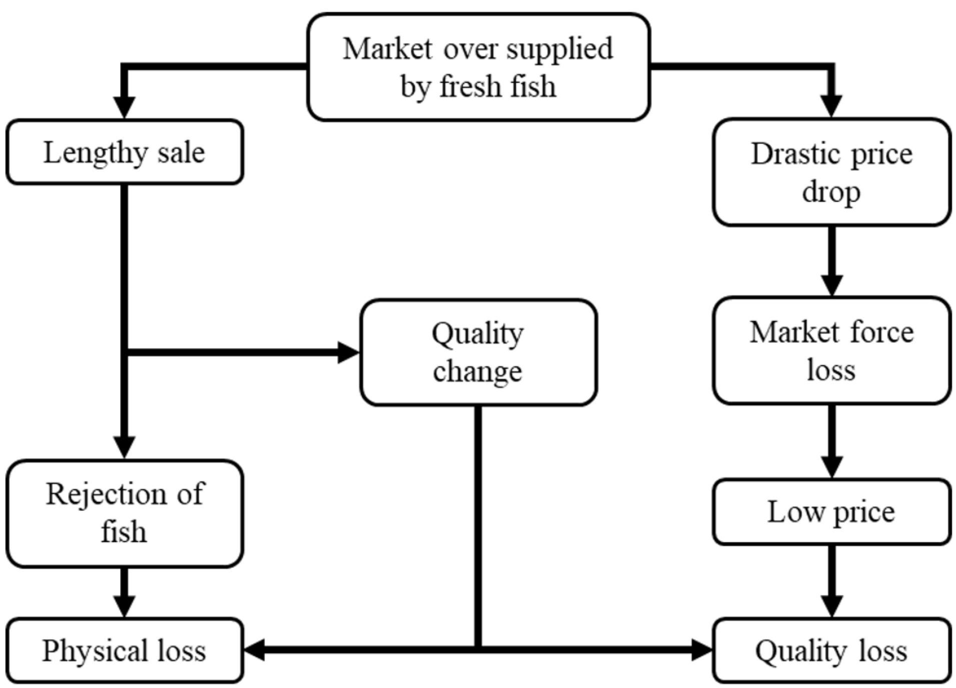

Figure 1. Market force loss resulting in physical loss and quality loss (Getu et al. 2015)

2. MATERIALS AND METHODS

2.1 Target commodities and study areas

The assessment of economically important capture and aquaculture commodities was conducted in major producing regions of the target species (Figure 2). Sampling locations were determined based on the production data of the Bureau of Fisheries and Aquatic Resources (BFAR). Consultation meetings with respective BFAR regional offices and Local Government Units (LGUs) were conducted to seek assistance in selecting landing sites and wet markets. Key considerations in the identification of landing sites include the volume of production, accessibility of the area, and willingness of the respondents. Wet markets were chosen upon verifying that most traded fishery commodities are sourced from the identified landing areas. The number of landing sites and wet markets assessed in each region is shown in Table 1. Target species for capture fisheries include small pelagics such as anchovies, scads, neritic tunas, mackerels, fusiliers, and sardines, while assessed aquaculture commodities were tilapia, shrimp, mangrove crab, and mussel.

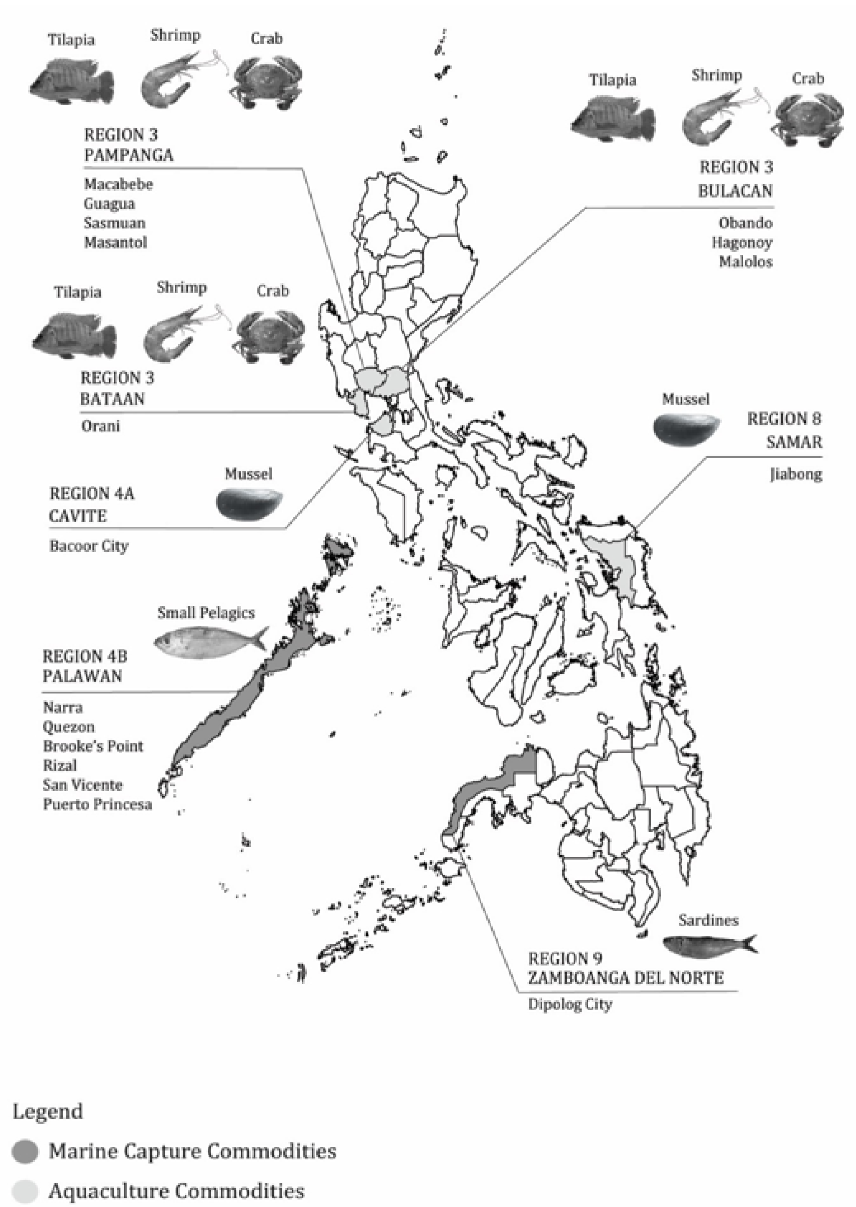

Figure 2. Assessed commodities in selected major producing regions in the Philippines

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

Commodity	Region	Landing Site		Wet Market	
		No. of areas assessed	Total no. of recorded landings	No. of areas assessed	Total no. of recorded tradings
Small Pelagics[1]	Region IV-B	12	2210	7	1122
Sardines[1]	Region IX	4	2121	1	199
Tilapia[2]	Region III	-	-	8	650
Shrimp[2]	Region III	-	-	8	455
Mangrove Crab[2]	Region III	-	-	8	448
Mussel[2]	Region IV-A and VII	2	1312	2	365

[1]*Capture Commodities*
[2]*Aquaculture Commodities*
-No assessment conducted

2.2 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 to generate qualitative and indicative quantitative data on fisheries PHL quickly. Application of EFLAM involved semi-structured interviews and direct observation in engaging with the members of fishing communities and determining where the fish loss occurs, indicative loss levels, variables that affect losses, seasonal variations, perceptions of fish losses by those affected, and opportunities for loss reduction interventions. In addition, the Questionnaire Loss Assessment Method (QLAM) was employed during the actual assessment, which is based on a formal survey approach. Questionnaires for QLAM were formulated following the initial data gathered from the EFLAM.

Technical enumerators were deployed to collect data five times a week in selected landing sites and wet markets. On-site interview with fishers, fish farmers, boat operators, crew members, brokers, and traders in landing sites was conducted to collect pertinent information regarding their fishing and postharvest handling practices, actual volume, value and breakdown of catch, and reasons for the losses incurred during their most recent fishing/trading activities. Stall owners and vendors in wet markets were also interviewed regarding the marketing and distribution of vended fish.

The monthly number of respondents in landing sites was set but not limited to 30% of the actual landings per area (Ward and Jeffries 2000). Assessment is carried out per batch of landed or traded fish; therefore, respondents can be interviewed multiple times. Complete enumeration was done in wet markets with a small population of vendors, whereas, for a large population of wet market vendors, the sample size was computed based on the preliminary data collected ($n \geq 30$) using the Z-distribution test. Standard deviation was determined to calculate the margin of error using the following equation:

$$(Eq.\ 1) \quad E = Z_{\alpha/2} \frac{\sigma}{\sqrt{n}}$$

The margin of error derived was used to determine the initial sample size through the Z-distribution formula utilizing the equation:

$$(Eq.\ 2) \quad n_0 = \left[\frac{Z_{\alpha/2}(\sigma)}{E}\right]^2$$

The initial sample size from the sample variance was used in the determination of the final sample size using the Finite Correction Formula:

$$(Eq.\ 3) \quad n = \frac{n_0\, N}{n_0 + (N-1)}$$

Where:
E is the margin of error;
$Z_{\alpha/2}$ is the z-value that locates an area $\alpha/2$ in each tail of the z-distribution, given the appropriate degrees of freedom;
σ is the standard deviation;
n is the number of preliminary interviewed respondents;
N is the total population number;
n_0 is the initial sample size from the sample variance;
n is the final sample size.

Based on the scoping or initial data gathering, MFL was not applicable to some species. Assessment of landing sites for aquaculture commodities such as tilapia and shrimp was not conducted because these species have a steady year-round production. On the other hand, mangrove crab has a high demand even if it is a high-value species; thus, MFL was not also evident. Target commodities in landing sites such as small pelagics, sardines, and mussels were assessed for one year. Data collection for both capture and aquaculture commodities in wet markets was carried out for a minimum duration of five months.

2.3 Computation of losses

Market force loss, primarily caused by unexpected market supply and demand situations, was computed using the collated raw data from the QLAM. Incurred losses were calculated and expressed in terms of volume and monetary value using the following equations:

$$V_{TMFL} = \sum_{i=1}^{n} (BPr_i - RPr_i) \times SMFL_i \quad \text{(Eq. 4)}$$

$$TMFL = \sum_{i=1}^{n} \frac{(BPr_i - RPr_i)}{BPr_i} \times SMFL_i \quad \text{(Eq. 5)}$$

Where:
n is the number of respondents interviewed;
V_{TMFL} is the total value of market force loss in PHP;
BPr is the best price or highest price of the commodity per kg in PHP;
RPr is the reduced price of the commodity in PHP;
SMFL is the volume subjected to market force loss of each respondent (kg);
TMFL is the total market force loss in kg.
Percentage loss:

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

Where:
TMFL is the total market force loss in kg;
TCA is the total catch assessed in 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 a given area.

2.4 Data analysis

Descriptive statistics were used to quantitatively describe and summarize features of the collected data from the assessed landing sites and wet markets. Market force and financial losses were quantified using Microsoft Excel spreadsheet.

3. RESULTS AND DISCUSSION

3.1 Overall loss

Approximately 3.98% and 0.44% of capture commodities assessed in landing sites and wet markets, respectively, were recorded as losses due to MFL (Table 2). This equates to 21.9 MT volume loss out of 549.2 MT of landed catch assessed and 0.31 MT out of 70.97 MT of traded fishery commodities. Monthly loss in landing sites ranged from 0% to 9.48%, with a higher percentage of losses recorded from March to May that correspond to peak fishing season (Table 3). Key players in landing areas incurred an estimated financial loss amounting to PHP 466,410, whereas minimal loss was suffered by wet market vendors (Table 2). The highest loss in landing sites was recorded in sardines at 2.14%, while the documented loss for mixed pelagic species was estimated at 1.84%. Small pelagics such as anchovies, scads, neritic tunas, mackerels, fusiliers, and sardines are susceptible to MFL due to their seasonality. Studies suggest that small pelagic fishes are heavily exploited in the Philippines (Dalzell et al. 2008). According to Dalzell et al. (1991), the swift collapse of this fishery has a negative impact on the socio-economic development in the country as most of the landings are absorbed by the poor and lower-income groups. Given the pressing issues of the declining fish stocks in major fishing grounds, BFAR implemented a closed fishing season policy to

Table 2. Overall estimated loss of capture commodities

Commodity	Landing Area				Wet Market			
	Volume Assessed (MT)	Volume Loss (MT)	TMFL (%)	FL (PHP)	Volume Assessed (MT)	Volume Loss (MT)	TMFL (%)	FL (PHP)
Small Pelagics	378.02	10.13	1.84	247,075.80	53.34	0.12	0.17	6,280.00
Sardines	171.21	11.75	2.14	219,333.90	17.63	0.19	0.27	7,290.00
TOTAL	**549.23**	**21.88**	**3.98**	**466,409.70**	**70.97**	**0.31**	**0.44**	**13,570.00**

TMFL – Total Market Force Loss
FL – Financial Loss

Table 3. Monthly estimated loss of capture commodities

Month	LANDING				WET MARKET			
	Total Volume Assessed (kg)	Market Force Loss (kg)	Percent Loss (%)	Financial Loss (PHP)	Total Volume Assessed (kg)	Market Force Loss (kg)	Percent Loss (%)	Financial Loss (PHP)
January	25,064.10	16.80	0.07	420.00	4,479.00	0.00	-	0.00
February	12,807.35	42.67	0.33	3,200.00	5,394.00	15.50	0.29	930.00
March	83,988.10	7963.83	9.48	172,617.50	7,837.50	32.00	0.41	1,850.00
April	82,795.60	5674.90	6.85	82,107.65	8,236.45	67.50	0.82	3,500.00
May	76,864.50	5375.62	6.99	111,179.63	7,169.30	0.00	-	0.00
June	44,415.89	47.35	0.11	1,600.20	10,164.25	50.48	0.50	1,495.00
July	28,749.40	790.65	2.75	19,860.25	7,840.00	97.05	1.24	4,055.00
August	34,890.00	797.98	2.29	46,554.50	6,338.25	8.00	0.13	400.00
September	35,039.10	0.00	-	0.00	5,828.00	30.30	0.52	1,340.00
October	25,527.15	20.40	0.08	421.00	2,644.50	0.00	-	0.00
November	35,652.29	0.00	-	0.00	2,493.50	0.00	-	0.00
December	63,429.60	1157.42	1.82	28,449.00	2,548.50	0.00	-	0.00

conserve fishery resources by allowing a productive spawning season (Ani 2016). By virtue of the DA-DILG Joint Administrative Order No.1 s. 2011, the closed season is being implemented from December to February in the Zamboanga Peninsula to promote consistent positive growth in sardine production. This prohibition applies to all commercial operations in a conservation area of 22,260 square kilometers, including parts of the East Sulu Sea, the Basilan Strait, and Zamboanga Sibugay province. This period coincides with the peak spawning period of various species of sardines. A three-month closed fishing season from November to January for round scad is also enforced annually within the conservation area Northeast of Palawan, in accordance with the joint DA-DILG Administrative Order No. 1 s. 2015. The said policy is a critical fisheries management approach that aims to help reduce overfishing and protect fish stocks' regeneration (Brillo et al. 2016; Israel et al. 2016).

Since the strict enforcement of the closed fishing season, a significant increase in small pelagic fish catch has been observed at the end of the closure period (DA-BFAR 2013; Mesa 2014; Bagsit et al. 2021). According to Narvaez (2017), fishing regulation incentivizes operators to increase the fishing effort and, consequently, the volume of catch by using more gears or boats (Beets and Manuel 2007) during the open period to compensate for their inactivity during the ban. This coincides with the study of Sys et al. (2017) on the Belgian beam trawl fishery, wherein an increase in recorded landings was attributed to the intensification of fishing efforts after the implementation of spawning closure in the Celtic Sea. Similar findings were reported by Bagsit et al. (2021) in the Visayan Sea, given that fishers affected by the seasonal fishing closures (SFC) "race to fish" to offset the low catches during the SFC period.

Following the lifting of the three-month closed fishing seasons in the country's principal fishing grounds, fish prices in the local markets have been steadily declining (Ocampo 2021) because of the increased fish supply that floods the market. In comparison to lean season, the market value of fish and fishery products is significantly lower during peak season regardless of their quality (Muyot et al. 2021). This is because the supply of fish exceeds the demand of the consumers, and the market competition is high, thus, prompting fisherfolk to sell their products at a reduced price to compensate for their capital and prevent further loss of income. Moreover, fishery commodities are highly perishable; hence, the lack of appropriate storage infrastructure and services during peak season instigates rapid quality deterioration in fish. This may lead to revenue loss brought by price reduction or complete discarding of the products.

The minimal loss was documented in aquaculture commodities, accounting for 0.16% and 0.23% of the total catch assessed in landing sites and wet markets, respectively (Table 4). Among the four commodities assessed, price drop due to oversupply in landing areas was recorded only in mussel. Monthly loss in landing sites ranged from 0% to 0.47%, with highest percentage loss recorded in July due to low market demand (Table 5). The same commodity displayed the highest MFL in wet markets at 0.14%.

Table 4. Overall estimated loss of aquaculture commodities

Commodity	Landing Area				Wet Market			
	Volume Assessed (MT)	Volume Loss (MT)	TMFL (%)	FL (PHP)	Volume Assessed (MT)	Volume Loss (MT)	TMFL (%)	FL (PHP)
Tilapia	0	0	0.00	0.00	15.44	0.04	0.05	2,652.50
Shrimp	0	0	0.00	0.00	5.41	0.01	0.01	2,927.50
Mussel	209.16	0.33	0.16	12,591.00	51.84	0.10	0.14	2,725.00
Mangrove Crab	0	0	0.00	0.00	3.14	0.02	0.03	5,645.00
TOTAL	**209.16**	**0.33**	**0.16**	**12,591.00**	**75.83**	**0.17**	**0.23**	**13,950.00**

TMFL – Total Market Force Loss
FL – Financial Loss

Table 5. Monthly estimated loss of aquaculture commodities

Month	LANDING				WET MARKET			
	Total Volume Assessed (kg)	Market Force Loss (kg)	Percent Loss (%)	Financial Loss (PHP)	Total Volume Assessed (kg)	Market Force Loss (kg)	Percent Loss (%)	Financial Loss (PHP)
January	32,512.00	107.24	0.33	1,400.09	-	0.00	-	0.00
February	23,478.50	8.64	0.04	135.00	-	0.00	-	0.00
March	27,523.00	12.26	0.04	352.00	-	0.00	-	0.00
April	20,135.00	0.00	-	0.00	-	0.00	-	0.00
May	12,940.00	41.88	0.32	1,130.00	4,983.43	24.80	0.50	5,330.00
June	8,709.50	1.00	0.01	25.00	3,043.55	10.01	0.33	1,437.50
July	7,241.90	34.33	0.47	956.00	1,858.80	7.55	0.41	665.00
August	14,315.00	43.85	0.31	920.00	8,630.95	67.67	0.78	2,630.00
September	15,130.50	0.00	-	0.00	13,984.53	35.69	0.26	1,905.00
October	21,124.50	6.25	0.03	150.00	11,366.83	7.52	0.07	463.00
November	14,405.25	28.41	0.20	531.00	17,270.39	6.26	0.04	610.00
December	11,641.50	48.15	0.41	933.50	14,689.32	4.61	0.03	909.50

It was followed by tilapia at 0.05%, mangrove crab at 0.03%, and shrimp at 0.01%. Apart from the increase in the supply of commodities, cases of very few buyers were also reported in sampled wet markets, which resulted in price reduction despite having good quality. The estimated financial loss of landed and traded aquaculture commodities sums up to PHP 12,591 and PHP 15,642, respectively. Marginal loss in wet markets can be attributed to the vendors' tendency to purchase only enough products that can be sold throughout the day. The effort to balance the fish demand to the amount of harvest and seasonal availability could lessen the potential price reduction associated with oversupply during peak catch or harvest seasons.

Market dynamics is undoubtedly a significant factor that determines the fate of fishery commodities—whether they can be sold at a reasonable price, reduced price, or even be discarded in some cases. While lower retail prices would alleviate consumers' distress, particularly the hard-pressed, when inflation persists (PIDS 2020), it could lead to a loss of potential revenue to fisherfolk; thus, affecting their perspective towards fishing (Akande and Diei-Ouadi 2010). Persistent surpluses could discourage producers and compel them to decide to withdraw from the market (PIDS 2020). Therefore, the government should take measures to curb price collapses associated with oversupply during peak seasons to ensure equitable benefit sharing from the fisheries industry and reduce postharvest losses and wastes across the supply chain in pursuit of food security.

3.2 Estimated loss per commodity

3.2.1 Small pelagics

Small pelagics play a vital segment in the fisheries industry as these are considered the primary source of inexpensive animal protein, especially for the poor and lower-income groups (FAO 2014; Ani 2016; Isaacs 2016). Fisheries production in municipal and commercial sectors comprises mostly small pelagic species such as scads, mackerels, sardines, anchovies, neritic tunas, and fusiliers (Candelario et al. 2017). Palawan is considered the "Fish Bowl" of the Philippines because of its richness in terms of marine biodiversity (Candelario et al. 2018). According to PSA (2019), Palawan contributed a 10.14% share of the total fisheries production volume in 2016. It also accounts for 92% of the total landed catch of round scad, the most important small pelagic fishes in terms of volume/tonnage in the entire country (DA-DILG 2015; Pastoral et al. 2000).

Out of 378.02 MT catch assessed in selected landing sites in municipalities of Narra, Quezon, Brooke's Point, Rizal, San Vicente, and Puerto Princesa, 10.13 MT or 2.68% was considered a loss (Table 6). Monthly loss ranged from 0% to 7.24%, with the maximum loss recorded in April (Figure 3). As a result, industry players incurred an estimated financial loss of PHP 247,076. Roundscad, locally known as "galunggong," accounts for most of the catch assessed and loss incurred in small pelagics. Roundscad is an important fishery resource in Palawan that constitutes 92% of the landed catch at Navotas fish port and comprises 22% of the total landed catch nationwide. A closed season is being implemented from November to January through the DA-DILG Joint Administrative Order to increase reproductive capacity, spawning potential, and recruitment of round scad. It covers the area of northern Palawan from the West Philippine Sea to the Northern Sulu Sea under Regions IV-B and VI with a total area of 35,943 km^2 (DA-DILG 2015). It was observed during the assessment that the peak production period is between March and May, a month after lifting the fishing ban. Dalzell et al. (1991) reported that the peak season for round scads occurs throughout dry and declines during wet seasons.

At the end of the closed fishing season in Palawan, the supply of round scad and other small pelagic species is expected to increase, and, as a result, the price is projected to go down and stabilize. This

Table 6. Estimated loss per commodity

Commodity	Landing Area			Wet Market				
	Volume Assessed (MT)	Volume Loss (MT)	% Loss	Volume Assessed (MT)	Volume Loss (MT)	% Loss	TMFL (%)	FL (PHP)
Small pelagic	378.02	10.13	2.68	53.34	0.12	0.22	0.05	2,652.50
Sardines	171.21	11.75	6.86	17.63	0.19	1.08	0.01	2,927.50
Tilapia	0	0.00	0.00	15.44	0.04	0.26	0.14	2,725.00
Shrimp	0	0.00	0.00	5.41	0.01	0.17	0.03	5,645.00
Mussel	**209.16**	**0.33**	**0.16**	**51.84**	**0.10**	**0.19**	**0.23**	**13,950.00**
Mangrove crab	**0**	**0.00**	**0.00**	**3.14**	**0.02**	**0.64**		

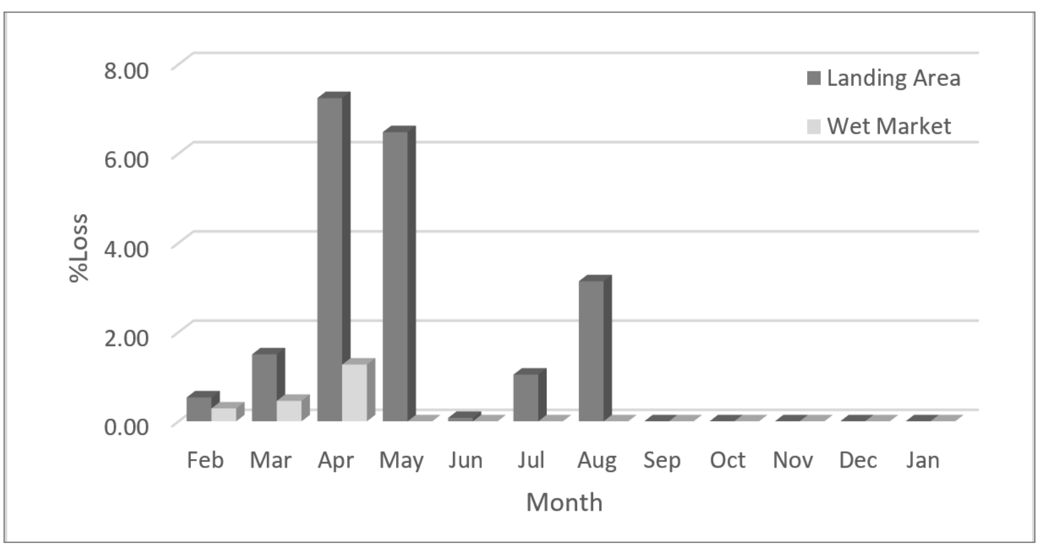

Figure 3. Estimated monthly loss (%) of small pelagics

will ease the burden of the consumers amidst the rising commodity prices. However, this occurrence may put the fisherfolk at a disadvantage because of lower farm gate prices. Small-scale fishers, particularly in Quezon and Puerto Princesa City, Palawan, typically sell their catch to a *consignacion* or fish broker. In contrast, direct selling of catch to traders and dried fish processors is carried out upon landing in the municipalities of Narra, San Vicente, Brooke's Point, and Rizal. Only a limited volume of small pelagics are landed and traded in various municipalities in Palawan, as most of the catch is transported to Metro Manila. Given this relatively short supply and value chain, the quantified loss is marginal. Postharvest losses due to oversupply during peak season are stirred up by a lack of infrastructure facilities such as ice plants and well-equipped fish ports, as well as limited technical knowledge on processing technologies. There are no large-scale fisheries postharvest facilities in Palawan. Fish processing mainly involves drying, which is generally small-scale and employs only members of immediate families or closely-knit communities.

In wet markets, out of 53.34 MT, the minimal loss was recorded at 0.12 MT or equivalent to 0.22% of the total catch assessed. Postharvest losses were high between February and April, equating to the peak fishing season (Figure 3). According to the respondents, stocking unsold products will only cause additional inputs from purchasing ice; hence, they would prefer to process unsold fish as dried than allow them to deteriorate and become unsuitable for human consumption. Drying is one of the oldest and dominant preservation methods that is often used in combination with salting or smoking for additional preservation (Espejo-Hermes 2004). Since fish are highly perishable, this processing technique prolongs the product's shelf life, allowing the vendors to sell them for an extended period.

3.2.2 Sardines

The Zamboanga Peninsula is known as the Sardines Capital of the Philippines, with almost 60%-70% contribution to the country's annual sardine production. The sardine industry is mainly based in Zamboanga City, where most canneries are located, and Dipolog City, which is recognized as the "Bottled Sardines City" (Ani 2016). Sardines are a cheap source of protein, as well as macro- and micronutrients for low-income households in developing countries. In addition, it is among the best sources of Omega-3 fatty acids, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), which makes it ideal for canning and bottling (Isaacs 2016).

Assessment of postharvest losses was carried out in Dipolog City, where unusual beaching of sardines, particularly *Sardinella lemuru*, has been reported. A total of 171 MT sardines were assessed in major landing areas in Dipolog City. The recorded loss was estimated at 11.75 MT, equivalent to 6.86% of the total catch assessed (Table 6). Analysis of monthly losses revealed that the highest MFL at 21.42% was incurred during March (Figure 4). During this period, tons of wriggling sardines are washed ashore.

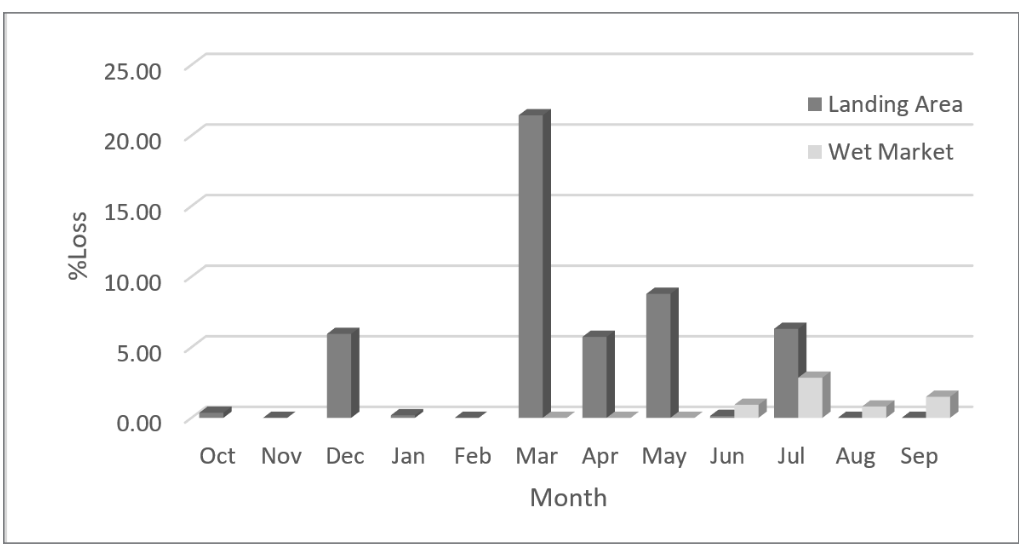

Figure 4. Estimated monthly loss (%) of sardines

This unusual beaching of sardines, locally known as "tamban," is attributed to the annual, three-month-long ban on commercial fishing of sardines (Ani 2016). A Joint Administrative Order by the DA and DILG was promulgated in 2011 to conserve sardines in East Sulu Sea, Basilan Straight, and Sibuguey Bay. The fishing ban for commercial fishing operators extends from December to February, the peak of the spawning season for sardines. However, it does not apply to municipal waters, a zone designated for marginal fishers extending up to 15 km from the shoreline (Rola et al. 2018).

Sardines are the most abundant fish landed by small-scale artisanal fishers in Zamboanga del Norte that are commonly utilized for drying and bottling. Direct selling of catch to market vendors and processors of bottled and dried sardines is carried out upon landing. Buyers and fish catch traders are limited within Zamboanga del Norte or, in some cases, Zamboanga City. During the annual glut season, which occurs between March and May, demands drop down, resulting in a sharp price reduction (Assefa 2018). The estimated financial loss incurred during the assessment amounted to PHP 219,334. Buyers who purchase sardines intended for animal feed production or locally termed as "icers" procure a large volume of sardines for only PHP 180.00 per styrofoam container, which has an average volume of 45 kg. With the absence of cold storage or proper chilling facilities, fishers resort to dumping excess catch back into the sea or allowing it to rot due to fishers and processors' inability to cope with the volume. A portion of the excess catch is also donated to correctional institutions in Dapitan, a neighboring city from Dipolog. Processors in the bottled sardines industry cannot accommodate an excessive volume of raw materials due to a lack of workforce and limited production capacity. Fishing during the glut period occurs at night; thus, landed catch is usually kept overnight. As a result, fishers often fail to meet the stringent physical quality parameters of small and medium enterprise (SME) processors as raw materials for bottled Spanish sardines (RFLP 2013). Sardines, particularly *S. lemuru* are at risk of oxidation and rancidity because of their high-fat content (Mahrus et al. 2012; Isaacs 2016). Dried fish processors are also constrained as the latter part of the peak season for sardines coincides with the onset of the southwest monsoon, which makes it difficult for processors to dry the excess sardines (RFLP 2013).

Out of 17.63 MT sardines assessed in wet markets, only 0.19 MT or 1.08% was documented as losses. Sardines also have a low demand in wet markets because most of these species are sold to traditional processors or retailers who purchase these fish and sell them to far-flung rural areas through "habal-habal" (single motorcycle), where the vendor loads their fish intended to be sold in retail.

3.2.3 Tilapia

Tilapia is one of the most cultured freshwater fish in the Philippines, next to milkfish, mainly because of its low input support, fast growth rate, and profitability (Islam and Sarker 2018). Low inputs needed for production can increase possible profit (Travis 2018). Estimation of losses in farmed tilapia showed that MFL was not apparent despite having large volumes of fish transported to wet markets (Table 6). For aquaculture commodities, the timing of pond harvests is usually tailored to meet the local supply and demand patterns to limit postharvest losses. The price of tilapia usually revolves around PHP 90 to PHP 100 per kilogram, regardless of the supply volume. Tilapia in wet markets are always sold out because vendors tend to attract customers by offering free cleaning and filleting of tilapia. Compared to other fishes, tilapia prices are lower and affordable, especially for those in the low-income sector. Market vendors also obtain stocks that they can ultimately sell throughout the day. However, some market vendors tend to lower their selling price due to the number of competitors also selling the same commodity. Such cases were minimal; hence, the recorded loss was estimated only at 0.26% of the 15.44 MT catch assessed.

3.2.4 Shrimp

Losses in shrimp due to market forces in wet markets were estimated at 0.17% or 0.01 MT out of 5.41 MT catch assessed (Table 6). Though considered negligible, the incurred loss can be attributed to the competition in sales in the wet market. The demand for shrimp, particularly in marginalized groups, is low owing to the substantially high retail price, ranging from PHP 280 to PHP 450 per kilo. Most traders were eventually forced to lower the cost of selling everything they had acquired for the day. An average PHP 40.00 price difference was recorded, but several cases of drastic price reduction were also experienced wherein it goes beyond half the original or best price per kilo.

The utilization of shrimp even in a global setting may be affected by the shift of farmers' and consumers' preferences towards other cheaper fish alternatives. In fact, international shrimp prices were once affected due to low import demand, and countries, including Japan and United States, experienced financial losses as shrimp markets weakened. This problem inclined farmers to grow more profitable commodities like tilapia, leaving a negative effect on the shrimp industry (The Fish Site 2008). However, the unusually large shrimp harvest in Asia reported last April 2018 instigated oversupply and lower shrimp prices in the international trade. Higher imports demand in most markets, especially China, resulted from increased availability of shrimp at a reduced price.

3.2.5 Mussel

Shellfish, including mussels, are known to be susceptible to the occurrence of toxic red tide. Paralytic shellfish toxin-contaminated mussels are not safe for human consumption as they pose a threat to human health (Rodriguez et al. 2010). In fact, mussel farming is often left out as an alternative livelihood because of this condition, even though it does not require high capital investment. The banning of farming and consumption is usually done when toxic red tide occurs to ensure consumers' safety as these algal toxins cannot be altered by cooking methods (Gupta 2016). According to mussel farmers and traders interviewed during the assessment, the incidence of toxic red tide occurred during the midyear of 2017, affecting some bodies of water, including Regions IV-A and VIII. Harvesting, trading, and consumption of shellfish were prohibited due to high levels of red tide toxin. A sudden increase in supply was experienced in January 2018 upon lifting the red tide warning, resulting in a decrease in market prices.

The estimated losses of mussels in landing sites and wet markets were recorded at 0.16% and 0.19%, respectively (Table 6). The higher financial loss was recorded in landing areas amounting to PHP 12,591.00, compared to wet markets with only PHP 2,725. Financial loss incurred ranged from PHP 150.00 to PHP 200.00 per "canastro" which is comprised of 40 kg of mussel. Boiling unsold mussels and selling them in a plastic pouch the following day have been practiced by some traders to minimize postharvest losses as further postharvest processing of raw materials can help prolong the shelf-life of the product.

3.2.6 Mangrove crab

Mangrove crab farming requires relatively low investment compared to other more intensive types of aquaculture. High potential profit gain could encourage farmers to venture into the business, thereby increasing the production supply (Shelley and Lovatelli 2011).

A total loss of 0.64% from the 3.14 MT total volume assessed was recorded in mangrove crab in wet markets (Table 6). The increase in mangrove crab volume can be associated with the situations when fish farmers or workers were given a share of the harvest as incentives, which their wives usually sell at the market. Although each vendor has a small amount of stock acquired for vending, the number of competitors was high, leading to a forced price drop. Good quality mangrove crabs are highly expensive, ranging from PHP 800.00 to PHP 1000.00 per kilogram, making them unmarketable for those who belong to the low-income sector. Furthermore, increased prices of mangrove crab in the domestic markets can also be linked to its strong demand for export markets (Aldon and Dagoon 1997). The financial loss per kilo of crab was approximately PHP 60.00. However, vendors often reduce the price up to PHP 100.00 to PHP 180.00, especially if there are only little to no buyers. Vendors chose to sell the crabs at a lower price rather than storing them for a longer period because of the high tendency for meat spoilage (Lalitha and Thampuran 2012).

3.3 Mitigating the losses

3.3.1 Value chain analysis

Fish and fishery products undergo different stages of postharvest handling and processing that may create and build value before ending up in the markets. A participatory value chain analysis (VCA) should be conducted with fisheries stakeholders to map-out key processes and flows in the supply chain and distribution channels of priority commodities. Kaplinsky and Morris (2000) defines value chain as the full range of activities required to bring a product or service from conception through the different phases of production and delivery to final consumers. It contributes to a deeper understanding of the relationships and interactions between consumers, suppliers, and several market players. Analysis of the value chain is carried out mainly to define areas such as the process, product, feature, or the entire chain itself that requires upgrading to deliver maximum value for the least possible total cost (Kaplinsky and Morris 2000). This will help identify bottlenecks and critical points for government interventions to involve the disadvantaged actors in the chain effectively.

3.3.2 Market linkage

Lack of market is one identified problem that contributed to the incurred losses. Establishing market linkages between the fishers and fish farmers is an important measure to reduce the burden of acquiring financial losses in the sector. Since trading of fishery commodities is confined within the area and neighboring municipalities, as evident in cases of oversupply in Palawan and Dipolog City, determining outside markets is deemed necessary. Domestic and, in some cases, regional markets, whether agriprocessors, wholesale and retail markets, hotels, or institutions, can offer significant potential to small-scale fishers. It is important for government and non-government organizations to intervene and work with the stakeholders. Collaboration with the programs of the Department of Labor and Employment (DOLE), Department of Trade and Industry (DTI), and other institutions should be undertaken to forge upstream and downstream linkages among enterprises and players along the supply and value chains. Exploring domestic market potentials and supporting promotional activities are recommended to develop local demand for fishery products (Shepherd 2007).

3.3.3 Suggested retail price (SRP)

It is recommended to implement a price regulating mechanism such as the suggested retail price (SRP) that should be area and species-specific. This is to ensure the availability of fishery commodities at reasonable prices at all times without denying a fair return on investment to the fisherfolk. Under the Implementing Rules and Regulations (IRR) of Republic Act No. 7581, otherwise known as the Price Act of 1992, regular monitoring of essential or prime commodities should be conducted to identify and investigate the causes of market and price irregularities, determine price trends, provide the basis for establishing SRP and ceiling, and develop database system on prices. The government may also impose price control measures, specifically during emergencies and similar occurrences (DOJ-OFC 2015). The price floor, which refers to the lowest legislated price that can be charged on a commodity, is generally applied to protect the resource suppliers or producers. However, the price floor may tempt producers to produce more, especially if it is higher than the equilibrium price, which could lead to persistent surpluses (PIDS 2010). Therefore, market interventions through price regulation should strike a balance between improving market competition and providing adequate protection to producers and consumers against profiteering (DOJ-OFC 2015).

3.3.4 Establishment of cold storage or ice-making facilities

Fish and other fishery resources are highly perishable commodities; thus, they are susceptible to postharvest losses and contamination by biological hazards. Stiffening of fish muscle, known as rigor mortis, commences due to the action of enzymes within 12 hours after the fish is caught. During fish spoilage, the breakdown of various components and the formation of new compounds responsible for changes in fish meat's odor, flavor, and texture occurs. Therefore, it is recommended to freeze the fish at temperatures between -18°C to -30°C by utilizing cold storage facilities to slow down and reduce the microbial metabolism responsible for the spoilage (Ghaly et al. 2010). Appropriate on-site cold storage facilities play a crucial role in the supply and demand of fishery resources, as it withstands seasons by allowing fisherfolk to store and keep their catch for extended periods. Depending on the product type and temperature of the cold storage, fish can be stored for a minimum of four months (Table 7) (Johnston et al. 1994) without noticeable changes in quality. Fish may then be sold during off-peak or lean season to command higher prices. Efficient cold storage provides not only fresh produce year-round but also minimizes postharvest losses and wastage, thereby allowing fish

Table 7. Practical storage lives (PSL) for fish (Johnston et al. 1994)

Commodity	Storage life in months		
	-18°C	-25°C	-30°C
Fatty fish (sardines, salmon, ocean perch)	4	8	12
Lean fish (cod, haddock)	8	18	24
Flat fish (flounder, plaice, sole)	9	18	24
Lobster, crabs	6	12	15
Shrimp	6	12	12

producers to maximize yield and profit.

There is an existing cold storage facility in Dipolog City, which is a joint project of BFAR Region IX and the provincial government of Zamboanga del Norte. It was established to accommodate fish catch during the glut season when there is excess sardine catch. The main potential clients are members of the In-glass Sardines of Dipolog Association. However, the said facility is not yet operational due to key technical specifications being unmet by the contractors. In addition, sardines need gutting before they can be held in cold storage; hence, there is a need for a mechanized system for gutting that is compliant with current Good Manufacturing Practices (cGMP) to process large quantities of sardines for cold storage (RFLP 2013).

Another alternative to prolong the shelf life of raw materials and reduce postharvest losses is the establishment of commercial-scale ice production facilities in strategic places. Chilling is the most common practice to keep the freshness of fish. According to Espejo-Hermes (2004), chilling is defined as lowering of temperature close to or just below the initial freezing point, typically between -1.10°C to 2.20°C, to considerably retard the rate of spoilage. For tropical countries, the ideal water-ice-fish ratio is 1:2:6 (Shawyer and Medina-Pizzali 2003). Storage of fish in ice-chilled will prolong the shelf life of the commodity for a maximum period of two weeks (Johnston et al. 1994; Nair 2002).

3.3.5 Postharvest processing technologies

Adoption of innovative and low-cost processing technologies in areas that experience a surge in supply of raw materials during peak fishing season is also necessary to curtail the economic impacts of postharvest losses. Fishers and fish farmers may venture into fish processing that does not require high capital investment, such as drying, smoking, fermentation, pickling, canning, bottling, and value-adding, instead of selling it at meager prices during peak season. Technology transfer training should be carried out to small-scale fishers and processors on available postharvest technologies to improve their processing and operational capabilities and ensure compliance with relevant food safety and product standards. This initiative will significantly reduce postharvest losses and wastage and improve economic returns for fish processors and fishers during glut season and beyond.

The creation of organizations or cooperatives comprised of small-scale fishers, fish farmers, traders, and processors is also recommended to enable them to obtain higher returns. They can lower their cost-per-unit by combining supplier purchases, sales, and other expenditures. This will also facilitate easier and cost-effective business transactions, increase access to government support programs, and close linkage to suppliers, customers, services, and competitors.

3.3.6 Livelihood support

Small-scale processors face intense competition from more established small and medium enterprises (SMEs). They are often beset with productivity and efficiency constraints caused by substantial barriers such as lack of access to financial services, poor market information, limited technical and management knowledge, and lack of access to improved processing technologies (Francisco and Canare 2019). These inhibit them from maximizing their growth potential, penetrating bigger domestic and international markets, and surviving in a highly competitive environment. In addition to capacity enhancement training programs, livelihood assistance to fisherfolk in the form of production inputs such as basic postharvest and processing equipment, market and credit linkages, and other production, postharvest, and marketing-related interventions is essential to ensure sustainable livelihood and enterprise development.

3.4. Limitations of the study

There are limitations in this study that could be addressed in future research. The assessment was conducted only to provide baseline information on the magnitude of market force loss, factors contributing to losses, and possible key points for government interventions that may be useful to policymakers. Research findings, including the recommended management interventions, were backed up by both literature and actual field observations in particular sites and the specific time of the year to add credibility to the estimates. For policy prescription, a more rigorous approach should be carried out, such as using econometric modeling to depict the trend and the causal relationships between MFL and the factors that affect it to ensure that policies are correctly guided.

4. CONCLUSION

Market patterns and conditions such as oversupply during peak fishing seasons, certain phenomena affecting fishery production, socioeconomic characteristics, and preferences of consumers contribute to postharvest losses. Assessed capture commodities in selected landing sites and wet markets recorded an estimated loss of 3.98% and 0.44%, respectively. The total financial loss incurred in both supply chains amounted to PHP 480,160. Estimation of losses per commodity showed that landed sardines obtained the highest loss at 6.86%, while mixed species of small pelagics recorded approximately 2.86% loss. This can be attributed to the oversupply of fish catch at the end of the closure period, leading to drastic price reductions. Minimal losses were documented in aquaculture at 0.33% and 0.23% for landing and trading, respectively, amounting to PHP 26,541.

While lower retail prices would alleviate consumers' distress, it could lead to losses of revenue to fisherfolk; thus, affecting their perspective towards fishing. Therefore, to ensure the availability of fishery commodities at reasonable prices without denying a fair return on investment to the fisherfolk, it is recommended to:

1. Conduct participatory Value Chain Analysis;
2. Establish market linkages between producers and consumers;
3. Implement a price regulating mechanism such as the suggested retail price (SRP) that should be area and species-specific;
4. Establish cold storage and commercial-scale ice production facilities in strategic places;
5. Encourage stakeholders to venture into fish processing and value addition; and
6. Provide livelihood support to small-scale fishers, fish farmers, traders, and processors.

The paper may serve as a general basis for policy direction to address the losses due to fluctuations in fish supply and changing marketing environments. This may also be used as a reference for more rigorous economic studies such as econometric modeling to depict the trend and the causal relationships between the MFL and the factors that affect it.

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AUTHOR CONTRIBUTIONS

Tadifa GC: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing - Original Draft, Visualization. **Banicod RJS:** Conceptualization, Methodology, Validation, Formal analysis, Writing - Review & Editing. **Peralta DM:** Conceptualization, Methodology, Formal analysis, Investigation. **Ramos CAM:** Conceptualization, Methodology, Formal analysis, Investigation. **Montojo UM:** Conceptualization, Methodology, Writing - Review & Editing, Supervision, Project administration, Funding acquisition.

CONFLICT OF INTEREST

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

ETHICS STATEMENT

The authors carried out no animal or human studies.

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