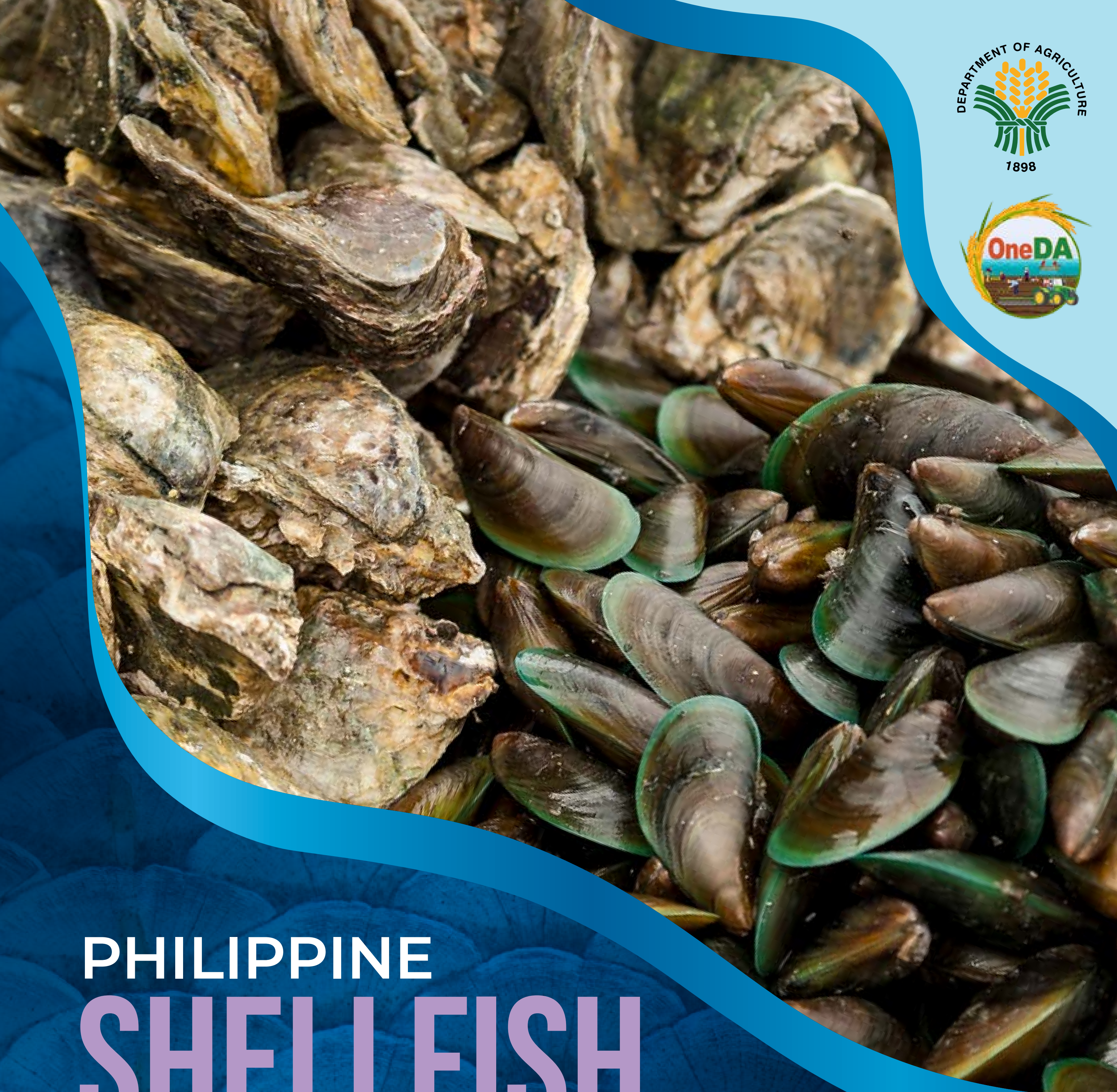
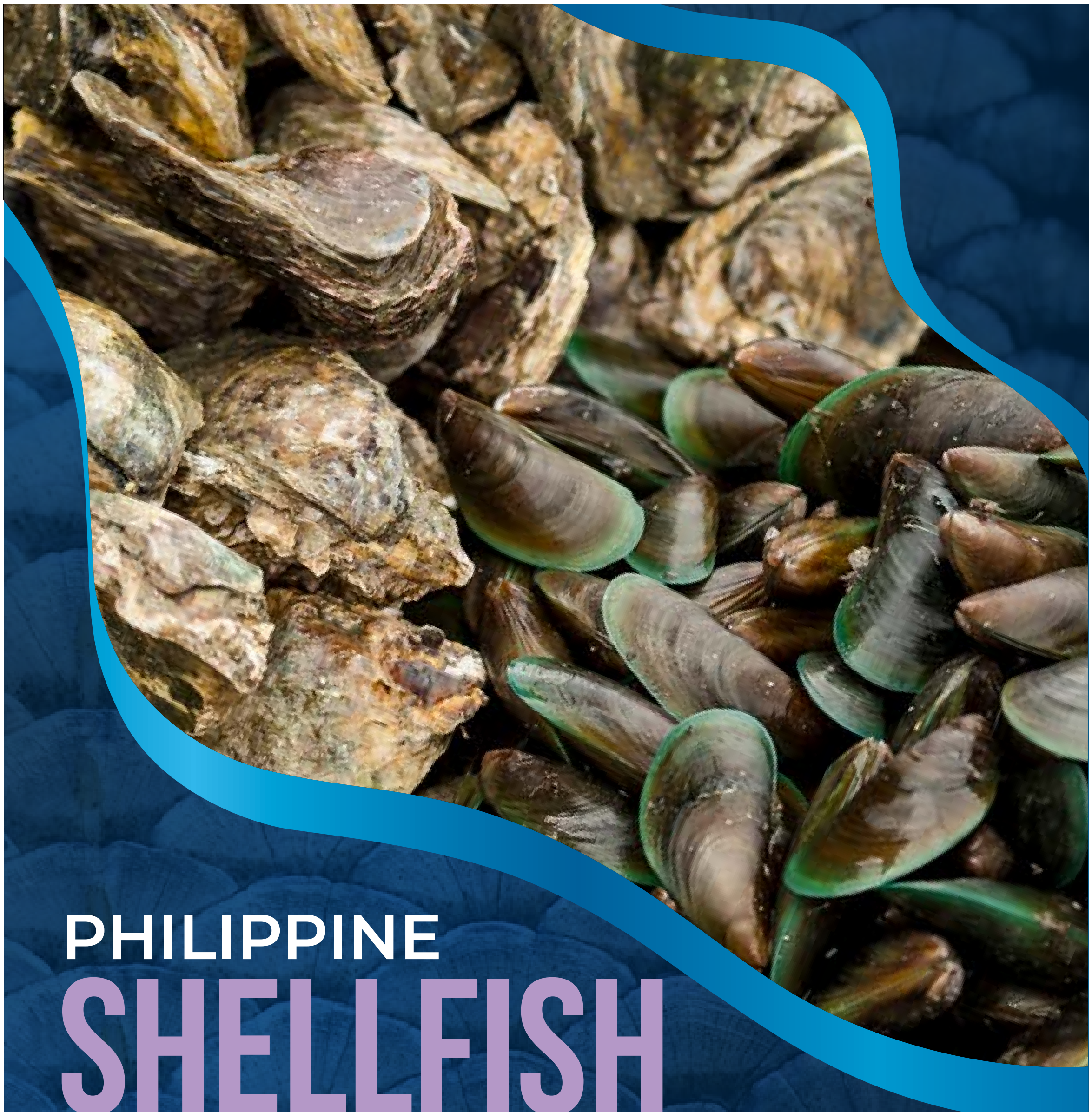


PHILIPPINE SHELLFISH INDUSTRY ROADMAP 2021-2025



PHILIPPINE SHELLFISH INDUSTRY ROADMAP 2021-2025

DEPARTMENT OF AGRICULTURE
BUREAU OF FISHERIES AND AQUATIC RESOURCES
"Tagapagtaguyod ng Malinis at Masaganang Karagatan"
ISO 9001:2015 | CIP 5387/19/12/1117

The Philippine Shellfish Industry Roadmap (2021-2025)

ISSN: 2945-4409

Published by:

Bureau of Fisheries and Aquatic Resources
Department of Agriculture
Diliman, Quezon City, Philippines

Cover & Book Design:

Alphabet Communications Graphics & Print
Quezon City, Philippines
alphabetprinting@gmail.com

PHILIPPINE SHELLFISH (TAHONG AND TALABA) INDUSTRY ROADMAP DEVELOPMENT TEAM

Focal Person

Dennis D. Tanay, Ph.D., BFAR NFDC Chief

Team Leader

Dr. Westly R. Rosario, PRC Chairman for Board of Fisheries

Co-Team Leader

Dr. Ma. Junemie Hazel Ramos, SEAFDEC

Mr. Raymond S. Rodolfo, ASIN

Technical Experts/Consultants

Dr. Nonita Cabacaba, GMFDC

Mr. Marc Lawrence Romero, BFAR

Mr. Juan R. Relox Jr., BFAR

Mr. Roy C. Ortega, BFAR NBFTC

Jose B. Gamboa III, BFAR NFDC

Dr. Ulysses Montojo, NFRDI

Ms. Ma. Theresa Oclos, NFRDI

Ms. Marites Chiuco, NFRDI

Ms. Amor Diaz, BFAR-FIDSSD

Mr. Francisco Reyes Jr., BFAR-NFDC

Ms. Rogelyn V. Laban, BFAR-NFDC

Ms. Ana Marie Magallanes, GMFDC

Ms. Sandra Macasojot, GMFD

Technical Writer

Ashley D. Salinas, BFAR NFDC

Industry Experts

Mr. Christopher Baterina, Province of Ilocos Sur

Mr. Neon Tomas B. Rosell II, ASIN

Hillel B. Cabria, ASIN

Ms. Evangeline Tayag, Marigold Manufacturing Corporation

DA-BFAR Program Management Team (PMT)

Ms. Cordelia Nipales, BFAR-NFDC

Ms. Nerafe Muyalde, BFAR-NFDC

Mr. Regino Regpala, BFAR-NFDC

Ms. Editha Roxas, BFAR-NFDC

Ms. Mary Joy Agustin, BFAR-NFDC

Mr. Racquel Ferrer, BFAR-NFDC

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ATTACHMENTS

ACRONYMS

ASIN	Agriculture Sustainability Initiatives for Nature, Inc.
BFAR	Bureau of Fisheries and Aquatic Resources
FAO	Food and Agriculture Organization
GMFDC	Guian Marine Fisheries Development Center
HAB	Harmful Algal Bloom
HACCP	Hazard Analysis Critical Control Point
IMTA	Integrated Multi-trophic Aquaculture
NFDC	National Fisheries Development Center
NFRDI	National Fisheries Research Development Institute
NSDP	National Shellfish Development Program
NSSP	National Shellfish Sanitation Program
PRC	Professional Regulation Commission
PHRDC	Philippine Human Resource Development Center
PSA	Philippine Statistics Authority
SEAFDEC	Southeast Asian Fisheries Development Center

MESSAGE

The Department of Agriculture (DA) envisions a Philippines that is food-secure and resilient, with empowered and prosperous fisherfolk. The Commodity Industry Roadmap (CIR) for Shellfish gives fisherfolk and the private sector the support they need to increase productivity and profitability in the shellfish industry while using sustainable, competitive, and resilient technology and practices.

The CIR addresses significant challenges confronted by the industry, like the lack of both private and public investments. Likewise, it provides strategies for then implementation of the Philippine National Shellfish Sanitation Program (PNSSP), environmental monitoring, establishment of hatcheries, research and development, and product development.

Furthermore, the CIR integrates other critical strategies under the "OneDA Reform Agenda." These strategies allow stakeholders to lower production costs, reap the benefits of the shellfish industry value chain, and target interventions for economies of scale. To gain a regular market for their produce, the DA will help organize farmers and fishers create links with key actors in the food sector. In collaboration with the private sector, concerned agencies, and local governments, critical infrastructures such as shellfish hatcheries, Harmful Algal Bloom (HAB), environmental monitoring laboratories, and market stalls will be planned out according to their impact on supply markets and climate change. We incorporated the PNSSP into the CIR to address the industry's sanitary concerns, which includes the profiling of existing and potential shellfish growing fields and the improvement of laboratory facilities.

The CIR will help fisherfolk gain and improve their knowledge and abilities in entrepreneurship and farm business management through education and training. Agripreneurship, when combined with agri-industrialization, will be an integral approach to modernizing the country's fisheries sector, creating jobs and income opportunities, and lifting millions of smallholder farmers out of poverty.

I am positive that this roadmap will help improve the lives of shellfish fisherfolk and develop a shellfish industry that is robust, resilient, and globally competitive.

Tungo sa Masaganang Ani at Mataas na Kita!

WILLIAM D. DAR, Ph.D.
Secretary
Department of Agriculture

FOREWORD

Our country teems with ecologically and economically important fisheries resources. Recently, the Department of Agriculture has intensified its efforts in crafting management plans for priority commodities to ensure their sustainable utilization.

Following the Comprehensive National Fisheries Development Program, we have launched several management plans for important marine commodities. And now, we are honored to present to you the Industry Roadmaps for Priority Aquaculture Commodities including Seaweed, Milkfish, Tilapia, Shrimp, and Shellfish. These roadmaps are a product of a wide participatory process led by the Department of Agriculture's Bureau of Fisheries and Aquatic Resources and the Philippine Council for Agriculture and Fisheries, and participated in by industry leaders, stakeholders, and experts from the academe.

These roadmaps take into consideration the challenges faced by the sectors in previous years and the corresponding strategic actions to address these issues, from short to long-term actions designed to address problems from the production to the trade level. We are positive that with the appropriate support from the government, and active participation by our stakeholders, these roadmaps will be instrumental in developing the Seaweed, Milkfish, Tilapia, Shrimp and Shellfish Industries into globally competitive, inclusive, and resilient industries.

Guided by the OneDA Reform Agenda, the Department of Agriculture will continue harmonizing its efforts with all stakeholders to achieve a food-secure Philippines and *Masaganang Ani at Mataas na Kita* for our fisherfolk.

CHERYL MARIE NATIVIDAD - CABALLERO
Undersecretary for Agri-Industrialization and for Fisheries
Department of Agriculture

MESSAGE

As one of the identified priority fishery commodities, the Bureau Fisheries and Aquatic Resources sees the immense potential of intensifying the commercial development of shellfish aquaculture in order to improve the income of marginal fisherfolk and increase the industry's contribution to the country's tood security.

This "TNT" (Tahong and Talaba) Roadmap envisions a globally competitive, sustainable, and radically-industrialized production of high-quality *tahong* and *talaba* in the Philippines, contributing significantly to increased livelihood opportunities and income of marginal fishertolk engaged in its farming, depuration, processing, and marketing by 2040. To attain this, we are targeting an increase in production by 25% every five years through the following major activities: (1) developing and promoting sustainable and environment-friendly farming technologies and practices, (2) providing livelihood opportunities to marginalized fisherfolk, (3) implementation of Philippine National Shellfish Sanitation, (4) product development, (5) capacity building, (6) infrastructure investments on hatcheries, depuration, processing and marketing, and (7) research and development. Statistics showed an annual increase of 4.69% in oyster and mussel production in the Philippines despite industry constraints, including pollution, poor sanitary quality, microbial, and HAR occurrence. These strategies, among others, aim to address the issues and challenges that hamper the growth of the shellfish industry.

The Department of Agriculture's Bureau of Fisheries and Aquatic Resources commits its full support for the implementation of this roadmap, towards creating a meaningtul contribution for our shared Vision of a food-secure Philippines, with prosperous fisherfolk, free from hunger and poverty.

Maraming salamat at Mabuhay ang Industriya ng Pangisdaan!

COMMODORE EDUARDO B. GONGONA, PCG (Ret.)
Director, Bureau of Fisheries and Aquatic Resources
Department of Agriculture

PREFACE

Shellfish aquaculture production is one industry with massive potential for development in the Philippines. Basic information on the biology and geographical distribution of mussels and oyster grounds has been available since the 1980s. Yet, there is no commercial production of the species by a farmer's group or private company. Generally, the production is at the family level, with produce sold along roads or highways. Depuration of produce before marketing is never done.

Shellfish farming is an aquaculture endeavor that has more gain than otherwise. Oysters and mussels help in cleaning our coastal waters and estuaries. Farming is easy and profitable because feeds and other similar inputs are not required. Shellfish diseases rarely occur. Oysters and mussels, sold raw or processed, have wide acceptance in the Philippines and other countries. According to official data, shellfish production, particularly oysters and mussels, is increasing annually.

A national roadmap is an essential tool to optimize the national economic benefits of shellfish farming. The roadmap will help many marginal fishers or fish farmers living along the tributaries and shorelines of the country. Integrating shellfish with sea cage farming is also a sustainable strategy to minimize the negative impact of fish culture in marine cages. The roadmap shall also allow identifying new production areas for shellfish and using post-harvest protocols like depuration that shall ensure food safety for consumers and allow export of Philippine shellfish products in the future.

WESTLY R. ROSARIO, DR.F.T.
Team Leader
Shellfish (Tahong and Talaba) Roadmap Development Team

EXECUTIVE SUMMARY

In the Philippines, the oyster and mussel industry provides a large portion of the income for marginal fishers in estuaries and coastal areas. For decades, the business has provided low-cost, high-quality protein to the country. However, even back then, the industry was a backyard venture, and most cultural practices remained traditional.

Many of the issues that the shellfish sector faces were identified in the past. Many of these issues, however, still exist in the sector. Siltation and pollution, red tide or Harmful Algal Bloom (HAB), inadequate funding infrastructure support, land reclamation and urbanization, limited market demand and low prices for shellfishes, seed supply uncertainty, and inadequate sanitary plans in densely populated urban areas, and a lack of shellfish processing program before market are among the issues.

The TNT Roadmap shall implement the National Shellfish Development Program (NSDP) that offers strategies to increase production through sustainable optimization of farming efforts and advanced technologies. The focus shall be on the evaluation of farming areas for oysters and mussels, promotion of modern farming and post-harvest technologies, developing manpower experts on oysters and mussels, and extensive technology programs.

The general objective of the Program is to attain sustainable growth of the industry to enable it to contribute to the overall food production and food security while increasing the income of various shellfish stakeholders with consideration to the environment. Various strategies shall be implemented such as the capacity building of implementers and farmers, technology livelihood packages, research and development projects, profiling and assessment of existing and potential mussel and oyster grounds, the establishment of support infrastructures like hatcheries, processing and depuration facilities, policy formulation, strengthening of market linkages, and development of value-added products, among others.

INTRODUCTION

Rationale

In the Philippines, oysters and mussels are two of the most important aquaculture fishery commodities. The slipper-shaped oyster (talabang tsinelas) and the green mussel (tahong) are the most commercially cultivated mollusk species in the Philippines, largely for their meat and consumption by Filipinos. For decades, the sector has provided low-cost, high-quality protein to marginal coastal fisherfolks. Shellfish industry over 10 years (2011-2020) showed an annual shellfish production averaging at 49,656.65 MT (PSA, 2020) or a 4.69% average annual percentage increase for the last 10 years. The data showed the top producing regions are Region VI (21,388.62 MT), Region III (11,425.52 MT), Region IV-A (6,424.42 MT), Region VIII (5,373.93 MT), and Region I (2,049.61 MT).

The Philippines being an archipelagic country is especially suitable for shellfish farming having grounds with spawners of indigenous species. The tropical nature of the coastal waters in the country provides suitable farming conditions for better growth and reproduction of various species. Considering their high value and cheap inputs for their production, the cultivation of oysters and mussels is a strategy worth pursuing to help the marginalized fisherfolk. Their production, however, is still hampered by several factors. The average area of an oyster farm is less than one hectare and production is intended only for the local market. On the other hand, one significant problem of existing shellfish areas like the province of Cavite is the over-congestion of farms. Many farming structures were abandoned. Reclamation of oyster grounds to expand the national highway was also cited as one of the reasons why the production of the commodities decreased.

Environmental factors such as pollution and siltation, which have a negative impact on the productivity of culture grounds, also limit the rate and intensity with which production can be increased. Farmers also find it difficult to keep track of the sanitary quality of their produce. As a result, hotels and restaurants who can afford to pay a premium for this product are rarely enticed to buy it locally due to a lack of quality control (PHRDC, 1991).

Because the industry is still a developing sector in the Philippines, there are few regulations on cleanliness and sanitation during the growing, harvesting, and marketing processes. Oysters and mussels are grown in rivers and estuaries that contain variable quantities of pollution, particularly animal waste. In the Philippines, outbreaks of harmful algal blooms (HAB) or paralytic shellfish poisoning (PSP) are also a major impediment to the industry's growth. As of 2007, HAB was affecting five major producers, including Capiz, Bulacan, Pangasinan, Iloilo, and Negros Occidentales. Furthermore, the shellfish industry's expansion is slowed by the uncertainty of seed supply and quality in the aquaculture industry.

Statistics showed an annual increase of 4.69% in oyster and mussel production in the Philippines despite some industry constraints that include pollution, poor sanitary quality, microbial, and HAB occurrence. To increase the amount and quality of these commodities produced in the country, a multitude of interventions should be implemented.

Currently, the mussel and oyster industry relies solely on wild seed supplies, and farmers have yet to fully adopt more advanced farming technologies designed for the industry. The establishment of hatcheries can ensure the industry's long-term viability. This is required to guarantee that juveniles are available all year. To improve production, advanced technologies from other countries could be used.

The primary purpose of the TnT Roadmap is to design strategies that seek to implement a sustainable mussel and oyster industry by promoting newly developed farming, with an integrated approach to uplift the socio-economic condition of fishing communities dependent on coastal fisheries for livelihood. Development efforts under the Program enshrined in the Roadmap will focus on the promotion of applicable farming technologies, particularly on oysters and mussels, to enhance the country's production; and the provision of livelihood opportunities to small-scale and marginalized fisherfolk, particularly in poverty-stricken areas. The Program shall be a vehicle for poverty alleviation and food security. Its goal and objectives are in line with the National Government's thrust and BFAR's mandate under Republic Act 8550 (The Fisheries Code of 1998), namely, "conservation, protection and sustained management of the country's fishery and aquatic resources, poverty alleviation and the provision of supplementary livelihood among municipal fisherfolk, improvement of aquaculture productivity within ecological limits, and upgrading of post-harvest technology."

Objectives

The general objective of the program is to achieve sustainable growth of the mussel and oyster industry to contribute to the overall food production and food security of the country and increase income for various stakeholders with consideration to the capacity of the environment through the following specific objectives:

a. To develop, enhance adoption and promote sustainable and environment-friendly farming technologies and practices, like IMTA (Integrated MultiTrophic Aquaculture);

b. To provide livelihood opportunities to more marginalized fisherfolk;

c. To strengthen quality and food safety mechanisms for domestic supply and export;

d. To manage and regulate existing and new areas for shellfish production through profiling and classification of shellfish grounds and prudent resource management;

e. To reduce post-harvest losses and to develop potential value-addition technologies for mussel and oysters;

f. To improve marketing channels from production areas to consumers;

g. To ensure safe and quality mussel and oyster products for public consumption through regular water quality and food safety monitoring, depuration, and relaying technologies;

h. To ensure reliable seed supply through the establishment of spat collection areas and hatchery facilities;

i. To establish production support infrastructures like processing and depuration facilities as a means of elevating food safety and export market.;

j. To study and improve the production of other potential bivalve species like scallops, cockles, and windowpane oysters.

k. To develop policies, procedures, and work instructions that are compliant with food safety standards of the domestic and international markets.

INDUSTRY SITUATION AND OUTLOOK

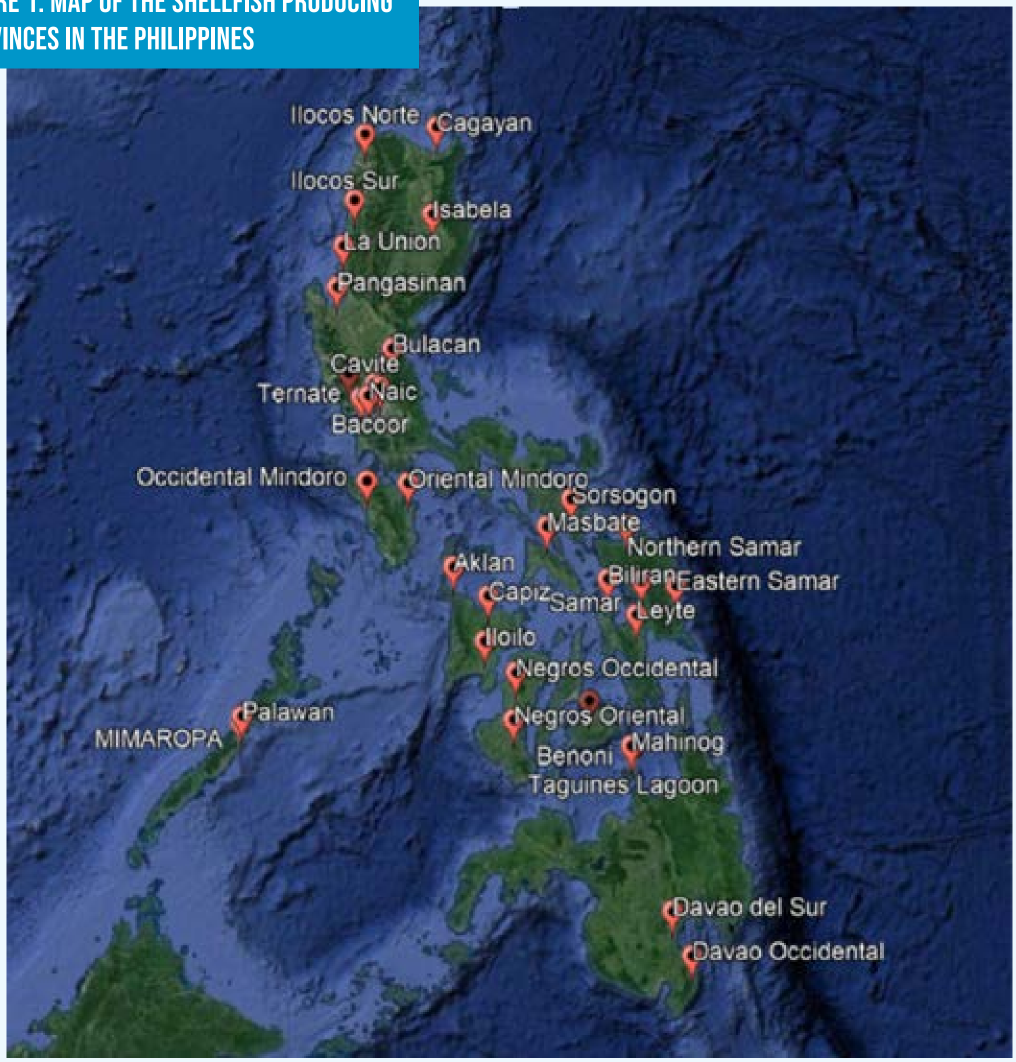
Structure

Industry Definition

One of the major contributors to food security and livelihood for the country's growing population are the oyster and mussel industries. The country's economic and food sustainability are aided by technological advancements and development for its manufacturing and end-product innovations. Different aquatic environments and cultivation systems are used to cultivate and grow these commodities. The sector also provides market trade prospects for adjacent countries. The slipper oyster *Crassostrea iredalei* and the green mussel *Perna viridis* are two economically important bivalves in the Philippines that are predominantly farmed by fishermen as a primary or secondary source of income.

In 2020, the total production of oysters and mussels reached 74,993.02 MT valued at PhP 1,551,688,000.00 which showed an estimated 18% increase in production from 2019's data by PSA. A declining trend of production was observed from 2013 to 2015 but eventually recovered for the succeeding years showing an average of 15% annual production from 2016 to 2020. The 10-year production data showed that the top producing regions are Region VI (21,388.62 MT), Region III (11,425.52 MT), Region IV-A (6,424.42 MT), Region VIII (5,373.93 MT), and Region I (2,049.61 MT). Production areas or provinces from the top producing regions include Aklan, Capiz, Iloilo, Negros Occidental, Bulacan, Cavite, Samar, Leyte, Biliran, Pangasinan, La Union, Ilocos Norte, and Ilocos Sur as reported by the Regional Shellfish Focal Persons of the Bureau of Fisheries and Aquatic Resources (Figure 1).

FIGURE 1. MAP OF THE SHELLFISH PRODUCING PROVINCES IN THE PHILIPPINES



In terms of culture practices, the methods remain traditional for most of the production areas which still make use of broadcast and stake or tulos methods (Table 1). Raft and longline methods are also present in the provinces as BFAR initiated the dissemination and promotion of these culture methods through the provision of livelihood technology packages in 2016. This is under the National Shellfish Industry Development Program wherein the livelihood component has proposed raft units to be distributed as an additional source of income for the fisherfolk especially in the coastal areas. Oysters and mussels remain to be the most farmed species in these culture practices. Other farmed shellfishes in some regions like Region VIII include winged oysters and abalone which also offer potential in culture and market.

TABLE 1. SHELLFISH CULTURE PRACTICES AND SPECIES BY REGION AS REPORTED BY BFAR REGIONAL SHELLFISH FOCAL PERSONS

Region	Shellfish culture practices /method			
	Structure type	Shellfish Commodity	No. of units	Covered Area
I	Raft	Oyster	1186	206.655 ha
		Green Mussel	18	10.925 ha
	Stake	Oyster	220	6.71 ha
	Long line	Oyster	412	4.0 ha
II	Raft	Oyster	65	1,625 sqm
	Stake	Oyster	--	380 lin m
	Broadcast	Oyster	--	2.8 has
III	Raft	--	--	--
	Stake	Oyster		12.485 has
		Mussel		14.20 has
IV-A	Raft	Oyster	5	5mx5m
	Stake	Oyster	75	6.327
	Broadcast	Mussel	163	94.729
	Others	Mussel	3	2
IV-B	Raft	Mussel, Oyster	--	1 ha
	Long line	Mussel	--	1 ha
V	Raft	Oyster	31/15	Sorsogon & Masbate
	Stake	Mussel	3,000	Sorsogon
	Long line	Mussel		Sorsogon
VI	Raft	Oyster, Mussel	626	52.48
	Stake	Oyster, Mussel	788	185
	Longline	Mussel	10	2.53
	Hanging	Oyster, Mussel	412	111.60
	Broadcast	Oyster, Mussel	72	20.25
VII	Raft	Oyster	538	6.602 has.
	Stake	Oyster	4 (farm areas)	0.5 has.
	Longline	Mussel, Oyster, Wing Oyster	1,834	17.86
	Others	Abalone	5	0.48
X	Raft	--	1,396 units (tires)	--
XI	Raft	Mussel	26	0.1386 HA
	Raft	Oyster	2	0.0060 HA
	Stake	Oyster	2 Farms maintained	3.12 HA

The reliance of oyster and mussel producers on natural spatfall is one of the primary difficulties and limits facing the Philippine industry. Other variables, including environmental and socioeconomic issues, have had an impact on seed supply quantity and quality. Seed production at hatcheries has proven critical to the long-term viability of fisheries and aquaculture, and it is a popular practice (at least for oysters) in countries such as Vietnam, Japan, the United States, Australia, France, and others. The cultivation of wild or hatchery-produced seed has the potential to relieve pressure on native populations. Oyster hatcheries are still scarce in the Philippines (Table 2). As a result, there is a need to increase the industry's capability in terms of training government technical extension workers and possible private investors in order to address the issue of seed resource unreliability.

TABLE 2. LIST OF HATCHERY FACILITIES FOR OYSTERS AS REPORTED BY BFAR REGIONAL SHELLFISH FOCAL PERSONS

Shellfish culture practices /method					
Region	**Name of Hatchery**	**Area**	**Location**	**Ownership Type** (Private, Gov't)	**Annual Production Capacity**
I	Regional Mariculture Technology Demonstration Center (RMATDEC)	0.25	Alaminos City, Pangasinan	Gov't	2,531,250 pcs
IV-B	Arton Aquafarms		Magsaysay, Occidental Mindoro	Private	30 M spats
IV-A	ASIN Oyster Hatchery	1000 sqm	San Juan, Batangas	Private	5 M spats; 9000 strings (5 cultches/ string) with at least 5 spats per cultch(2020 production)

TABLE 3. LIST OF POST-HARVEST FACILITIES FOR OYSTERS AND MUSSELS AS REPORTED BY BFAR REGIONAL SHELLFISH FOCAL PERSONS

Shellfish culture practices /method				
Region	**Name of Processing Facility**	**Product Forms**	**Location**	**Ownership Type** (Private, Gov't)
II	DONSEBA BAGOONG	Bottled Bagoong	Villa Leonora, Buguey, Cagayan	Private
V	Community Fish Landing Center	Tahong Chips Bottled Oyster	Sorsogon, Masbate, Camarines Sur, Camarines Norte, Catanduanes, Albay	Government
VIII	Maligaya Agri-Business Association (MABA)	Tahong Sticks, Tahong Crackers (Plain and Spicy), Bottled Tahong (adobo classic, adobo spicy, adobo sa gata, menudo, escabeche, bopis)	Brgy. Maligya, Jiabong	Private
	Super JJED	Tahong Crackers, Bottled Tahong (Adobo Garlic, Adobo Hot, Tahong in Brine, Escabeche)	Brgy. Alejandria, Jiabong	Private
	Carmela's Tahong Crackers	Tahong Crackers	Brgy. Alejandria, Jiabong	Private
	Sherly Jumagdao	Tahong Crackers	Brgy. Alejandria, Jiabong	Private
XI	Distributed Post Harvest Equipment Only (smokehouse, stainless working table, elevated solar dryer, pressure cooker, oyster shucker, banyera, utility cabinet, scoop net)	Oyster Bagoong and fresh oyster	Brgy. Balasinon, Sulop Davao del Sur and Brgy. Bagumbayan, Malalag D/S	Donated by Gov't. Agency
NCR	Marigold Manufacturing Corporation	Oyster Sauce	Pasig City	Private

Product Forms

Mussels and oysters are very popular in the Philippines. According to the FAO, if the sanitation issue can be resolved, the country has strong export potential. Mussels and oysters, on the other hand, might also be considered as possible feed for high-value carnivores such as groupers, lobsters, and mangrove crabs, which are easily exportable, due to their low cost of production.

Shellfish is primarily made up of 75-80% water, 15-20% protein, 2-5 percent fat, and 1-2 percent minerals. Shellfish, in general, contain significant amounts of digestible proteins, essential amino acids, bioactive peptides, long-chain polyunsaturated fatty acids, astaxanthin and other carotenoids, vitamin B12 and other vitamins, minerals such as copper, zinc, inorganic phosphate, sodium, potassium, selenium, iodine, and other nutrients, all of which provide a variety of health benefits to the consumer (Venugopal et. al., 2017). Although shellfish are generally safe to eat, their exposure to a variety of environmental conditions, the filter-feeding behavior of shellfish like oysters, clams, and mussels, and poor farming and handling procedures can all pose health risks due to the presence of numerous dangers. Pathogenic organisms, parasites, biotoxins, industrial and environmental contaminants, heavy metals, process-related additives like antibiotics and bisulfite, as well as the existence of allergy-causing substances in their bodies, are all potential risks. At various phases of harvesting, farming, processing, storage, distribution, and consumption, most hazards can be handled by proper preventive measures.

Shellfish processing is mostly limited to the more popular crustaceans and mollusks. In the Philippines, shellfish is consumed domestically. It is used as food and can be processed into oyster paste, with the shells powdered as a calcium supplement for poultry and livestock.

Abalone, mudsnail, mussels, oysters, cuttlefish, squid, octopus, and ark shells are among the mollusks transported live or in processed forms such as dried, salted, and frozen/chilled. They are, in general, highly perishable goods that require meticulous attention to maintain quality after harvesting, whether they are delivered fresh or processed.

Shellfish processing technologies have been created, but the majority of them are exported due to high export demand and plenty in the catch, or because there is no local need. However, given the current availability of appropriate technologies, the use of other possible species appears to have a bright future.

There are several different types of post-processing for mussels that are used in different parts of the world such as canned, frozen, marinated, smoked, dried, powdered, and pickled foods (CMFRI, 1980). The mussel is made into crackers or bottled in the Philippines, similar to adobong tahong (NSCB, 2006). Samar State University (Doncillo & Cambras, 2017) investigated mussels for their potential as sausage, meatloaf, and dry, with the latter receiving the most approval.

Calcium carbonate is a powerful chemical found in the empty shells of oysters, mussels, and other mollusks. Because of the high calcium carbonate concentration in their shells, they have potential as a value addition for lime production to substitute commercial lime. For crop cultivation and agricultural applications, powdered shells are useful liming materials.

Oyster products developed by a JICA-oriented project (PHRDC, 1985-90) namely smoked, canned and depurated oysters and oyster sauce could be utilized. These products were market-tested with positive results by the same project (PHRDC, 1990-93). Two types of oyster powder were developed by the University of the Philippines Visayas (DOST assisted 2017-18) may also be utilized. The large size oysters could be smoked, canned, and depurated while the small sizes could be processed into oyster sauce and oyster powder.

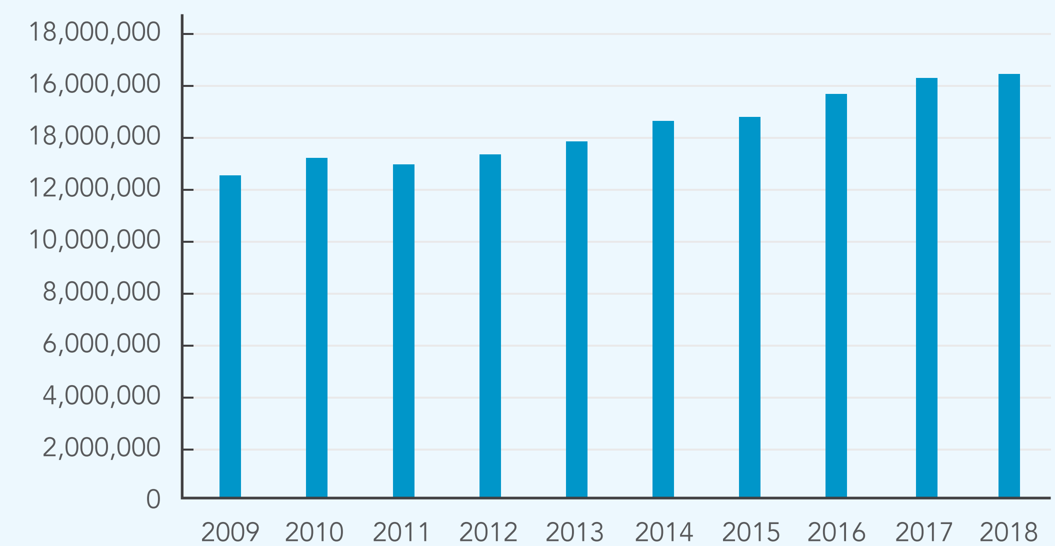
Glude et al (1982) identified three barriers to oyster and mussel marketing: product wholesomeness, unpredictable supply, and an insufficient mechanism for delivering them to market places. If these restraints are addressed, demand can be increased, and production will increase in response.

Industry Performance and Outlook

Global Shellfish Industry

Globally, more than 15 million tons of marine bivalves for human consumption are produced each year (average period 2010–2015), accounting for almost 14% of total marine production. Aquaculture accounts for 89 percent of marine bivalve production (with a total economic value of $20.6 billion per year), whereas wild fishing accounts for only 11 percent (FAO, 2016). In 2018, total production was 16 million metric tons (MT) worth $30 million (Figure 2).

FIGURE 2. WORLD SHELLFISH PRODUCTION (IN MT) (FAO, 2021)



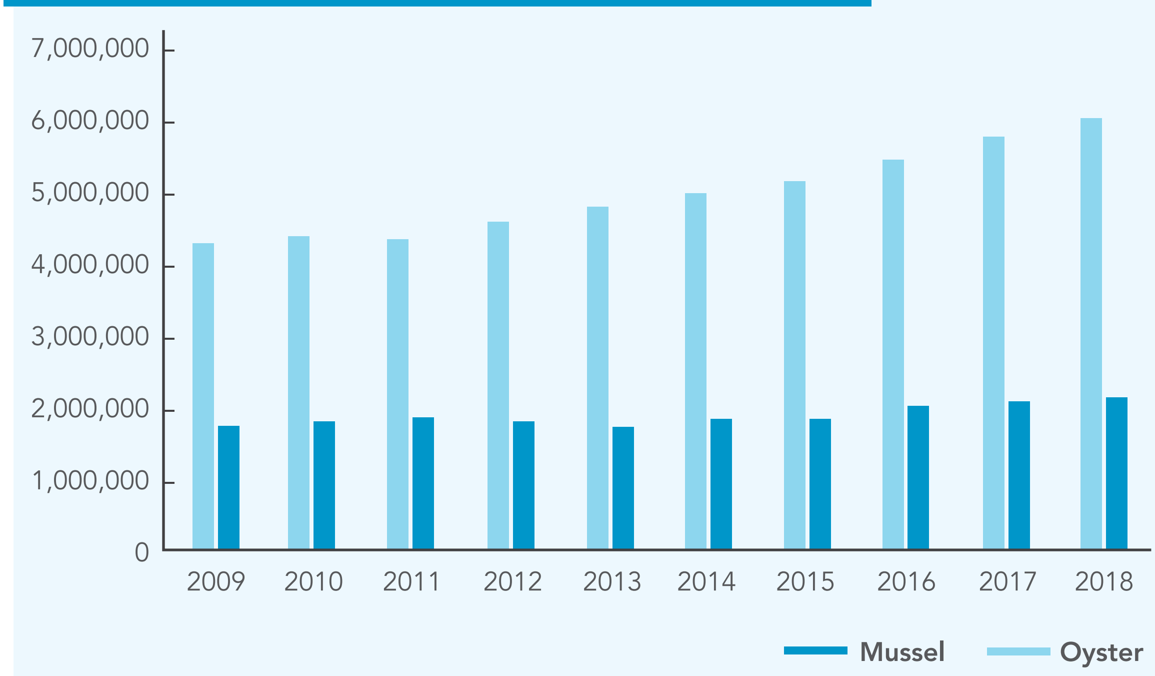
A total of 79 marine bivalve species are recorded as farmed and 93 species are listed as captured in the FAO Global Fishery and Aquaculture Statistics database. They can be grouped into four major groups: clams, oysters, mussels, and cockles. Clams and oysters are the two most important species groups, accounting for 38 percent and 33 percent of global output, respectively. Scallops account for 17% of global production, whereas mussels account for 13%. FishStat FAO 2010–2015 data shows that the global production of marine bivalves is more than 15,000 MT per year.

Seed supplies for aquaculture production, on the other hand, are frequently fished or obtained from natural stocks. Due to diminishing seed resources and environmental concerns with the seed fishery, land-based hatcheries are producing an increasing amount of seed for marine bivalve aquaculture. Since the 1970s, direct capture output of marine bivalves has remained relatively steady (1,780 MT per year), whereas aquaculture production has surged from 1,180 MT per year in 1970–1974 to 13,470 MT per year in 2010–2015.

The total market value of marine bivalves is around 23 billion US dollars per year (2010–2015), but the full economic value is much higher due to the economic benefits from secondary products and services (e.g., shucking and packaging houses, transportation, prepared product manufacturing, and retail sales) (Schug et al. 2009). The production value in US$ kg1 is determined by market demand and the availability of the specific species.

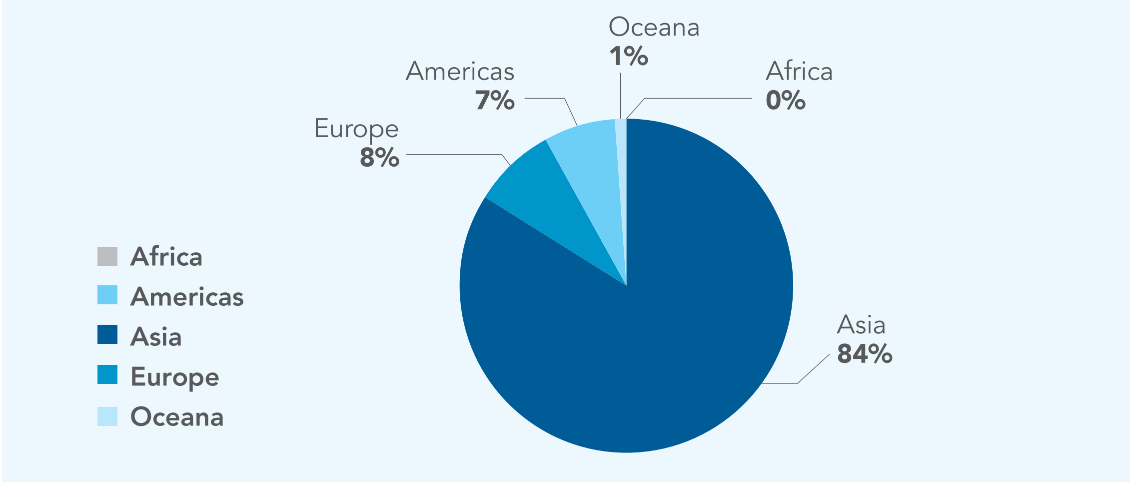
Oyster production has been steadily increasing for the last ten years (Figure 2), whilst mussel production has been declining in 2012 and 2013, although marginally increasing in the last five years.

FIGURE 3. WORLD OYSTER AND MUSSEL PRODUCTION FROM 2009 – 2018 (FAO, 2018)



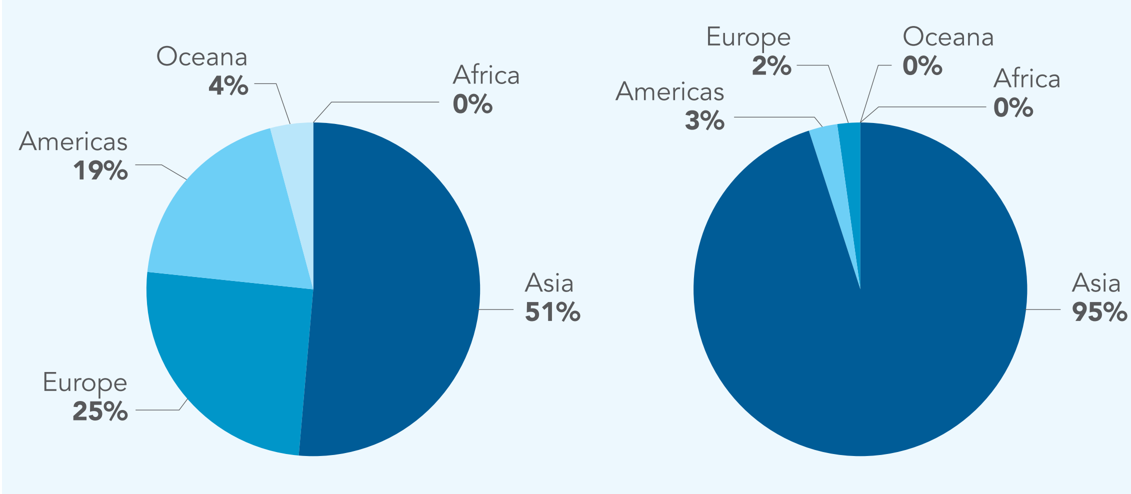
Among other major global land areas, Asia continues to lead in oyster and mussel production (Figure 4). However, due to several factors such as competing demands on space, diseases, and carrying capacity issues, total production in Europe has declined in recent decades. Africa produces the least amount of shellfish, accounting for less than 1% of global production.

FIGURE 4. AGGREGATED OYSTER AND MUSSEL PRODUCTION PER MAJOR GLOBAL LAND AREA



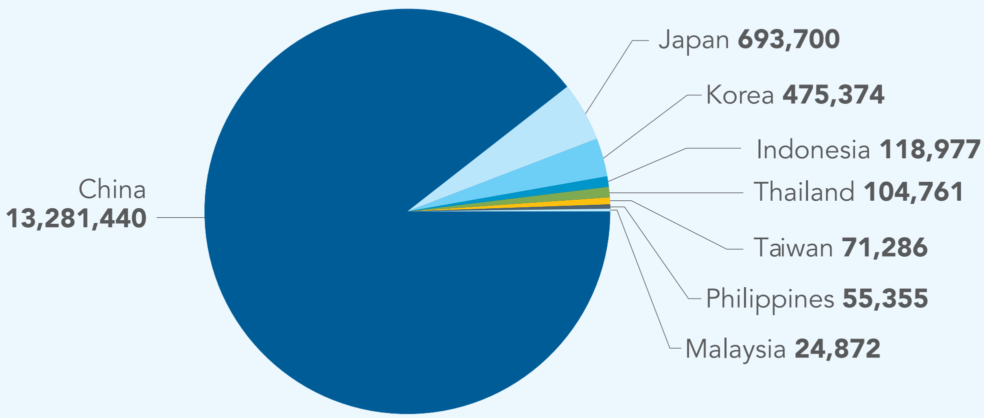
For both oysters and mussels, Asia dominates the production figures. Asia contributes 95% of oyster output, and 51% of mussel production, followed by Europe with a considerably bigger proportion (Figure 5).

FIGURE 5. WORLD OYSTER (LEFT) AND MUSSEL (RIGHT) PRODUCTION PER MAJOR GLOBAL LAND AREA



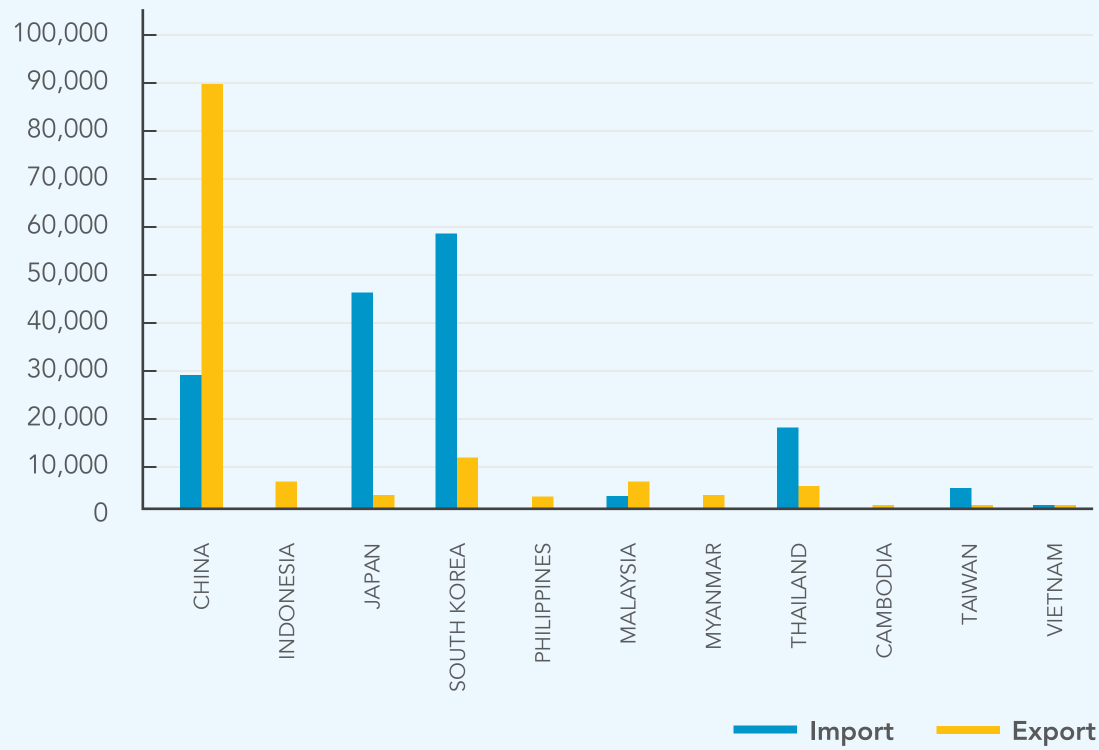
Asia's production, particularly in China, has come to dominate global production patterns and trends, and has become a substantial contributor to global production growth. Due to the rising protein need of China's growing population, the production of marine bivalves is still on the rise. China is followed by Japan, South Korea, Indonesia, and Thailand in terms of volume of shellfish production in 2018 (Figure 6).

FIGURE 6. SHELLFISH PRODUCTION IN SELECTED ASIAN COUNTRIES (FAO, 2018)



According to the 2018 aggregated data on the trade flows for shellfish inclusive of oysters, mussels, scallops, cockles, and clams, China still leads the export volume with 90,596 MT (Figure 7). This was followed by South Korea (10,123 MT), Indonesia (4,934 MT), Malaysia (4,785 MT), and Thailand (3,544 MT). Meanwhile, South Korea led the import volume (58,707 MT) followed by Japan (45,91 MT), China (28,016 MT), Taiwan (4,062 MT), and Thailand (16,615 MT).

FIGURE 7. EXPORT AND IMPORT TRADE FLOWS IN THE PHILIPPINES AND SOME NEIGHBOURING ASIAN COUNTRIES (IN MT)



Tahong and Talaba Industry in the Philippines

Oyster farming in the Philippines began in 1931, when a broadcast method of culture was used to build an oyster farm in Hinigiran, Negros Occidental. The practice has now expanded throughout the Philippines, including locations in Visayas, Luzon, and Mindanao. In 1955, the BFAR oyster farming station in Binakayan, Cavite, established a demonstration mussel farm (Yap, 1999). According to the National Statistics Office's 2002 Census of Fisheries, there were a total of 5,463 aquaculture operators engaged in oyster (3,041) and mussel farming (2,422) in open coastal waters.

Four species of oysters are cultured, the slipper-shaped oyster *Crassostrea iredalei*, the subtrigonal oyster *C. malabonensis*, and the curly or palm rooted oysters *C. palmipes* and *Saccostrea cucullata*. The species receiving particular attention in terms of culture are *C. iredalei* and the moderately sized *C. malabonensis*. They are particularly abundant in Bacoor Bay and extend to the entire Manila Bay from Tarnate, Cavite to Mariveles, Bataan, along the coast of Northern Luzon, Lingayen Gulf, Tayabas and Sorsogon; and to some extent in Batangas Bay, Banate Bay in Iloilo, Binalbagan, Hinigaran and Himamaylan, Negros Occidental, and in areas around Catbalogan, Western Samar, Northern Leyte and Palawan. Commercial farming however tends to concentrate along the coast of various provinces largely in Bulacan, Capiz, Cavite, Pangasinan, Sorsogon, and Negros Occidental.

There are three species of mussels in the Philippines that are used as food: the green mussel *Perna viridis*, the brown mussel *Modiolus metcalfei*, and *M. philippinarum*. In some parts of the country, the green mussel, or "tahong," as it is known locally, is the only species of mussel produced economically. Although brown mussels are gathered from natural areas, they are not appropriate for farming because they are known to adhere to living adults developing in dense mats on muddy bottoms, rather than ropes or bamboo poles. In the Philippines, *Perna viridis* has a limited spread. They are mainly found in Bacoor and Manila Bays in Luzon as well as in Sapian Bay in West Visayas, Maqueda Bay in East Visayas, and several bays and inlets along the northern coast of Panay Island. The brown mussel, on the other hand, is widely distributed, occurring in Luzon, most Visayan islands, and Mindanao. Other important bivalves in the Philippines include cockle, scallop, and carpet clam. Abalone production in the Philippines is also important.

With the University of Rhode Island and the University of Maine, BFAR-NFDC had first scientifically identified the so-called new "black mussel" species which proliferated in the Philippine waters in 2015. Shellfishers have been finding these mussels in portions of the Philippines since 2014, and they are morphologically different from native mytilids. These mussels, which have a thick black periostracum, were first discovered in Manila Bay near an international shipping port in 2013, and then in western Tambac Bay (about 16.28° N, 119.9° E) later that year. They were discovered near the village of Tucok (Dagupan City; 16.0272° N, 120.3147° E) the following year, and in early 2016, they were discovered in Longos, San Fabian, Pangasinan (16.1887, 120.4043). The nonnative mussels were identified as *Mytella charruana*, the charru mussel, by sequencing mitochondrial cytochrome oxidase I polymerase chain reaction products. The charru mussel is native to the tropical Caribbean and western Pacific coasts of South America. Further research reveals that the Philippine charru mussels are most likely sourced from populations along South America's Caribbean coast. These mussels are a challenge for oyster and green mussel farmers because they outcompete these species and destroy other aquaculture infrastructures.

Bottom, stake, and hanging from a rack or raft-rack are the most prevalent oyster production methods. The stake approach is the one that is most commonly employed. The raft and hanging methods are the most productive, followed by the stake and lastly the bottom approach in terms of productivity. In shallow or intertidal environments, the bottom and stake methods are employed, whereas in deeper areas, the hanging method is used (Gallardo, 2001).

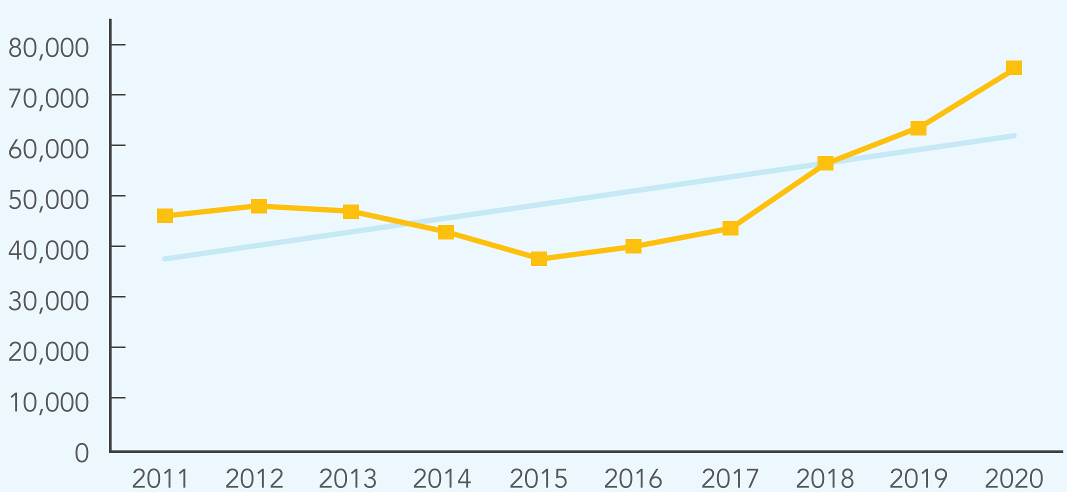
Shellfish resources have traditionally been exploited for food, and in the past, they were mostly pushed for small-scale fisheries in various locations across the country, primarily serving to the home market. However, due to increased demand for shellfish and by-products on the international market, notably shell craft items, small-scale shellfisheries have grown into a large-scale industry. The shell business became a substantial dollar earner for the Philippines during the 1970s and 1980s; exports of shells and shell crafts peaked in 1988 with a total volume of almost 10,000 mt, making the Philippines the world's top provider of shells and shell crafts (Floren, 2003).

Shellfish exploitation has thus played an important part in the country's economy, providing jobs and lives in rural areas while also producing revenue through local commerce and exports. Cultivation of a few molluscan species, harvesting of shellfish species from wild populations, and the shell craft sector now make up the country's shellfish business. Shellfish production in the Philippines, however, continues to rely on natural harvests rather than mariculture of commercially important species, unlike in other nations such as Japan, France, and China, where mollusk mariculture is widely practiced. Overharvesting and resource depletion may arise as a result of such a situation.

To protect customers' health, ease domestic and international trade, and protect the Philippines' reputation as a producer of safe and nutritious seafood, the National Shellfish Sanitation Program (NSSP) was formed. It is based on national legal requirements as well as best international practices. The NSSP comprises codes of practice for microbiological and marine biotoxin monitoring. It includes scientific advice to support food safety policy and risk management decisions on shellfish growing areas classification and the degree to which shellfish must be treated if necessary before they are safe to eat. Sanitary surveys combined with microbiological monitoring in the vicinity of harvesting zones give an estimate of the risk of bacterial and viral pathogen contamination. In addition, routine monitoring of marine biotoxins is carried out. Two bays, Sapian, Capiz, and Sorsogon, Sorsogon, were used to test implementation of NSSP. There have been no toxic algal blooms in Sapian Bay, although there have been multiple dangerous algal blooms in Sorsogon Bay. Both areas have local legislations i. e. basic fisheries ordinance that includes identification of shellfish growing areas among other different fisheries uses. A year's worth of monitoring data was gathered to confirm existing shellfish growth regions and/or identify potential shellfish growing sites.

In 2020, the total production of shellfish inclusive of mussels and oysters reached 74,993.02 MT valued at PhP 1,551,688.00 which showed an estimated 18% increase in production from 2019 based on the PSA data. A declining trend of production was observed from 2013 to 2015 but eventually recovered for the succeeding years showing an average of 15% annual production from 2016 to 2020 (Figure 8).

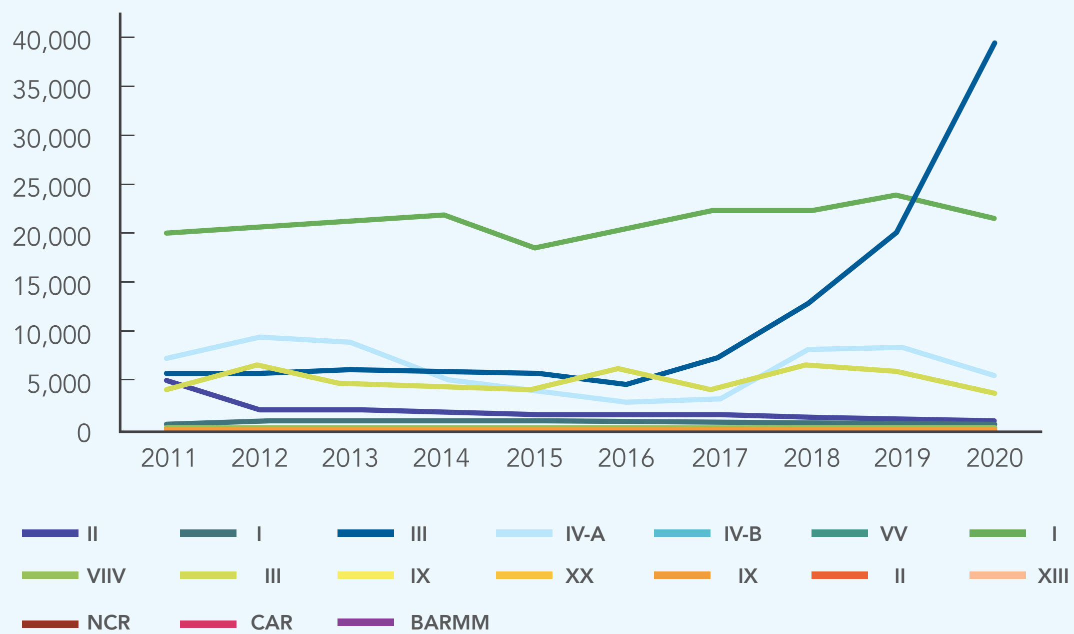
FIGURE 8. TOTAL 10-YEAR PRODUCTION DATA (IN MT) FOR MUSSELS AND OYSTERS IN THE PHILIPPINES



Source: PSA, 2020

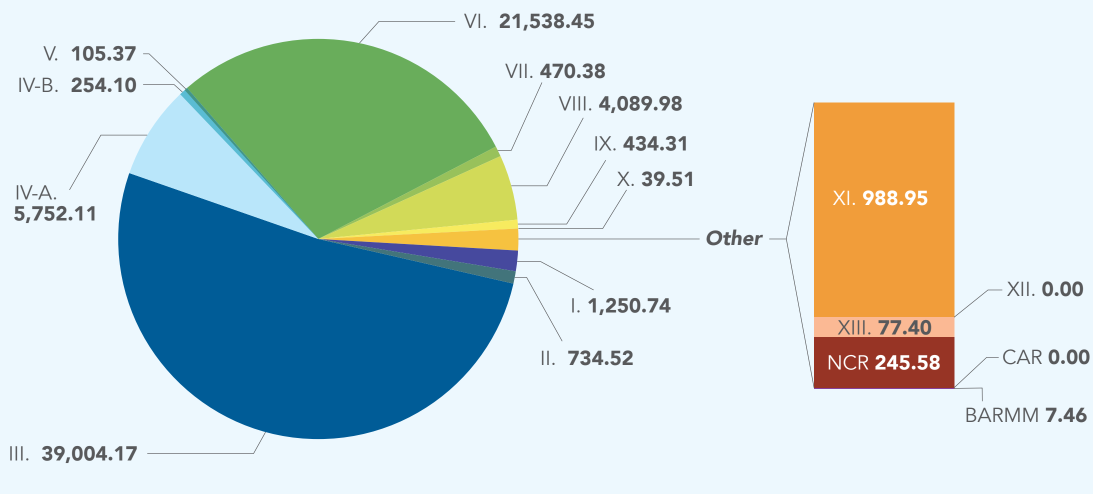
The 10-year production data (Figure 9) showed that the top producing regions are Region VI (21,388.62 MT), Region III (11,425.52 MT), Region IV-A (6,424.42 MT), Region VIII (5,373.93 MT), and Region I (2,049.61 MT). Meanwhile, based on the 2020 PSA data of production alone, Region III (39,004.17 MT) ranked first and switched places with Region VI (21,538.45 MT). This was followed by Region VIII (4,089.98 MT), Region IV-A (5,752.11 MT), and Region I (1,250.74 MT), completing the top 5 producing regions (Figure10). The rest of the regions produced either less than 1,000 MT of oysters/mussels, or nil.

FIGURE 9. TEN-YEAR MUSSEL AND OYSTER PRODUCTION DATA (IN MT) BY REGION



Source: PSA, 2020

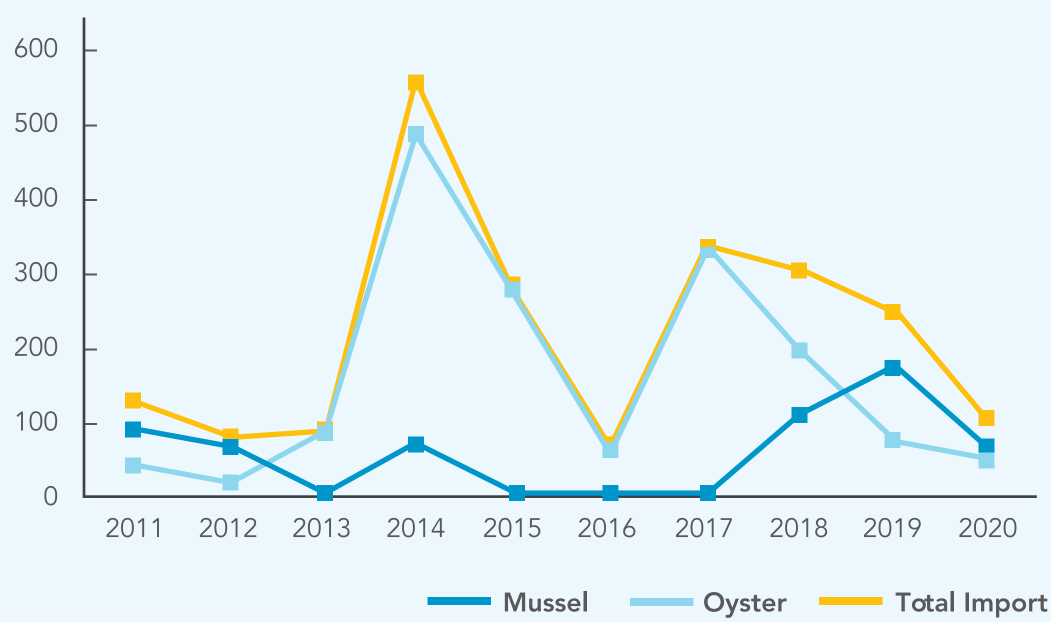
FIGURE 10. 2020 SHELLFISH PRODUCTION DATA (IN MT) BY REGION



Source: PSA, 2020

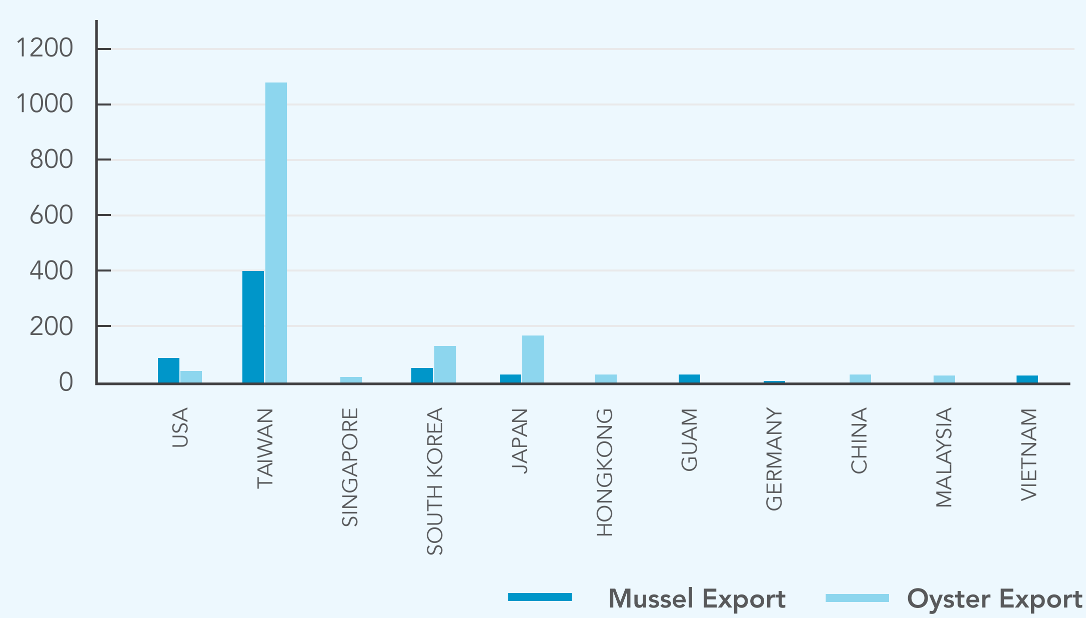
Decreasing trends for export from 2018 to 2020 was observed in the country (Figure 11). Export data for shellfish declined for the last four years (2017-2020) with a 60% decline last year (2020) from 2019. A drastic decrease in export was seen in oysters compared to mussel products.

FIGURE 11. TEN-YEAR TNT EXPORTATION IN THE PHILIPPINES (IN MT).



According to PSA data, mussel products of the Philippines are being exported to the United States of America, Taiwan, Singapore, Korea, Japan, Hongkong, Guam, and Germany with an average gross export of 16.62 MT for the last 10 years. Exported mussels came from Iloilo City, Zamboanga City, and Metro Manila. Taiwan ranked first in the data of our exportation both for oysters and mussels. This is followed by the USA, Japan, and Korea (Figure 12). Sources of exportation in the Philippines are Iloilo City, Zamboanga City, and Metro Manila. For oysters, data for export is recorded for Vietnam, the USA, Taiwan, Singapore, Korea, China, Malaysia, Japan, and Hongkong with an average gross of 19.21 MT for the last 10 years (2011-2020). This comes from Cebu City, Metro Manila, and Region VII.

FIGURE 12. DESTINATION COUNTRIES WHERE THE PHILIPPINES EXPORTED TNT FOR THE LAST 10 YEARS (IN MT).



Meanwhile, importation data for shellfish showed an increasing trend from 2011 to 2019 with a sudden drop of 59% in 2020 (Figure 13). Importation is dominated by mussels with an average gross volume of 267 MT from 2011-2020 which we imported from Australia, Canada, Chile, China, France, Hongkong, Ireland, Japan, New Zealand, Norway, Singapore, Spain, Taiwan, and USA. For oysters, we also have a minimal importation average gross volume of 17.22 MT which we imported from Australia, Canada, Chile, France, Hongkong, Indonesia, Italy, Japan, Korea, New Zealand, China, Thailand, and the USA. The bulk of our importation data comes from New Zealand and Chile where the highest imports for mussels were recorded. For oysters, the majority of imports come from Korea and Japan (Figure 14).

FIGURE 13. TEN-YEAR TNT IMPORTATION IN THE PHILIPPINES (IN MT).

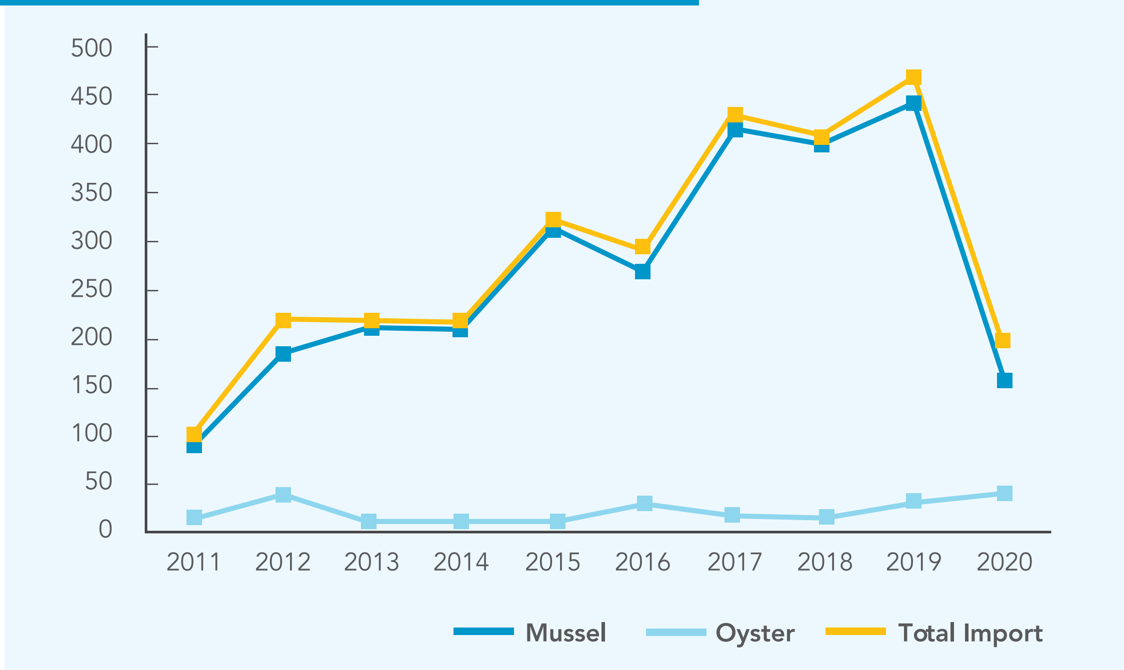
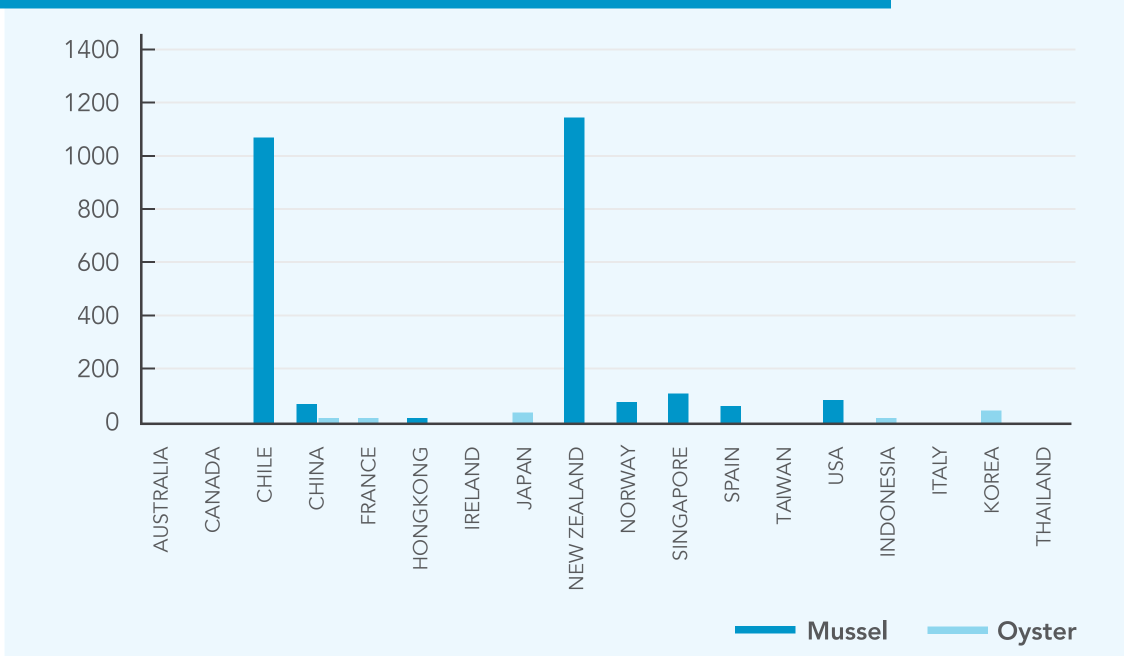


FIGURE 14. COUNTRIES WHERE THE PHILIPPINES IMPORTED TNT FOR THE LAST 10 YEARS.



The per capita consumption for mussels by region can be seen in Table 4. The per capita consumption is based on the average of 2015 - 2016 data from Philippine Statistics Authority. The data shows that the Davao Region, Eastern Visayasand National Capital Region have the highest consumption requirements for mussels. The market price for mussels increased to PhP 103.00 from 2020's annual average price of PhP 98.61, according to PSA data. For oysters, PSA 2012 data on the per capita consumption was recorded at 0.60 grams per day (Table 5).

TABLE 4. AVERAGE PER CAPITA CONSUMPTION DATA FOR MUSSELS IN 2015 - 2016 BY REGION (PSA, 2017) (KG/YR)

REGION	PRODUCTION (MT)
PHILIPPINES	0.383
NCR	0.792
CAR	0.402
I	0.0406
II	0.294
III	0.555
IV-A	0.162
MIMAROPA	0.787
V	0.141
VI	0.234
VII	0.213
VIII	0.881
IX	0.082
X	0.190
XI	0.887
XII	0.321
XIII	0.512
BARMM	0.088

Increasing and above the 2012 per capita production levels were recorded in oysters at 0.35 kilogram per annum with a production index of 127.2% (27.2% difference from 2012) in 2018. Oyster also registered increasing daily per capita net food disposable levels at 0.74 grams in 2018 which is higher as compared with their base year's records. A minimal supply of calories came from oysters with 0.53 grams per day per person. Less than 0.1-gram values were reported for daily per capita protein and fat supply. Adequacy in production was still maintained in oysters. According to the 2019 Self-Sufficiency Ratio

(SSR) data of PSA, oysters registered 100.1 indicating that the food production capacity for oysters is just enough to support the food needs of the population. Oysters also exhibited a low and declining import dependency ratio (IDR) at 0.1%. Table 5 shows the different per capita values for oysters for the last five (5) years as compared to the 2012 per capita values.

TABLE 5. PER CAPITA VALUES FOR OYSTERS (PSA, 2019)

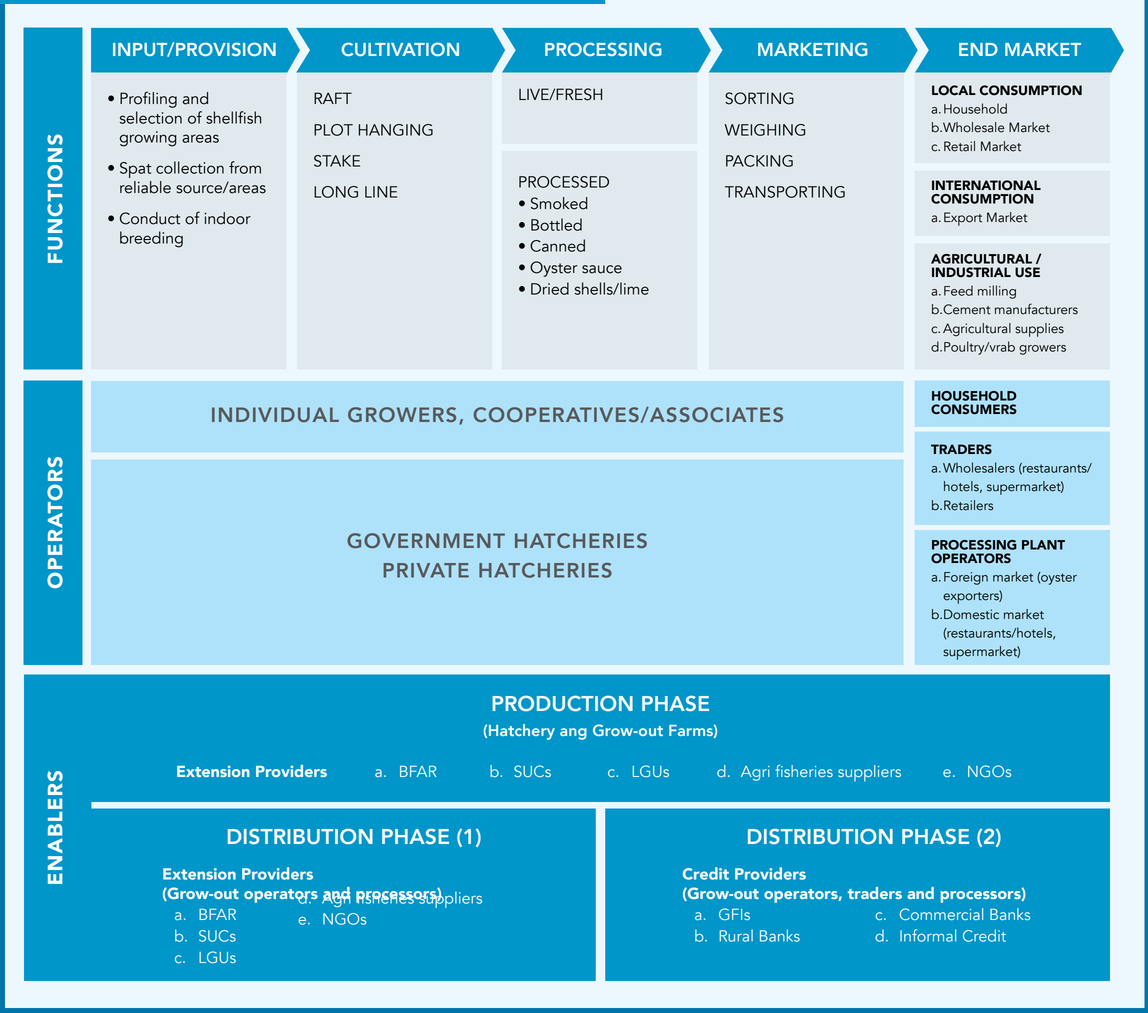
	2012 per capita	2014	2015	2016	2017	2018	2019	% point difference	2019 per capita
per capita consumption (g/day)	0.60								
per capita production (kg/annum)	0.21	111.36	74.8	72.4	81.87	100.0	127.2	27.2	0.35
per capita net food disposable (g/day)	0.58	109.1	74.4	72.7	81.1	100.0	127.8	27.8	0.96
Daily per capita calories supply (in g)		0.45	0.33	0.33	0.36	0.45	0.57		
Daily per capita protein supply (in g)		0.07	0.03	0.03	0.04	0.04	0.06		
Daily per capita fat supply (in g)		0.01	0.01	0.01	0.01	0.01	0.02		
Self-sufficiency ratio (SSR)		101.95	101.14	100.23	101.37	100.58	100.1		
Import Dependency ratio (IDR)			0.03	0.02	0.04	0.03	0.1		

ANALYSIS OF THE COMMODITY INDUSTRY

Value Chain Map (Structural Analysis)

From the provision of inputs to delivery to the end market, the value chain outlines the operations that an organization engages in to create a product or service. Functions, operators, and enablers make up its conceptual foundation.

FIGURE 15. VALUE CHAIN STRUCTURAL MAP FOR SHELLFISH



Functions are the interconnected operations that provide a useful product for the market. The input to be provided, cultivation and processing procedures, and marketing strategies to come up with an effective or efficient ultimate sale are all examples of these (end market).

Operators are a group of businesses that participate in the creation of a product or service as participants or actors. BFAR Hatcheries are regarded as the main participants in the shellfish production business since they are the primary source of competitive technologies that will be transmitted to secondary players such as individual growers, cooperatives, and associations. Household consumers, traders, and processing plant operators, on the other hand, are actors in the market activity.

Enablers are a type of support system that aids in the completion of the process. They help hatcheries, grow-out farms and operators, processors, and traders with technical and financial assistance.

The value chain is simple and straightforward. Seeds are still mostly obtained from the wild, with environmental and biological factors playing a big role. The state of technology and socio-political issues also have an impact on spit collection. Spats are collected and moved to grow-out zones. External variables, such as spat collection, are a part of growing shellfish in open-access areas. Harvesting is done with the help of family or hired labor. The live shellfish is then separated from the dead shellfish. Shellfish farmers sort their catch by size and type, as well as cleaning fouling organisms to some extent. Oysters are transported in baskets, plastic containers, and sacks once they have been harvested. After harvest, the commodity is either sold straight to customers or goes through post-harvest processing. Raw oysters have a three-day shelf life on average (Tanay, unpublished).

In the Philippines, there are three types of supply chains that operate in the raw oyster and other shellfish industries (SFRDC 1991). The first sort of distribution channel comprises a farmer selling their produce directly to consumers from a stand along the highway or at the market. The second form of distribution route, in which the farmer deals directly with a distributor, is the most popular. When the demand for oysters was still high in the early 1990s, wholesalers frequently acquired the product before harvest (SFRDC 1991). The third channel involves a landing site operator who uses a bidding system to ease the sale of shellfish to wholesalers. The operator receives a 3 to 5% fee from the sale of shellfish in this supply chain. Producers (i.e. spat collectors and growers), processors, sellers, and consumers are all important players in the raw oyster and mussel value chain. The actions that make up the shellfish value chain are largely done and shared in the home.

The trade part can engage the entire family. The shellfish is normally collected by males, while the product is processed by women and children. Marketing can be done by both men and women. This is in line with findings from other studies, which show that men are more likely to engage in demanding activities while women are more likely to engage in activities that need patience and meticulous attention (Ferrer et al., 2014; Sumagaysay, 2014). Similarly, in gender role profile and value chain analysis of raw oysters in Capiz and Bulacan, female participation was limited at the selling and marketing of raw oysters, among the identified stages in oyster production. Furthermore, in regions where there is a market for shucked oysters, women make up the majority of the workforce. Also, in the absence of technology and reliance on physical work, women's participation is restricted to marketing and, to a lesser extent, processing. Male oyster growers, on the other hand, complain about the intensive labor involved in the industry.

Raw oyster marketing is carried out with the help of family members. Retailers/vendors and middlemen are two major avenues. The shellfish is usually sold live in the shell. At the retailer's location (stalls or restaurants), oysters are thoroughly cleaned of foaling organisms, silts, and other substrates.

Shell-on or shucked oysters are available in markets. A sharp knife is used to shuck the oysters. The meat is extracted from the shells and placed in a clean water-filled container. The meat is weighed and volumetrically measured. Oysters, shell-on or unshucked, are sold by the basket or kilogram. Green mussels can be purchased shell-on or unshucked. These are also offered by the basket or kilogram, much like unshucked oysters. Oyster production is currently insufficient to meet local demand. Many farmers are apprehensive to enter into contracts with foreign businessmen because they are concerned that they will not be able to meet the contract's minimum quantity requirements (FAO, 2012). Oysters are available all year at the local market, but demand is stronger during certain months, particularly during the summer when oysters are prepared for outings and other gatherings. On the other hand, because of the difficulty in harvesting during severe weather, the supply is rather limited.

SWOT Analysis

The analysis of strengths, weaknesses, threats and opportunities of the mussel and oyster industry is anchored on the value chain map. The chain consists of the operational strategies in the industry from farm to processing, to market then finally to the consumers.

The value chain divides the business's value-adding activities into two categories: primary and support activities, with cost and value drivers outlined for each value activity. Table 6 provides an overview of the strengths and weaknesses of the industry as well as the opportunities and threats that have been observed.

TABLE 6. STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS OF THE OYSTER AND MUSSEL INDUSTRY

Sub-system	Strengths	Weaknesses	Opportunities	Threats
Inputs	• Existing areas for shellfish spat collection and production • Locally available culture inputs • Available facilities for laboratory testing and environmental monitoring	• Unreliable seed supply • Outdated profile of shellfish areas • Farmers still rely on traditional culture methods such as stake • Unorganized fisherfolk • Unsustained supply of input assistance • Lack of data on natural spatfall timing in potential breeding grounds	• Potential areas for the expansion of shellfish seed collection areas • Potential adoption of shellfish seed hatchery by the private sector • Supply of inputs	• Calamities • Pandemic • Competition in the use of the area. • Presence of pesticides from surrounding fishponds and agricultural areas
Cultivation	• Available pool of experts • Whole household can be engaged in the entire value chain	• Farmers still rely on traditional culture methods such as stake • Unreliable seed supply and unpredicted spatfall • Outdated profile of shellfish culture areas	• Potential for poverty reduction • Source of employment • Wide array of business opportunities	• Red Tide [1,2] • Calamities • Over-exploitation • Pollution and hazardous contaminants[3, 4]

Sub-system	Strengths	Weaknesses	Opportunities	Threats
	• Rich shellfish resources • Potential areas for expansion • Available environment-friendly shellfish culture technologies • Available marine biotoxin laboratory for red tide monitoring of culture areas • Capacitated staff to conduct red tide monitoring	• Unavailability of data profiled for shellfish farm growers • High bacterial load in traditional culture grounds[5] • HABs occurrence in culture grounds • Shellfish sanitation program is not yet in place • Outdated technologies and support facilities for seed production • Lack of regular water quality (including heavy metals and pesticide) and bacteriological monitoring • Lack of water circulation or oceanographic studies • Lack of policy regarding translocation of spats and broodstocks	• Establishment/ Institutionalization of more shellfish hatchery facilities • Potential shellfish species for breeding and grow-out production • R&D investments in shellfish seed production • Certification of seeds produced from hatcheries • Establishment/ Institutionalization of more shellfish hatchery facilities • Potential shellfish species for breeding and grow-out production • R&D investments in shellfish seed production • Certification of seeds produced from hatcheries	• Reclamation • Episodic water quality deterioration • Siltation / Shallowing of river bottom or seabed in culture areas • Poaching
Handling and Processing	• Numerous existing value-adding technologies • Healthy and affordable food option	• Poor sanitation, handling packaging and labeling • Lack of post-harvest facilities • Lack of cold chain protocols from harvest to processing • Weak policy enforcement on food safety • Lack of accessible and clean water supply in communities • Lack of policies, procedures, and work instructions that are compliant with food safety standards of the domestic and international markets	• More potential products can be derived from shellfish • High demand in the export and local market • High demand • for condiment	• Red tide • Calamities • Hazardous contaminants[6] • Sustainability of raw materials
Trading	• Potential high profit and rates of return • Employment and engagement of women	• Prices are unstandardized • Low compliance to the regulation of importing countries • Unavailable cold chain system and protocols	• High demand for cheap and affordable seafood • Aggressive marketing	• Red Tide • Calamities • Trade border rejection[7]

1. Montojo et al (2010)
2. Montojo et al (2012)
3. Opinion et al (2016)
4. Perelonia el (2016)
5. Rana et al (2016)
6. Cambia et al (2018)
7. Benitez, K.C.D (2020)

In general, the sector has a number of challenges, including the incidence of harmful algal blooms (HAB), food safety, poor water quality, and low customer acceptance (Montojo et al. 2006; Azanza et al. 2010). The requirement for a consistent supply of inputs, the need to increase the shelf-life and quality of processed shellfish products, and a lack of active marketing were all cited as constraints in the development of the shellfish business. All of these can be used to identify potential investing possibilities for women (Sumagaysay, 2014). Inadequate legal enforcement, a lack of assistance from enablers, a lack of post-harvest infrastructure, and disorganized fishermen were among the industry's constraints.

Anthropogenic and natural challenges to the sector are both possibilities. Pollution, overexploitation, and food safety issues were anthropogenic dangers that might be avoided if appropriate precautions were taken, while natural hazards included the occurrence of toxic algal blooms and the incidence of harsh weather, particularly typhoons.

Predictability and quantity of spat fall are also important factors in the long-term viability of shellfish farming operations. When collectors are deployed too soon or too late after the peak of spat fall, production is reduced due to bio-fouling and low recruitment, respectively. Two interventions were suggested to address the problem of oyster spat fall. The first step is to monitor spat fall in both traditional and potential oyster grounds. Farmers will be instructed when to deploy their oyster spat collectors as a result of spat fall monitoring, which will address the problem of unpredictability. Integrating the collection of environmental elements (such as salinity and temperature) during the spat fall monitoring will allow forecasting, which will be useful information for farmers when deciding when to stop cultivation. The second recommendation is to make hatchery-bred oyster seed production more institutionalized. Aside from decreasing the effect of climate on seed availability, hatchery development of oyster spats also provides a way to improve oyster quality. Simple chromosome manipulations, such as the establishment of tetraploid breeders to produce triploid oyster seeds, will result in huge oysters that are preferred in the export market.

Uba et al. also discovered signs of worsening habitat conditions (2019). As a result, management measures in the area should be adjusted. An ordinance must be used to execute harvest control rules like size limits, maximum harvest volume, and harvest frequency. Furthermore, due to the small-scale nature of some shellfish species, such as horse mussels, there were no accurate data of the volume of production of other shellfish species (Decastillo Jr., pers. comm.). The shellfish industry's full potential can also be hampered by a lack of sufficient enforcement of rules, minor support from enablers, and a lack of post-harvest infrastructure. The same problems were reported by Brown et al. (2010), Roxas et al. (2017), Rosales et al. (2017), and Jontila et al. (2018) on their study of the value chains of small-scale fisheries in the country.

Farm Income/Costs and Returns Analysis

Cost Return Analysis for Mussel and Oyster Farm Using Different Modules

TABLE 7. ESTIMATED COST AND RETURNS OF ONE-HALF HECTARE SHELLFISH FARM USING PLOT HANGING METHOD WITH PLASTIC STRIPS AS COLLECTORS

PARTICULARS	TOTAL COST
A. FIXED COST	
1. Materials and Labor for Plot Construction (Lifespan: 2 years)	
a. Bamboo and Labor for (7cm.Ø) 24 pcs. X P350.00/pc	8,400.00
b. Bamboo horizontal pole (10 – 15 cm. Ø) 6 pcs. X P100.00/pc.	600.00
c. Monofilament nylon line (No. 10 or 20) 2 kgs. x P380.00/kg	760.00
d. Contract labor for construction	10,500.00
TOTAL COST PER ONE HALF HECTARE (139 plots x 20,260.00/plot)	**2,816,140.00**
2. Dug-out Banca, 5 meters Long (Lifespan: 5 years)	15,000.00
3. Tools and Diving Paraphernalia (Lifespan: 3 years)	3,000.00
4. Shed (Lifespan: 3 years)	6,000.00
TOTAL FIXED COST	**2,840,140.00**
B. PRODUCTION COST	
1. Operating Cost	
a. Plastic strips (60 rolls (90 m/roll) @ P290.00/roll)	17,400.00
b. Labor	
Hanging of Plastic straps P180.00/person/day x 4pers. x 7 days	5,040.00
Harvesting per sack P30.00/sack x 1668 sac	50,040.00
Caretaker P3,000.00/mo. X 12 mos./ Person x 1 person (man/hour) (2 hrs/day x Php 50/hr x 30 days)	36,000.00
2. Depreciation	
a. Plot	1,408,070.00
b. Dug-out banca	3,000.00
c. Tools and diving paraphernalia	1,000.00
d. Shed	2,000.00
3. Miscellaneous	
a. Municipal permit	15,000.00
b. Repair and maintenance (10% cost of ½ hectare plot)	284,014.00
TOTAL PRODUCTION COST	**1,821,564.00**
C. RETURNS	
1. Gross Income (Sale of 2,450 sacks at P 1,000.00/sack)	2,450,000.00
2. Net Income (Gross Income minus total production cost)	628,436.00
3. Returns (Per Peso invested)	0.34

TABLE 8. ESTIMATED COST AND RETURN ANALYSIS OF A ONE-HALF HECTARE SHELLFISH FARM USING THE STAKE METHOD

PARTICULARS	TOTAL COST
A. FIXED COST	
1. Materials and Labor for Plot Construction (Lifespan: 2 years)	
a. 5,000 pcs bamboo (Puno) @ P 100.00/pc (pisigin variety-6.7 m length)	500,000.00
b. Contract labor staking	10,500.00
c. Boat rental and towing charges x 4	6,000.00
TOTAL COST	**516,500.00**
2. 1 Dug-out Banca, 5 meters Long (Lifespan: 5 years)	15,000.00
3. Tools and Diving Paraphernalia (Lifespan: 3 years)	3,000.00
4. Shed (Lifespan: 3 years)	6,000.00
TOTAL FIXED COST	**540,500.00**
B. PRODUCTION COST	
1. Operating Cost	
a. 1 caretakerP3,000.00/month x 12 months	36,000.00
b. Harvesting P30.00/sack x 625 sacks	18,750.00
2. Depreciation	
a. Plot	258,250.00
b. Dug-out banca	3,000.00
a. Tools and diving paraphernalia	1,000.00
b. Shed	2,000.00
3. Miscellaneous	
a. Municipal permit	15,000.00
b. Repair and maintenance (10% cost)	54,050.00
TOTAL PRODUCTION COST	**388,050.00**
C. RETURNS	
1. Gross Income (Sale of 625 sacks at P 1,000.00/sack)	625,000.00
2. Net Income (Gross Income minus total production cost)	236,950.00
3. Returns (Per Peso invested)	0.61

TABLE 9. ESTIMATED COST AND RETURN ANALYSIS OF A ONE (1) MODULE 9M X 6M RAFT

PARTICULARS	TOTAL COST
A. FIXED COST	
1. Materials and labor for 9mx6m raft construction (Lifespan: 5 years, 2 croppings/yr)	
22 pcs Class A Bamboo @ Php 350.00/pc	7,700.00
1 roll P.E. Rope No. 20 @ Php 2,548.00/roll	2,548.00
1 roll P.E. Rope No. 8 @ Php 450.00/roli	450.00
½ roll G.I. Wire No. 10 @ Php 3,000.00/roll	1,500.00
4 pcs Plastic Drum @ Php Php 1,300.00/pc	5,200.00
4 pcs Fabricated Concrete Sinker @ Php 1,800.00/pc	7,200.00
3 pax Laborer for Raft construction @ 380.00/pax	1,140.00
15 rolls Plastic Strip @ Php 240.00/roll	3,600.00
3 spool Nylon Twine @ Php 600.00/spool	1,800.00
1 Can Marine Epoxy A and B (4L/can) @ Php 1,100.00/can	1,100.00
TOTAL FIXED COST	**32,238.00**
B. PRODUCTION COST	
1. Operating Cost	
a. 1 caretakerP3,000.00/month x 12 months	36,000.00
b. Harvesting P30.00/sack x 26 sacks	780.00
2. Depreciation	3,223.80
3. Miscellaneous	
a. Municipal permit	15,000.00
b. Repair and maintenance (10% cost)	3,223.80
TOTAL PRODUCTION COST	**58,227.60**
C. RETURNS (1st Run)	
1. Gross Income (Sale of 625 sacks at P 1,000.00/sack)	26,000.00
2. Net Income (Gross Income minus total production cost)	-7,338.00
3. Returns (Per Peso invested)	-0.22
C. RETURNS (2nd Run)	
1. Gross Income (Sale of 625 sacks at P 1,000.00/sack)	26,000.00
2. Net Income (Gross Income minus total production cost)	26,000.00
3. Returns (Per Peso invested)	0.78

TABLE 10. ESTIMATED COST AND RETURN ANALYSIS OF A ONE (1) MODULE 110 X 1.2M JAPANESE LONGLINE (PARALLEL TYPE)

PARTICULARS	TOTAL COST
A. FIXED COST	
1. Materials and labor for japanese longline preparation (Lifespan: 5 years, 2 croppings/yr)	
Buoy, V-230, 50 pcs.	33,750.00
Polyethylene ropes, 24mm dia, 1 roll	3,816.00
Anchor rope, 24mm dia, 6 rolls	8,203.50
G.I. wire, 16mm dia, 2 rolls	1,203.00
Anchor, 68.75 kgs, 6 pcs	5,400.00
Strings, 14 mm, 16 rolls	12,000.00
Joint rope 7mm, 5 rolls	1,500.00
Oysters seeds, 180 strings	6,750.00
TOTAL FIXED COST	**72,622.50**
B. PRODUCTION COST	
1. Operating Cost	
a. 1 caretakerP3,000.00/month x 12 months	36,000.00
b. Harvesting P30.00/sack x 469 sacks	14,070.00
2. Depreciation	14,524.50
3. Miscellaneous	
a. Municipal permit	15,000.00
b. Repair and maintenance (10% cost)	7,262.25
TOTAL PRODUCTION COST	**86,856.75**
C. RETURNS (1st Run)	
1. Gross Income (22,500kg/48 kg/sack at P 1,000.00/sack)	446,750.00
2. Net Income (Gross Income minus total production cost)	381,893.25
3. Returns (Per Peso invested)	4.39

TABLE 11. ESTIMATED COST AND RETURN ANALYSIS OF A ONE (1) MODULE 20M X 4M MODULAR LONG LINE (MUSSEL)

PARTICULARS	TOTAL COST
A. FIXED COST	
1. Materials and labor for modular longline preparation (Lifespan: 5 years, 2 croppings/yr)	
PP Rope, 12 mm, 1 roll	3,990.00
PP Rope, 8 mm , 1 roll	1,788.00
Monofilament nylon, 120 lbs., 1 kgs	400.00
Plastic jugs, 20 L with cap, 36 pcs	7,020.00
Rice Sacks (Class A), 50 kgs cap, 36 pcs	558.00
Marine Epoxy (A&B), 1 pint per can, 1 pair	495.00
TOTAL FIXED COST	**14,251.00**
B. PRODUCTION COST	
1. Operating Cost	
a. 1 caretakerP3,000.00/month x 12 months	36,000.00
b. Harvesting P30.00/sack x 17 sacks	510.00
2. Depreciation	2,859.20
3. Miscellaneous	
a. Municipal permit	15,000.00
b. Repair and maintenance (10% cost)	1,425 .10
TOTAL PRODUCTION COST	**55,785.30**
C. RETURNS (1st Run)	
1. Gross Income (800 kgs at P 150.00/kg)	120,000.00
2. Net Income (Gross Income minus total production cost)	64,241.70
3. Returns (Per Peso invested)	1.15

Production Cost for Value-Adding Products of Mussels and Oysters

TABLE 12. PRODUCTION COST FOR BOTTLED SMOKED MUSSELS IN CORN OIL

INGREDIENTS	UNIT	UNIT PRICE	TOTAL PRICE
Green Mussel	50 kgs	140.00	7,000.00
Corn Oil	9 liters	187.88	1,690.92
Sili	250 g	50.00	50.00
Paminta			5.00
Asin			5.00
MSG			10.00
Atsuete			25.00
Laurel			10.00
MATERIALS			
LPG			150.00
Kusot			30.00
Bottle (set)	32	15.00	480.00
Label	32	5.00	160.00
Labor	3pax(5 hours)	175.00	525.00
TOTAL COST			**10,140.92**
Production Cost per bottle			**316.90**

TABLE 13. PRODUCTION COST FOR BOTTLED PICKLED (ATSARA) OYSTERS

INGREDIENTS	UNIT	UNIT PRICE	TOTAL PRICE
Oyster Meat	6 kgs	430.00	2,580.00
Ginger			50.00
Sili (bell pepper)	2 pcs		42.50
Sili (Labuyo)			10.00
Onion			15.00
Paminta			10.00
Salt			5.00
MSG			10.00
Sugar	1/2 kgs		27.50
Vinegar	2 liters		62.00
MATERIALS			
LPG			60.00
Caps,seal bottles	22	15.00	330.00
Label	22	5.00	110.00
Labor			250.00
TOTAL COST			**1,835.00**
Production Cost per bottle			**83.41**

TABLE 14. BOTTLED OYSTERS IN CORN OIL

INGREDIENTS	UNIT	UNIT PRICE	TOTAL PRICE
Oyster Meat	6 kgs	430.00	2,580.00
Corn Oil	2 liters	187.88	751.52
Sili		10.00	10.00
Paminta		10.00	10.00
Salt		5.00	5.00
MSG		10.00	10.00
Atsuete		10.00	10.00
Bay Leaf		10.00	10.00
MATERIALS			
LPG			60.00
Kusot			10.00
Caps,seal bottles	22 pcs	15.00	330.00
Label	22 pcs	5.00	110.00
TOTAL COST			**4,146.52**
Production Cost per bottle			**188.48**

Benchmark Analysis

Local

Because seed is available year-round and the temperature is excellent for mollusk cultivation, tropical locations like the Philippines are ideal for oyster and mussel culture. Oysters can produce two crops per year (Aldon & Buendia, 1998).

Four species of oysters are cultured, the slipper-shaped oyster *Crassostrea iredalei*, the subtrigonal oyster *C. malabonensis*, and the curly or palm rooted oysters *C. palmipes* and *Saccostrea cucullata*. The species receiving particular attention in terms of culture are *C. iredalei* and the moderately sized *C. malabonensis*. They are particularly abundant in Bacoor Bay and extend to the entire Manila Bay from Tarnate, Cavite to Mariveles, Bataan, along the coast of Northern Luzon, Lingayen Gulf, Tayabas and Sorsogon; and to some extent in Batangas Bay, Banate Bay in Iloilo, Binalbagan, Hinigaran and Himamaylan, Negros Occidental, and in areas around Catbalogan, Western Samar, Northern Leyte and Palawan. Commercial farming however tends to concentrate along the coast of various provinces largely in Bulacan, Capiz, Cavite, Pangasinan, Sorsogon, and Negros Occidental.

There are three species of mussels in the Philippines that are used as food: the green mussel *Perna viridis*, the brown mussel *Modiolus metcalfei* and *M. philippinarum*. In some parts of the country, the green mussel, or "tahong," as it is known locally, is the only species of mussel produced economically. Although brown mussels are gathered from natural areas, they are not appropriate for farming because they are known to adhere to living adults developing in dense mats on muddy bottoms, rather than ropes or bamboo poles. *Perna viridis* has a restricted distribution in the Philippines. They are mainly found in Bacoor and Manila Bays in Luzon as well as in Sapian Bay in West Visayas, Maqueda Bay in East Visayas, and several bays and inlets along the northern coast of Panay Island. The brown mussel, on the other hand, is found across the Philippines, including Luzon, the Visayan islands, and Mindanao. Cockle, scallop, and carpet clam are other major bivalves in the Philippines. The Philippines is also a major producer of abalone.

Traditional farming methods are still used by mussel and oyster farmers and growers in the country. Small-farm and family businesses dominated the operations. The farms range in size from 0.5 ha to 5 ha, with an average production of 50 metric tons per hectare.

Bamboo stakes are still used in oyster and mussel farming in the Philippines, which increases the rate of siltation in places where stake farms are located. The raft method, which promotes faster oyster growth and thus higher output yield, is an alternate way for producing shellfish in the Philippines. Thinning can be done on a regular basis, and rafts can be moved about to prevent siltation. The raft approach also makes it easy to carry seeds to different locations. It's also long-lasting and resistant to wear. The majority of shellfish items are marketed for home consumption in local markets. To address food safety, environmental integrity, and socioeconomic welfare, standardization of sanitary protocol for shellfish is not strictly applied.

In the Philippines, the shellfish sector is dealing with issues such as direct displacement of growing areas by housing and industrial estates, as well as environmental degradation (FAO, 1988). The necessity to adopt proper sanitation standards and practices is a major challenge.The Department of Fish Processing Technology of the University of the Philippines in the Visayas and BFAR-National Fisheries Development Center have done a lot of study on bivalve depuration. A simple filtration unit has been successfully tested;

but, due to the current low price of bivalves, installation of such a system by single farmers would not be economically feasible.

A National Shellfish Sanitation Program (NSSP) has already been formed to protect customers' health, ease domestic and international trade, and safeguard the Philippines' reputation as a safe and healthy seafood producer. Pilot experiments were undertaken in two bays: Sapian, Capiz, and Sorsogon, Sorsogon. Strengthened implementation of NSSP in every region should be of utmost importance to strengthen local legislations i. e. basic fisheries ordinance that includes identification of shellfish growing areas among other different fisheries uses; approval of areas where oysters and mussels can be harvested and marketed; and policies which will prohibit the marketing of the shellfish harvested from contaminated waters unless these are cleansed following established procedures.

International/ Global

The rapid growth of technology in the shellfish sector is a new trend in the industry. From the public to the private sector, advances in culture technology, marketing techniques, and business models solve challenges and remove barriers to clam and other seafood supply sustainability and expansion. These advancements have the potential to transform the way shellfish is grown, harvested, and sold. Shellfish and other by-products are sent directly from farmers to consumers, simplifying supply chains while enhancing income for producers and growers, and introducing innovative ways to bivalve production and traceability to the market.

Mollusks are cultivated in many nations throughout the world, in both the northern and southern hemispheres. Farming operations, on the other hand, have flourished across Asia, particularly in East and Southeast Asia. The artificial culture of the pearl oyster is still relatively new in China, but significant progress has been made in artificial spat rearing, adult culture, procedures for inducing pearl formation, and direct exploitation of pearl nacreous substance. In China, there are more than 10 institutes dedicated to mariculture research, with the majority of them working to develop the mollusc business. At the moment, a lot of work is being put into artificial propagation strategies, enhancing on-growing practices, and adopting new culture methods (Lovatelli, 1988).

Korea is also one of the Asian countries with a well-developed shellfish sector, which includes both marine and freshwater species (FAO, 1988). The Pacific oyster *Crassostrea gigas*, which is primarily obtained from coastal aquaculture, is the most important shellfish cultured in ROK. *Venerupis japonica*, a short-necked clam generated from mariculture landings, is the second most important species. Other shellfishes such as ark shell, black mussel, surf clam, abalone, and top shell followed. Among all the species of commercial importance, only the seedlings of the abalone *H. discus* have been propagated artificially. Because of the topographical characteristics of Korea's coastline, suspension culture technologies are well established. Longline culture, which is frequently practiced in Chungmu, South Korea, provides the majority of oyster output. The mussel and abalone are also often used in hanging culture. Bottom-cultured clams and cockles are grown in water depths of 5–15 meters. The Republic of Korea's shellfish business is severely hampered by a scarcity of seed, particularly for clam species. To address this issue and further grow the mollusc business, much applied research is being conducted. Artificial seedling production, on-growing technique development, disease prevention and treatment, as well as mollusc genetics and selective breeding, are all major scientific activities.

Meanwhile, Malaysia has been cultivating the blood cockle *Anadara granosa* since 1948, and it has grown into the country's most important and well-organized aquaculture business (Ng, 1984). However, since the late 1970s, the annual capture yield of this species has decreased due to several restrictions like overfishing and environmental degradation. Carpet clams, green mussels, and oysters are other important species in Malaysia. Rack and raft culture methods are used to culture *Crassostrea belcheri*, flat oysters, and *Saccostrea cucullata*. Fouling from other sedentary species and algae, predation by xanthid crabs and starfish, siltation, and limited spatfall are the principal restrictions to oyster culture. Mussels have a low consumer acceptance rate, which is the principal limitation to mussel culture. According to Nawawi (1993), Malaysia has two hatcheries (Fisheries Research Institute in Penang and Muka Head Station of the Science University of Malaysia in Penang). Cultches are suspended using rafts, floating longlines, and bottom longlines. The technique of choice is determined by cost, material durability, and environmental circumstances. With cultches suspended from the raft frame, grow-out rafts can be utilized for spat collection. Furthermore, research is undertaken to establish a bivalve purification system targeted at safeguarding consumer health and rendering bivalves viable in both domestic and international markets (Okada, 1963).

Several bivalves and gastropods, such as the Pacific oyster, hard clam, short-necked clam, blood cockles, purple and freshwater clams, are farmed on a considerable scale in Taiwan (Ting, 1984). Among these, the Pacific oyster *C. gigas*, along with the hard clam *M. lusoria* and the short-necked *G. veneriformis* are the most important shellfish cultured in Taiwan. Most cultured species acquire their seedlings from the wild, but due to poor and/or insufficient recruitment of specific species, hatchery technologies have been developed to assure a consistent supply of seed. In comparison to the blood cockle, which is still in the experimental stage, artificial seed production of the hard clam, purple clam, and abalone is reasonably well established.

In Taiwan, the majority of bivalve species are bottom-cultured. Suspension culture procedures are becoming more significant, especially in the culture of the Pacific oyster and abalone, due to a lack of suitable bottom culture regions and coastal water pollution. The restricted culture ground for purely bottom-dwelling species like clams is a major barrier to their production expansion in the country. The consumption of most shellfish cultured in Taiwan is domestic with the small abalone *H. diversicolor* being the only mollusk with a strong export market.

Thailand's shellfish business is also fairly established, both in terms of catch and culture. Three commercially important species of oyster are captured from natural beds and cultured: *Saccostrea commercialis*, *Crassostrea lugubris* and *C. belcher*i (Ng, 1987). *Perna viridis*, the green mussel, is one of the most important species in terms of quantity produced in Thailand, where it has been used for over 60 years. The blood cockle *Anadara granosa* is also a popular species in Thailand and every year the consumption of this bivalve exceeds local production. As a result, Thailand imports thousands of metric tons of marketable-size cockles and seeds from Malaysia each year. The Department of Fisheries is attempting to boost cockle culture in various areas in order to reduce cockle imports. Thailand has also shown a tremendous increase in canned clam exports. All of the clams come from catch fisheries, and stock depletion is becoming a severe problem due to increased fishing effort to meet expanding demand. Capture fisheries are becoming less viable for a variety of reasons, and as a result, coastal aquaculture is garnering a lot of attention. Although depuration of shellfish is not currently performed in Thailand, the Department of Fisheries is doing research into technological and commercially viable depuration technologies (Lovatelli, 1988).

In Japan, the oyster culture sector is well-developed (SRDC 1991). It began with broadcasting and has now progressed to raft and long-line tactics. Farm units have between 10 and 100 rafts, which are managed by fishing cooperatives. Each crop has a two-year cultivation phase. Researchers in Japan have already devised strategies for predicting spatfall. Spatfall happens just once or twice a year in the summer. Methods for hatching eggs have also been standardized. Hiroshima and Miyagi prefectures are home to Japan's biggest farming areas. The major species cultured is *C. gigas*, the Japanese or Pacific oyster.

Bivalve shellfish production is also a significant and rising sector of the US and global seafood industries. All of the United States' coastal regions have thriving shellfish industries. Shellfish growers in the United States harvested 37 million pounds of oysters, ten million pounds of clams, and 0.9 million pounds of mussels in 2016. The worth of these shellfish is estimated to be $340 million. In the United States, shellfish growing regions are divided into four categories: approved, conditional, restricted, and prohibited. Water quality standards are used to classify these areas. The National Shellfish Sanitation Program (NSSP) has developed a model ordinance that specifies the bacteriological requirements that must be followed for classifying shellfish. Shellfish may only be gathered for human consumption from waters that have been permitted. Depuration is required for shellfish brought in from other places (NOAA, 2021).

Competitive Analysis

Local

Mussels and oysters are very popular in the Philippines. It has good export potential if the sanitation problem can be solved. Mussels and oysters can also be used as a potential diet for high-value carnivores such as groupers, lobsters, and mud crabs, which are easily exported.

Due to the red tide problem, shellfish farming, particularly mussel and oyster farming, is frequently overlooked as a viable livelihood option in Philippine fisheries planning (Yap, 1991). This is unfortunate because oyster and mussel farming requires little capital investment, is labor-intensive, and does not involve a high level of competence. Due to paralytic shellfish poisoning, red tide is unquestionably a severe public health concern. Nonetheless, mussel and oyster survival and growth are unaffected. It only has an impact on their suitability for human consumption and, as a result, their marketability. Because the Philippines could not meet international standards, shellfish produced in the country rarely made it to the worldwide market.

International/ Global

China, for example, contributes a significant amount of shellfish to the international market. Due to the rising protein need of China's growing population, the production of marine bivalves is still on the rise. In terms of shellfish production volume in 2018, China was followed by Japan, South Korea, Indonesia, and Thailand. Other countries take into account a variety of issues, including the nutrient release from bio deposits on shellfish farms, carrying capacity models that aim to estimate cultured shellfish food limits and ensure the high quality of cultured shellfish that reaches international markets. Due to several factors such as competing demands on space, illnesses, and carrying capacity difficulties, total production in Europe has decreased in recent decades.

Overall, while mollusc culture production is vital to local economies, it has been hampered by international market conditions and, more recently, environmental issues such as the red tide. Shellfishes suffer from contamination of E. coli and have been unacceptable for export and even in some local areas. Another issue is the occurrence of red tide in select locations in Sabah (Malaysia), the Philippines, and maybe elsewhere in the region. Many coastal waters are rapidly polluted, which is an issue. Industrial crop species such as pearl oysters, windowpane oysters, and angel wing clams, which were once harvested in the wild, are now depleted, and culture technology is still developing (Rabanal, 1988).

MARKET TRENDS AND PROSPECTS

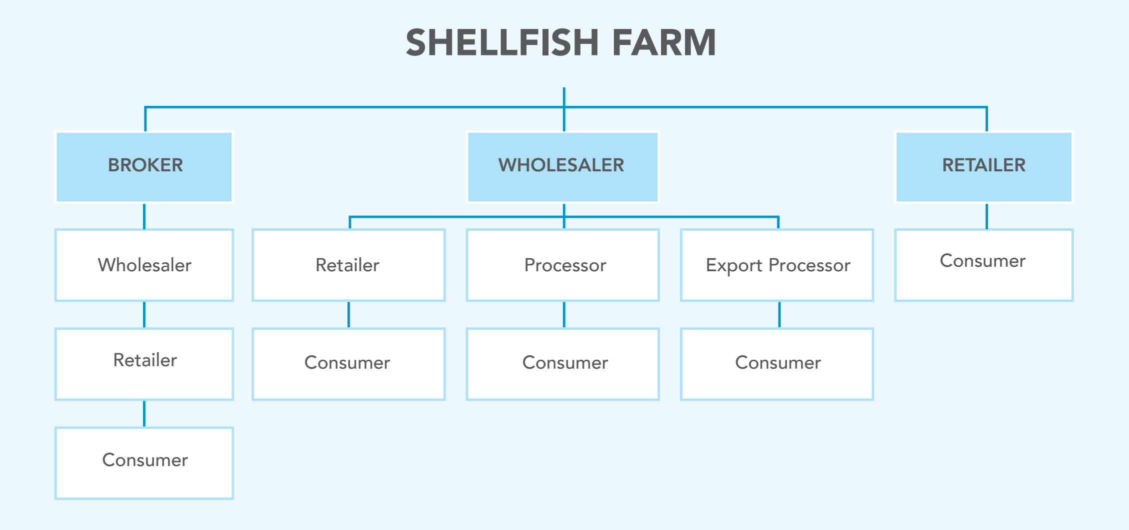
During the forecast period, 2020 to 2025, the global seafood market, which includes shellfish, is expected to develop at a compound annual growth rate (CAGR) of 5.8%. (Global Seafood Market 2020-2025, 2020). Shellfish, on the other hand, is frequently available in shops and restaurants. According to the Global Shellfish Market Research Study 2021-2025, supermarkets sold the most shellfish in 2019, with a proportion of nearly 62 percent in 2017. With a consumption market share of over 49 percent in 2017, Asia-Pacific is the largest consumer region. Following Asia-Pacific, Europe is the second-largest consumer market, accounting for 19% of total consumption.

High capita per consumption is one of the elements that will effect future market trends, as the market is the primary determinant of production. Over the years, shellfish consumption steadily grew. Shellfish also help to food security in many parts of the country by serving as a nutritious and varied supplement to a mixed diet. In the Philippines, many people rely on it as part of their regular diet. The proportion of shellfish consumed by the population determines production and market. According to the 2019 PSA data, the country's per capita production has been increasing. This simply goes to show that there is a significant demand for shellfish in the Philippines.

Factors such as high per capita consumption increased demand for shellfish as a result of rising consumer spending. Mollusks and other shellfish are particularly popular in both local and international cuisines. Many species of clams, mussels, oysters, winkles, and scallops are bivalve mollusks that are consumed by humans. These are widely consumed raw, served as appetizers in restaurants, or sold in supermarkets, hypermarkets, wet markets, or sidewalk stalls. Brokers, wholesalers, wholesaler-retailers, and retailers are among the middlemen involved in the marketing of shellfish, which they distribute to both domestic and international markets.

Demand for different mussel species is growing worldwide particularly on the blue mussel (*Mytilus edulis*) and the Mediterranean mussel (*Mytilus galloprovincialis*). Although production is increasing, it is still insufficient to meet global demand, resulting in rising prices in all major markets. China, with 879,000 MT per year, Chile, with 302,000 MT, Spain, with 216,000 MT, Thailand, with 115,000 MT, and New Zealand, with 94,000 MT, are the five major players. The Philippines accounts for under 1% of global production (FAO, 2018). In the Philippines, shellfish distribution channels are comparable to those for other fish items. The flow of goods from the farm to the customer is depicted in the diagram below.

FIGURE 16. FLOW OF GOODS FROM THE FARM TO THE CONSUMER



The Metro Manila area is the largest market for shellfish. Cavite, roughly a one-hour drive away, is the closest supplier. Other farms in the Visayas send their produce to Metro Manila in 24 to 48 hours by boat. Due to the high expense of air freight, it is not recommended. Aside from freshness, the size of the meat is another element that influences the price of shellfish. Harvesting should take place just before spawning, when the shellfish's mantle is thick and juicy.

When the catch is carried to the fish market, bidding takes place. Negotiated sales do happen, especially when the vendor is a reputable and established source. During the pandemic, online selling was introduced. Shellfish is now available for purchase from a number of internet retailers.

On any given trading day, market forces, such as supply and demand, decide the wholesale price of shellfish. The cost of production at the clam farm has no bearing on market prices in any way.

Filipinos have a strong preference for fresh meals, particularly fish and shellfish. The time between harvest and consumption has a direct impact on the quality of shellfish, which is particularly perishable. To ensure that the shellfish reach the market in good shape, better harvesting and post-harvesting processes are required.

Shellfish can be sold in both fresh and processed forms. Oysters can be exported fresh, chilled, or frozen, or kept in airtight containers like mussels or clams. Shells and by-products are also in high demand and are sold in a variety of nations.

In 2018, there was a decrease in the overall global commerce of mussels. Exports fell from 373 metric tons in 2017 to 360 metric tons in 2018. Imports were also down, mirroring the drop in exports. Italy, France, and the Netherlands were the top importers, all reporting decreasing trade. Mussels remained one of the cheapest seafood options on the market, with a value of roughly USD 2.00 per kilogram of live weight, but continuous demand allowed for significant price increases in 2018. (FAO, 2018).

Exportation is another element that influences shellfish output and future market patterns. However, the Philippines has only done modest exportation efforts to date because the majority of the country's produce is eaten locally as fresh, chilled, and processed food.

Similarly, increased consumer spending on other shellfish cuisines (such as smoked oysters, pickled oysters, and other value-added goods) is fueling market expansion. Like China and India, the Philippines has a long history of eating authentic shellfish-related foods. This can be seen in the variety of options available on the restaurant's menu. In addition, market growth for structured food services and the expanding trend of out-of-home dining in markets are predicted to promote shellfish production and growth in the country. The market will be dominated by fresh and chilled products in different forms, presentations, and packaging. Also, in the future, commodities in a practical pack ideal for catering and retail will become more popular, with more people purchasing these.

Key Demand Drivers

The consumer trend of focusing on product innovation and variations, food quality, food safety concerns, health benefits, social responsibility, production systems and technology, sustainability, and regional origin are the primary drivers of the shellfish market.

As people became more aware of the benefits and drawbacks of eating shellfish, they became more cautious when purchasing and eating shellfish such as oysters, which contain contaminants (e.g., metals, persistent organic pollutants) and microorganisms, including pathogenic bacteria and viruses that can cause human illness if cultured in polluted waters. Eating raw oysters or mussels has also been discouraged since it has been linked to a number of ailments, including shellfish poisoning. Culture sites will almost certainly influence consumption frequency, necessitating enhanced manufacturing processes and a better culture environment.

Freshness, size, look (fatty), taste, and affordability are all considerations to consider in addition to culture sites. Oysters and mussels are relatively inexpensive and widely available in various areas. Post-harvest infrastructure should also be established in coastal areas to increase and extend product shelf-life in order to retain freshness and product quality.

Oysters and mussels get very little attention when it comes to bettering production and marketing strategies. Even within the local market, consumption is limited despite improved nutritional profiles (high nutritional value), such as omega-3 fatty acids, proteins, vitamins, and minerals, and recognized traditional food status.

The extent to which these new trends will have an impact on shellfish demand in the future will be determined in part by the intensity of retail promotion as well as the size and economic condition of the consumer segments concerned. Until these consumer segments reach a minimum lucrative audience for producers and retailers, price, health and food safety, and technical quality - the current dominant trend – will continue to drive worldwide fish consumption.

The promotion efforts made by stakeholders, mostly governments and non-governmental organizations, but also the media, influential groups, and others, have a significant impact on the rise of consumer concerns. These stakeholders don't necessarily operate in the same way or have the same interests and aims, which often leads to more confusion than worry.

In many Asian and Pacific countries, the shellfish business has enormous potential for expanding local food supply and foreign exchange profits. Shellfish cultivation initiatives have been undertaken in numerous nations to realize this potential, with some showing promising results in terms of species cultivated, productivity, and export. However, the sector is confronted with a number of issues and limits in terms of environmental, ecological, social, and institutional factors.

a. Seed supply is one of the environmental restrictions - Seed supply inconsistency could be reduced by better management of spatfall regions and reseeding initiatives to create more natural beds.

b. Research - Applied research on the biology, culture techniques, and post-harvest handling of shellfish should be intensified.

c. Sanitation - Quality control and sanitation practices need to be enhanced to boost the commercial viability of fresh mollusks for both local and international markets.

d. Marketing - To diversify the present market, which is limited to specific places and communities, markets for different species should be formed through campaigns as well as product development.

e. Government/Public Involvement - To prevent and/or manage pollution, coordination between government agencies and the private sector should be maintained, as this could aid in the development and expansion of the industry.

f. Training - Training programs and extension activities for the target groups, particularly fishermen, technicians, and extension workers, should be implemented.

These restrictions and challenges that are impeding market expansion should be addressed as soon as possible.

Market Prospects

In terms of food production and cash earnings, the Philippines' shellfish sector has aided the country's economic development. The shellfish sector has given low-cost, high-nutrient shellfish. The production of mollusks for human consumption has not been extensively utilized. Oyster and mussel farming areas have been underutilized in the past. The lack of effective marketing and processing facilities, as well as adequate techniques to stimulate more shellfish consumption, is one factor for the underutilization of prospective aquaculture regions. Improved harvesting, post-harvest/processing methods, and an efficient scheme are all needed to increase shellfish quality.

In addition to the aforementioned factors to be produced, customers must be able to visualize a strategy framework in order to increase market growth.

- Increase the market for environmentally friendly fisheries products (domestic and export)
- Ensure the access to sufficient supply in food-deficient areas
- Increase the number of fishery-based MSMEs that are capable and competitive in the market (domestic and export)
- Establish comprehensive market information.
- Strengthen the enforcement of trade and marketing laws, policies, and regulations.
- Improve the marketing ability and expertise of fishing institutions, manpower, and professionals (LGUs, NGAs, and other industry participants).
- Product innovation should be established.
- HACCP protocols for both domestic and export products should be integrated.

By breaking it down into regional assessments, this will examine and address the shellfish industry's existing and future growth possibilities, untapped pathways, variables impacting the shellfish marketing potential, and demand and consumption trends in the local and worldwide market.

Local

Limited marketing networks, inadequate transportation service providers, limited infrastructure, and post-harvest facilities for proper trading and marketing are all issues that need to be addressed in the domestic market for shellfish goods. However, as the country's population grows and urbanization accelerates, the market for shellfish products grows, providing an opportunity for fishermen to produce more to fulfill the growing demand for shellfish as a low-cost protein source.

International/Global

In the export market, problems and constraints are usually related to limited market access, marketability, and competitiveness of Philippine seafood products in terms of variety, packaging, labeling, unstable market prices, existence of trade measures (conservation measures, stringent and tedious export-import procedures and export rejection at the border of the importing countries), food quality and safety issues (such as the presence of filth, and substandard end products, presence of microbial, chemical, and physical contaminants).

For commodities market expansion, multiple marketing methods, networks, and channels must be examined. Shellfish bivalves are in high demand all across the world. Although production is increasing, it is still insufficient to meet global demand. This is an excellent opportunity for Philippine shellfish to participate in the global market by exporting and exploiting trade opportunities.

SWOT ANALYSIS (Industry Level)

TABLE 15. STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS AT INDUSTRY LEVEL

Strengths	Weaknesses	Opportunities	Threats
• Locally available source of inputs • Existing resources for shellfish spat collection and grow-out areas • Favorable environment for shellfishes growth • Low capital/investment cost • Existing farming technologies • Farming technology is simple and easy to operate/manage • Skilled and experienced shellfish operators • Available new technologies from research studies • Availability of various value-added products from shellfish • Presence of vibrant market within the locality and outside the region • Involvement of women in the value chain • Significant local demand of shellfishes in the Philippines • Potential for export	• Prevalence of traditional farming methods such as stake • Unreliable seed supply • Capital for poverty-stricken areas • Zoning in some areas are still not in place • Weak regulatory and law enforcement for shellfish farming • Limited production to cater the needed volume of processing plants for oyster sauce making • Limited HACCP compliant facilities • Difficulty in complying with international standards for exportation • Lack of sustained budget support for shellfish development program activities	• Potential expansion of areas • Hatchery production technology for commercial adoption • Potential of depuration and relaying technologies to lessen the bacterial load • Abundant value-adding technologies • Presence of business establishments • Considerable local and international market potential • The local and international collaboration and companies to invest in any stage from spats to table are available	• Pandemic • Calamity • Price fluctuations • Inclement weather conditions • Siltation • Pest infestation/ invasive species • Poaching • Red tide • Unregulated harvesting •

TARGET SETTING

Vision

A globally competitive, sustainable, and radically-industrialized production of high-quality shellfishes in the Philippines, consequently increasing the livelihood opportunities and income of marginal fisherfolk engaged in farming, depuration, processing, and marketing of shellfishes by 2040.

Mission

Development of a highly competitive, sustainable shellfish industry in the Philippines that will meet the growing consumer demand for shellfish products in the Philippines and other countries that are of high quality, safe, and cost-competitive with maximum profitability.

Goals

- Increase production by 25% in 5 years (5% annual increase according to PSA, 2020)
- Increase number of fisherfolks engaged in shellfish farming by 5% in 5 years, 10% in 10 years and by 25% in 20 years
- Ensure quality and traceability of inputs and outputs
- Develop 40 TnT experts in the Philippines (at least two experts per region)
- Ensure reliable seed supply of mussels and oysters through the establishment of BFAR and private hatchery facilities
- Reseeding of economically important species like *Crassostrea iredalei* and *Perna viridis* to areas with small species
- Strengthen the implementation of the Philippine National Shellfish Sanitation Program through profiling of all existing and potential areas for shellfish culture for classification according to physicochemical, biological status of the areas
- Adoption of all available value-adding technologies for mussels and oysters at the farmer's level

Objectives

The program shall achieve sustainable growth of the shellfish industry to optimize its contribution in the overall food production and food security and income for various shellfish stakeholders with consideration to the environment through the following specific objectives:

1. To develop, enhance and promote sustainable and environment-friendly farming technologies and practices, like IMTA;
2. To provide more livelihood opportunities to marginalized fisherfolk (where a good market is established);
3. To strengthen quality and food safety mechanisms for domestic supply and export;
4. To manage and regulate existing and new areas for shellfish production through classification of shellfish grounds and prudent resource management;
5. To reduce post-harvest losses and to develop potential value-addition technologies for mussel and oysters;
6. To improve marketing channels from production areas to consumers;
7. To ensure safe and quality mussel and oyster products for public consumption through regular water quality and food safety monitoring, depuration, and relaying technologies;
8. To ensure reliable seed supply through the establishment of spat collection areas and hatchery facilities;
9. To establish production support infrastructures like processing and depuration facilities as a means of elevating food safety and export market.;
10. To study and improve the production of other potential bivalve species like scallops, cockles, and windowpane oysters.
11. To develop policies, procedures, and work instructions that are compliant with food safety standards of the domestic and international markets.

Goals, Objectives, and Targets (Matrix form)

TABLE 16. GOALS, OBJECTIVES, AND TARGETS

Issue/Problem	Strategy	Targets		
		Short Term	Medium Term	Long Term
No recent/ updated profile for existing and potential shellfish production areas Competition in resource utilization Environmental and sanitation problems affect seed quality and quantity	Profiling and mapping of shellfish production areas Classification of production areas in terms of microbial, heavy metals, and HAB occurrence Identification of new areas for production Conduct registration of shellfish growers in the area under FishR Strengthen Philippine National Shellfish Sanitation Program (PNSSP) Proper zoning of shellfish farms Identify new areas for production (e.g. offshore farming)	Registration of shellfish farmers and association conducted Existing and potential shellfish grounds for comprehensive profiling identified Proper zoning of shellfish farms conducted and implemented BFAR environmental monitoring laboratories and team capacitated/ upgraded	Existing and potential shellfish production areas profiled and classified Off-shore farming adopted	Updating of area profiles and classification conducted every 5 years
Unreliable seed source and/or supply	Identify viable sources of seed from the wild Refinement of hatchery protocols in spat production Establishment of shellfish seed spat hatcheries Provision of seeded collectors R&D on single shell oyster	Hatchery protocols in indoor breeding of oyster and mussel refined R&D on improved seed production conducted	Single spat oyster and mussel distributed to beneficiaries through hatchery Additional hatcheries established	Production and distribution of quality species of shellfish established

Issue/Problem	Strategy	Targets		
		Short Term	Medium Term	Long Term
	Genetic profiling of good quality broodstock Selective breeding program for shellfish	BFAR shellfish hatcheries established		
Occurrence of red tide or harmful algal bloom (HAB)	Intensification of monitoring and establishment of HAB testing laboratories Strengthen information dissemination Increase capacity of BFAR and LGU through training	Capacity skills training on HAB and laboratory testing conducted	Additional HAB testing laboratories established	Regular monitoring and information dissemination conducted
Environmental impact of shellfish farms	Assess environmental effects in established shellfish farms Conduct baseline studies in potential expansion areas Establish carrying capacity per area	IEC on role of shellfish in ecology, impacts of pollution and household sanitation of shellfish as well as environmental impacts of shellfish farms conducted		
Post-harvest losses and by-products Product quality and safety issues Products non-compliant to domestic and international standards	Introduce value-added products Introduce proper product handling Establishment of Post-Harvest Facilities Promotion of shell utilization as feed additive and agricultural use	Value-adding technologies developed Skills capacity training on shellfish value-adding technologies conducted Shellfish processing facilities established	Regular inspection of processing facilities to ensure hygienic standards	GAqP and HACCP standards fully implemented

Issue/Problem	Strategy	Targets		
		Short Term	Medium Term	Long Term
	Strengthen policy implementation on compliance with Philippine National Standards for Bivalves and Molluscs	Depuration facilities established Shellfish stalls distributed Skills capacity training of shuckers on local and international food safety standards conducted policies, procedures and work instructions that are compliant with food safety standards of the domestic and international markets developed		
High utilization of shellfish stocks	Stock assessment/profiling of shellfish gathering Protection and conservation of natural shellfish stocks/ population through policy formulation	Profile on shellfish gathering conducted Policy on shellfish gathering formulated	Regulations on collection, gathering and selling of shellfish stocks fully implemented	Stable
Translocation/ introduction of shellfish stocks	Precautionary approach on translocation/ introduction of shellfish Consultation on risk assessment	Policy formulation on species translocation conducted Risk assessment report crafted	Translocation of shellfish stocks monitored and regulated	Safe and regulated

Issue/Problem	Strategy	Targets		
		Short Term	Medium Term	Long Term
		Skills capacity training of personnel conducted and laboratory to certify stocks translocation established		
Low utilization/ prioritization of other high-value shellfishes	dentification of other high-value species Production technology verification/promotion of high-value species (e.g. abalone production, pearl farming, etc.) R&D on production/captive breeding (e.g. scallops, cockles, etc.)	R&D on the propagation of high value shellfish conducted	Technology verified from the R&D projects disseminated and adopted	Competitive
Occurrence of non-native species such as Charru mussel (*Mytella charruana*)	Value-adding product development for these species (e.g. bottled/smoked mussels, feed additive, etc.) Information dissemination on methods to minimize further spread (e.g. regular cleaning of boat hull, etc.)	Value-adding technologies for charru mussels developed Skill capacity training on value-adding technologies for Charru mussel conducted IEC activities on biology and control of non-native species conducted		
Limited market access and unstandardized pricing of shellfish	Strengthen market linkages Price monitoring and standardization	Agri-Aqua Fair participated Shellfish prices and value chain reviewed Shellfish prices standardized		

RECOMMENDATIONS FOR POLICIES, STRATEGIES, AND PROGRAMS

TABLE 17. RECOMMENDATIONS FOR POLICIES, STRATEGIES, AND PROGRAMS

Strategies/Policies/ Programs	Issues/Constraints/ Objectives being addressed	Timeframe	Lead Person
Implementation of National Shellfish Program	Lack of sustained budgetary support for the commodity programs and interventions	Long-term	BFAR Central Office
Inventory, profiling, and classification of existing and potential areas for shellfish farming	Space availability delineation Shellfish sanitation	Short -term	BFAR ROS, BFAR-NIFTDC
Institutionalization of Shellfish Hatcheries	Unreliable seed supply	Medium-term	BFAR Central Office
Strengthening of Philippine National Shellfish Sanitation Program	Sanitation and food safety issues	Medium-term	BFAR Central Office
Maximization of operational space allowed on a given area	Carrying capacity Sustainable farming	Medium-term	BFAR ROs
Development of shellfish products traceability and strengthening controls on products, fresh and processed, especially at borders and on markets.	Lack of product traceability and weak policy implementation on post-harvest and marketing	Long-term	BFAR
Establishment of specific network and knowledge for shellfish		Short-term	BFAR and other supporting agencies

INDUSTRY CLUSTER GOVERNANCE NETWORK (Implementation Team)

TABLE 18. INDUSTRY CLUSTER GOVERNANCE NETWORK (IMPLEMENTATION TEAM)

Industry Cluster Governance Network (Implementation Team)		
Role	**Actor/s**	**Responsibilities**
DA Secretary	William D. Dar	– Overall leadership and direct supervision of the National Shellfish Program
Undersecretary	Cheryl Marie Natividad-Caballero	
BFAR Director	Commodore Eduardo Gongona, PCG (ret)	
Shellfish Focal Person/Technology Center	BFAR-NIFTDC, Dr. Dennis D. Tanay (OIC, BFAR-NFDC)	– Serve as a focal unit to coordinate all shellfish related projects and activities of the region
Focal Technology Center	Lead: BFAR-National Integrated Fisheries Technology Development Center	– Capability building of BFAR Regional Focal Staff – Assist in environmental profiling of shellfish grounds – Provision of technical assistance – Distribution of seeded collectors and spats – Conduct R&D projects – Conduct of Technology Verification Projects – Coordination of shellfish-related projects of BFAR Regional Offices
Profiling of areas and beneficiaries of technology livelihood assistance	Lead: BFAR Aquaculture Division BFAR Regional Shellfish Focal Persons (RSFPs) Provincial Fishery Officers (PFOs) Local Government Units (LGUs)	– Identification of existing shellfish growing / production areas – Identify/propose potential areas for expansion – Criteria setting for the selection of target beneficiaries – Identification of target beneficiaries of input assistance

Industry Cluster Governance Network (Implementation Team)		
Role	**Actor/s**	**Responsibilities**
Capacity building of LGUs	Lead: BFAR Regional Offices (ROs) Provincial Fishery Officers (PFOs)	– Conduct of training/orientation/meetings with LGUs
Provision of input assistance	Lead: RSFPs PFOs LGUs	– Provision of farm implements to small scale and marginalized fisherfolk – Establishment of shellfish farms/units – Provision of technical assistance
Research and Development	Lead: National Fisheries Research Development Institute BFAR SUCs SEAFDEC	– Conduct research and development projects for the improvement of aquaculture, post-harvest technologies, and marketing for shellfish – Conduct of Technology Verification projects and socioeconomics – Conduct studies on hazardous contaminants and risk assessment1 – Conduct studies on sustainability (value chain) and product traceability
Infrastructure support for aquaculture and post-harvest	Lead: BFAR BFAR ROs Private stakeholders	– Construction of additional support infrastructures such as shellfish hatcheries and post-harvest facilities
Environmental and Food Safety Monitoring	Lead: BFAR ROs LGUs Regional Fisheries Quality Assurance Laboratories (RFQALs) Fisheries Product Testing Laboratories (FPTLs)	– Regular environmental and food safety monitoring in shellfish production areas

Industry Cluster Governance Network (Implementation Team)		
Role	**Actor/s**	**Responsibilities**
Post-harvest technology development	Lead: BFAR-Fisheries Post-Harvest Technology Division (FPHTD) NIFTDC BFAR ROs LGUs	– Develop value-adding technologies for shellfish – Conduct skills capacity training on post-harvest technologies
Strengthening of market linkages	Lead: BFAR-Fisheries Industry Development and Support Services Division (FIDSSD) Private stakeholders BFAR ROs LGUs National Anti-Poverty Commission	– Develop marketing links to assist shellfish farmers/gatherers in selling their produce – Provision of technical assistance – Coordinate participation to Agri-Aqua Fair activities
Red tide / Harmful Algal Bloom monitoring	Lead: Fisheries Resource Management Division BFAR Red Tide laboratories BFAR ROs FPTL	– Conduct periodic red tide or harmful algal bloom (HAB) monitoring – Provision of technical assistance
Shellfish Resource Profiling	Lead: National Stock Assessment Program (NSAP) NSAP enumerators BFAR ROs	– Conduct regional shellfish resource profiling – Collect shellfish catch and effort data
BFAR Shellfish Manual Development	Lead: Information and Fisherfolk Coordinating Unit (IFCU) Shellfish Technical Working Group	– Conduct of workshop on manual development – Publishing of shellfish manual and dissemination to different stakeholders

Industry Cluster Governance Network (Implementation Team)		
Role	**Actor/s**	**Responsibilities**
Information, Education, Communication	Lead: Information and Fisherfolk Coordinating Unit (IFCU) BFAR ROs NFDC	– Conduct IEC activities for the promotion of the commodity – Formulate policies on shellfish gathering
Policy Formulation	Lead: BFAR-Fisheries Planning and Economics Division (FPED) BFAR ROs IFAD NFDC	– Conduct IEC activities for the promotion of the commodity – - Formulate policies on shellfish gathering –
Monitoring and Evaluation	Lead: BFAR-Fisheries Planning and Economics Division (FPED) BFAR ROs NFDC	– Monitoring and evaluation – Preparation and submission of program/project progress, status, and accomplishments – Evaluation of overall program achievements
	Oyster Farmers/Fisherfolk/ Private Sector	– Serve as beneficiaries and responsible for culture management and facilities for the whole culture period

REFERENCES

Benitez, Kathlene Cleah D., Flordeliza D. Cambia , Riza Jane S. Banicod, Karl Bryan S. Perelonia, Gezelle C. Tadifa, Bryan E. Tanyag, Ana Trinidad F. Rivera, Ulysses M. Montojo. 2021. Concentrations, seasonality, and risk assessment of cadmium in scallop, *Bractechlamys vexillum* (Reeve 1853) in the Visayan Sea, Philippines. *Food Control* 126. Elsevier Ltd: 1–8. doi.org/10.1016/j.foodcont.2021.108021.

Banicod, Riza Jane S. Deserie M. Peralta, Gezelle D. Tadifa, Charlotte Ann M. Ramos, Jessica C. Esmao and Ulysses M. Montojo. (2021) Assessment of Postharvest Losses Due to Catching of Undersized Fishery Commodities and Size-Dependent Pricing in the Philippines. *The Philippine Journal of Fisheries* (In-Press)

Butardo Jr. 2010. "Paralytic Shellfish Toxin Concentration and Cell Density Changes in *Pyrodinium Bahamense - Noctiluca Scintillans* Feeding Experiments." *Toxicon* 55 (5). ElsevierLtd: 1017–23. doi:10.1016/j.toxicon.2009.09.017.

Brown, E O, Maripaz L Perez, Len R Garces, R J Ragaza, R A Bassig, and E C Zaragoza. 2010. *Value Chain Analysis for Sea Cucumber in the Philippines.* Penang, Malaysia: The WorldFish Center.

Cambia, Flordeliza D, Kathlene Cleah D. Benitez, Karl Bryan S. Perelonia, and Ulysses M. Montojo. 2018. Levels of Heavy Metals in Six Aquaculture Commodities Collected from Various Landing Sites of Manila Bay: Relationships with Size and Seasonal Variation. *The Philippine Journal of Fisheries* 26 (1): 26-34. doi.org/10.31398/tpjf/26.1.2018A0002.

Duncan, Peter, and Merlina N Andalecio. 2009. "Final Report: Evaluation of Production Technology, Product Quality and Market Potential for the Development of Bivalve Mollusc Aquaculture in the Philippines." Canberra, Australia: Australian Center for Agricultural Research.

El-Sayed, Abdel-Fattah M. 2006. *Tilapia Culture.* Cabi Publishing.

FAO. (1988). Yearbook of fisheries statistics, 1986. Rome, FAO.

Floren AS. 2003. The Philippine shell industry with special focus on Mactan, Cebu. Coastal Resource Management Project of the Department of Environment and Natural Resources and United States Agency for International Development.

Ferrer, A.J.G., Perez, M.L., Roxas, A.T., Avila, E.M. 2014. Expanding roles of men and women in aquatic agricultural systems in the Philippines. Asian Fisheries Science 27(S):185–194.

Gallardo, W.G.2001 .Farmer's methods of oyster and mussel culture in the Philippines. In: Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book. International Institute of Rural Reconstruction, International Development Research Centre, Food and Agriculture Organization of the United Nations, Network of Aquaculture Centers in Asia-Pacific and International Center for Living Aquatic Resources Management. pp. 371-379.

Modor Intelligence, Inc. (2020). *Global Seafood Market 2020-2025.* Modor Intelligence, Inc.

Glude, JB, MA Steinberg and RC Stevens, 1982. The feasibility of oyster and mussel farming by municipal fishermen in the Philippines. SCS/82/WP/103 Seafarming-Philippines Technical Report, TCP/PHI/8907 (1), Food and Agriculture Organization of the United Nations, South China Sea Fisheries Development and coordinating Programme, Manila, Philippines, July 1982, 48 p.

Jontila, J.B.S., Monteclaro, H.M., Quinitio, G.F., Santander-de Leon, S.M., Altamirano, J.P. 2018. Status of sea cucumber fishery and populations across sites with different levels of management in Palawan, Philippines. Ocean and Coastal Management 165:225–234. https://doi.org/10.1016/j.ocecoaman.2018.08.025

Lovatelli, A. (1988). Status of oyster culture in selected Asian countries. NACA-SF/WP/88/2, May 1988, 96 pp.

Montojo, Ulysses M, Setsuko Sakamoto, Mirriam F Cayme, Norvida C Gatdula, Elsa F Furio, Juan R Relox Jr., Shigeru Sato, Yasuwo Fukuyo, and Masaaki Kodama. 2006. "Remarkable Difference in Accumulation of Paralytic Shellfish Poisoning Toxins Among Bivalve Species Exposed to *Pyrodinium Bahamense* Var. *Compressum* Bloom in Masinloc Bay, Philippines." Toxicon 48 (1): 85–92. doi:10.1016/j.toxicon.2006.04.014.

Montojo, U.M., Romero, M.L.J., Borja, V.M., and Sato,S. (2010). Comparative PSP toxin accumulation in bivalves, Paphia undulata and *Perna viridis* in Sorsogon Bay, Philippines. In P. Lassus (Ed.), *Proceedings of the Seventh International Conference on Molluskan Shellfish Safety* (pp. 49-55) Nantes: Ifremer.

Montojo, U.M., Borja, V.M., Romero, M.L.J., Cayme, M.F., Sato, S., Fukuyo, Y. And Kodama, M. (2012). Vulnerability of tropical molluscan shellfishes against PSP contamination during bloom of *Pyrodinium bahamense* var. *compressum*. *Coastal Marine Science*, 35, 64-66.

19. Montojo, Ulysses M., Bernajocele Jalyn S. Baldoza a , Flordeliza D. Cambia a , Kathlene Cleah D. Benitez a , Karl Bryan S. Perelonia a , Ana Trinidad F. Rivera. 2021. Levels and health risk assessment of mercury, cadmium, and lead in green mussel (*Perna viridis*) and oyster (*Crassostrea iredalei*) harvested around Manila Bay, Philippines. *Food Control* 124. Elsevier Ltd: 1–10. doi.org/10.1016/j.foodcont.2021.107890 .

Nawawi M, 1993. A guide to oyster culture in Malaysia. Bay of Bengal Programme.

Ng, F. O. (1984). Cockle culture. SEAFDEC/SAFIS Extension Manual Series No. 13. 19 pp.

Ng, F. O. (1987). Shellfish Culture in Southeast Asia. SEAFDEC Secretariat, Special Publ. 72 pp.

NOAA. (2021). *Understanding Shellfish Aquaculture*. Retrieved from NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION FISHERIES: https://www.fisheries.noaa.gov/insight/understanding-shellfish-aquaculture#what-are-shellfish-classification-areas?

Okada, H. (1963). Report on oyster culture experiment in Malaysia, Kuala Lumpur, Malaysia, Ministry of Agriculture and Land, Fisheries Division.

Opinion, April Grace R., Joan A. Raña, Karl Bryan S. Perelonia, Camille C. Abendanio, and Flordeliza D. Cambia. 2016. Spatial and Seasonal Nutrient Trends in Manila Bay Aquaculture Farms. *The Philippine Journal of Fisheries* 24 (2): 39-73. doi.org/10.31398/tpjf/24.2.2016A0013.

Perelonia, Karl Bryan S., Camille C. Abendanio, Joan A. Raña*, April Grace R. Opinion, Jordan T. Villeza, and Flordeliza D. Cambia. 2016. Heavy Metal Contamination in Water and Fishery Resources in Manila Bay Aquaculture Farms. *The Philippine Journal of Fisheries* 24 (2): 74-97. doi.org/10.31398/tpjf/24.2.2016A0014.

R Core Team. 2015. "R: A Language and Environment for Statistical Computing." Vienna, Austria.

Rabanal, H. R. (1988). Development of the aquaculture industry in Southeast Asia: An overview. In J. V. Juario & L. V. Benitez (Eds.), Perspectives in Aquaculture Development in Southeast Asia and Japan: Contributions of the SEAFDEC Aquaculture Department. Proceedings of the Seminar on Aquaculture Development in Southeast Asia, 8-12 September 1987, Iloilo City, Philippines. (pp. 3-37). Tigbauan, Iloilo, Philippines: SEAFDEC, Aquaculture Department.

Rana, Joan A., Jonacel E. Domingo, April Grace R. Opinion, and Flordeliza D. Cambia .2016. Contamination of Coliform Bacteria in Water and Fishery Resources in Manila Bay Aquaculture Farms. *The Philippine Journal of Fisheries* 24 (2): 98-126. doi.org/10.31398/tpjf/24.2.2016A0015.

Rice, M.A., P.D. Rawson, A.D. Salinas and W.R. Rosario. 2016. Identification and Salinity Tolerance of the Western Hemisphere Mussel *Mytella charruana* (d'Orbigny 1842) in the Philippines. Journal of Shellfish Research 35: 865–873.

Rosales, R.M., Pomeroy, R., Calabio, I.J., Batong, M., Cedo, K., Escara, N., Facunla, V., Gulayan, A., Narvadez, M., Sarahadil, M., Sobrevega, M.A. 2017. Value chain analysis and small-scale fisheries management. Marine Policy 83:11–21. https://doi.org/10.1016 /j.marpol.2017.05.023

Roxas, A.T., Guliman, S.D., Perez, M.L., Ramirez, P.J. 2017. Gender and poverty dimensions in a value chain analysis of Milkfish mariculture in Misamis Oriental, Philippines. Asian Fisheries Science 30(S):343– 353.

Samonte-Tan, Giselle P B, and George C Davis. 1998. "Economic Analysis of Stake and Rack-Hanging Methods of Farming Oysters." *Aquaculture* 160: 239–49.

Schug DM, Baxter K, Wellman K (2009) Valuation of ecosystem services from shellfish restoration, enhancement and management: a review of the literature. Northern Economics Inc., Report, 58 pages

Seafarming Research and Development Center, Philippine Human Resources Development Center. 1991. The Science and Business of Growing Oysters. PHRDC. 158 p.

Seafarming Research Development Center (SRDC). 1991. The science and business of growing oysters. SRDC/Philippine Human Resource Development Center. Manila.

Silvander, J.K. 2013. Gender equality in value chains and the role of aid for trade in promoting gender equality and women's employment in developing countries. Ministry for Foreign Affairs, Finland. 60 pp.

Sumagaysay, M.B. 2014. Workspaces for women in the mussel industry value chain of Jiabong, Samar in the Philippines: promoting smallscale entrepreneurship. Asian Fisheries Science 27(S):175–184.

SFRDC. 1991. *The Science and Business of Growing Oyster*. Philippine Human Resources Development Center.

Tendencia, Eleonor A. 2007. "Polyculture of Green Mussels, Brown Mussels and Oysters with Shrimp Control Luminous Bacterial Disease in a Simulated Culture System." *Aquaculture* 272 (1). Elsevier B.V.: 188–91. doi:10.1016/j.aquaculture.2007.07.212.

Ting, Y. Y. (1984). Shellfish culture in Taiwan. In I. C. Liao and R. Hirano (eds.). Proceedings of ROC-JAPAN symposium on mariculture. TML Conference Proceedings 1: 129–142. Tungkang Marine Laboratory, Tungkang, Pingtung, Taiwan, R.O.C.

Uba, K.I.N., Monteclaro, H.M., Noblezada-Payne, M.M.P., Quinitio, G.F. 2019. Sexual dimorphism, asymmetry, and allometry in the shell shape of *Modiolus metcalfei* (Hanley, 1843) collected from Dumangas, Iloilo, Philippines: A geometric morphometric approach. Computational Ecology and Software 9:107–120

V. Venugopal, Nutrients and Nutraceuticals from Seafood, Bioactive Molecules in Food, 10.1007/978-3-319-54528-8_36-1, (1-45), (2017).

WorldFish Center. 2007. "Strategy for Sustainable Aquaculture Development for Poverty Reduction Project." Asian Development Bank.

Yap, W.G.1999 .Rural Aquaculture in the Philippines. FAO RAP Publication 1999/20.

Yap, Wilfredo G, Antonio C Villaluz, Ma Gracia G Soriano, and Mary Nia Santos. 2007. *Milkfish Production and Processing Technologies in the Philippines*. WorldFish Center and SEAFDEC AQD.

APPENDICES

FIVE-YEAR IMPLEMENTATION PLAN (2021-2025)

APPENDIX 1 VISION, MISSION, GOALS, OBJECTIVES, AND TARGETS

VISION

A globally competitive, sustainable, and radically-industrialized production of high-quality tahong and talaba in the Philippines, consequently increasing the livelihood opportunities and income of marginal fisherfolk engaged in its farming, depuration, processing, and marketing by 2040.

MISSION

Development of a highly competitive, sustainable tahong and talaba industry in the Philippines that will meet the growing consumer demand for shellfish products in the Philippines and other countries that are of high quality, safe, and cost-competitive with maximum profitability.

GOALS

1. Increase production by 25% in 5 years (5% annual increase according to PSA, 2020)
2. Increase number of fisherfolks engaged in shellfish farming by 5% in 5 years, 10% in 10 years, and by 25% in 20 years
3. Ensure quality and traceability of inputs and outputs
4. Develop 40 shellfish experts in the Philippines (at least two experts per region)
5. Ensure reliable seed supply of shellfish through the establishment of BFAR and private hatchery facilities
6. Reseeding of economically important shellfish species like *Crassostrea iredalei* and *Perna viridis* to areas with small species
7. Profile all existing and potential areas for shellfish culture for classification according to the physicochemical, biological status of the areas
8. Adoption of all available value-adding technologies for shellfish in the farmer's level

OBJECTIVES

The program shall achieve sustainable growth of the mussel and oyster industry to optimize its contribution in the overall food production and food security and income for various stakeholders with consideration to the environment through the following specific objectives:

a. To develop, enhance and promote sustainable and environment-friendly farming technologies and practices, like IMTA;
b. To provide more livelihood opportunities to marginalized fisherfolk (where a good market is established);
c. To strengthen quality and food safety mechanisms for domestic supply and export;
d. To manage and regulate existing and new areas for TnT production through classification of grounds and prudent resource management;
e. To reduce post-harvest losses and to develop potential value-addition technologies for tahong and talaba;
f. To improve marketing channels from production areas to consumers;
g. To ensure safe and quality TnT products for public consumption through regular water quality and food safety monitoring, depuration, and relaying technologies;
h. To ensure reliable seed supply through the establishment of spat collection areas and hatchery facilities;
i. To promote the establishment of production support infrastructures like processing and depuration facilities as a means of elevating food safety and export market.;
j. To study and improve the production of other shellfish species like scallops, cockles, abalone, and windowpane oysters

Short-Term Plan (2021 - 2025)

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)						RESPONSIBLE ENTITY
		2021	2022	2023	2024	2025	TOTAL	
Provision of farm implements (no. of raft units)	Livelihood support for fisherfolk		1 30,000	1 30,000	1 30,000	1 30,000	4 120,000	BFAR Regional Offices
Capacity building for project implementers (BFAR RFOs) (no. of national training)	Development of TnT experts and regular retooling of extension workers	1 4	1 250	1 250	1 250	1 250	5 1,004	BFAR NIFTDC
Skills capacity building for LGU extension workers (2 trainings/ region/yr) (no. of trainings)			34 8,500	34 8,500	34 8,500	34 8,500	136 34,000	BFAR Regional Offices
Skills capacity building for fisherfolk associations through community-based trainings (no. of trainings)			34 6,800	34 6,800	34 6,800	34 6,800	136 27,200	LGUs
Info-campaign on PNSSP through social media and traditional media	Distribution of IEC materials on PNSSP		2,000 2,000	1,000 1,000	1,000 1,000	1,000 1,000	5,000 5,000	BFAR-IFCU
Improvement/Upgrading of HAB and environmental monitoring laboratories (no. of laboratories upgraded)	Intensification of environmental monitoring			3 9,000	3 9,000	3 9,000	9 27,000	BFAR
Conduct of TnT Congress (no. of SC conducted)	Strengthening of industry stakeholders linkages			1 1,500	1 1,500	1 1,500	3 4,500	DA-BFAR

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)						RESPONSIBLE ENTITY
		2021	2022	2023	2024	2025	TOTAL	
Conduct R&D Projects related to mussels and oysters (no. of projects)	Research and Development to intensify and improve quality of production	1 1,500	1 1,500	1 1,500	1 1,500	1 1,500	5 7,500	NFRDI, NIFTDC, SEAFDEC, SUCs
Establishment of Talaisdaan Techno Demo Projects	Adoption of Integrated Multi-trophic Aquaculture			2 350	2 350	2 350	6 1,050	BFAR Regional Offices
Establishment of Oyster Hatchery (no. of hatcheries established)	Integration of oyster spat /seed production on current marine hatcheries	1 10,000	1 10,000	1 10,000	1 10,000	1 10,000	5 50,000	BFAR Central Office, BFAR NIFTDC, BFAR Regional Offices
Conduct training on Post-Harvest Technologies for TnT (e.g., branding for premium oysters, smoked oysters, oyster paste/ sauce) to BFAR RFOs (2 trainings/ region/yr) (no. of trainings conducted)	Information dissemination and skills capacity enhancement		34 3,400	34 3,400	34 3,400	34 3,400	136 13,600	RQALs, FPHTD, FPTL, National Centers
Training on Post-Harvest Technologies for TnT to LGUs (2 trainings/region/yr) (no. of trainings conducted)			34 3,400	34 3,400	34 3,400	34 3,400	136 13,600	BFAR Regional Offices
Community-based (CB) Training on Post-Harvest Technologies for TnT to fisherfolk associations (2 trainings/region/yr) (no. of trainings conducted)			34 3,400	34 3,400	34 3,400	34 3,400	136 13,600	LGUs
Regional Agri-Aqua Fair Participation (no. of Agri-Aqua Fairs participated)	Promotion and strengthening of market linkages		1 850	1 850	1 850	1 850	4 3,400	BFAR Regional Offices, FIDSSD, FIU

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)						RESPONSIBLE ENTITY
		2021	2022	2023	2024	2025	TOTAL	
Upgrading of BFAR Regional environmental monitoring facilities (no. of BFAR Regions/ NTC capacitated)			18 36,000				18 36,000	FRMD, Red Tide Laboratory (RTL), DOST, BFAR ROs, LGUs, NIFTDC
Profiling and Assessment of Potential and Existing TnT Facilities (no. of regions completely profiled)	Shellfish Resource Management		4 regions 3,340	4 regions 3,340	4 regions 3,340	3 regions 2,505	17 regions 14,195	BFAR Central Office, NIFTDC, BFAR Regional Offices, LGUs
Profiling and registration of TnT farm/hatchery operators, growers, processors, and traders (% of registered/profiled stakeholders)			25% 750	50% 750	75% 750	100% 750	100% 3,000	BFAR LGUs
Development of DA-BFAR TnT Manual (no. of workshops conducted)	Information, education, and communication (IEC) material development				2 150	2 150	4 300	All stakeholders
Formulation of policies on area classification, zoning and shellfish gathering (no. of workshops conducted)	Improve zoning of shellfish farming structures		2 150	2 150	2 150		6 450	BFAR FPED, stakeholders

Medium-Term Plan (2026 - 2030)

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)						RESPONSIBLE ENTITY
		2026	2027	2028	2029	2030	TOTAL	
Replacement of distributed culture units destroyed (no. of units distributed)	Sustain livelihood assistance projects to fisherfolk	500 15,000	500 15,000	500 15,000	500 15,000	500 15,000	2,500 75,000	BFAR
Profiling and Assessment of Potential and Existing TnT Facilities (no. of regions completely profiled)	Updating of shellfish resources profile every 5 years		4 regions 3,340	4 regions 3,340	4 regions 3,340	3 regions 2,505	17 regions 14,195	BFAR LGUs
Development of technology for granular and real-time monitoring of Red Tide and HAB (no. of technology developed)		1 10,000		1 10,000		1 10,000	3 30,000	NFRDI BFAR
Institutionalization of PNS for Bivalves and mollusks	Improve the traceability of mussel and oyster products							BFAR (IFAD, NFLD, FIQD, FHL, PHTD)
Capacity building on traceability of TnT products (no. of training)		17 1,700	17 1,700	17 1,700	17 1,700	17 1,700	85 8,500	
Regular monitoring and issuance of compliance certificates to farms and inspection of processing facilities and TnT products								
Adoption of off-shore farming technologies (no. of techno-demo projects established)	Establishment of technology demonstration projects on climate-smart technologies	2 1,000	2 1,000	2 1,000	2 1,000	2 1,000	10 5,000	BFAR

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)						RESPONSIBLE ENTITY
		2026	2027	2028	2029	2030	TOTAL	
R&D Technology Verification projects on other shellfish species (e.g. scallops, cockles, angel wing oyster, Manila clam, windowpane oyster, abalone) (no. of R&D conducted)	Intensification of production for other shellfish species	1 1,500	1 1,500	1 1,500	1 1,500	1 1,500	5 7,500	BFAR, NFRDI, SEAFDEC, SUCs
Training on product handling and processing of mussel and oyster	Improvement of product quality safety	17 1,700	17 1,700	17 1,700	17 1,700	17 1,700	85 8,500	BFAR
Commercialization of the use of apog (feed additives)	Reduction of post-harvest losses							NFRDI, BFAR
R&D on additional value-adding technologies (no. of value-adding technologies developed)	Product development		1 500	1 500	1 500	1 500	4 2,000	RQALs, FPHTD, FPTL, Regional Offices
Distribution of shellfish stalls to sellers (100 SS per region/yr)	Livelihood support for fisherfolk			1,700 42,500	1,700 42,500	1,700 42,500	5,100 127,500	RQALs, FPHTD, FPTL, Regional Offices
Facilitation of marketing	Equitable access and strengthen the local market network							BFAR-NFFTC & FIDSS and Regional counterpart
Establishment of market information system (no. of information systems developed)			1 1,000		1 1,000		2 2,000	BFAR-FIDSSD & FIMC and Regional counterpart

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)						RESPONSIBLE ENTITY
		2026	2027	2028	2029	2030	TOTAL	
Forge partnership with government financing institutions	Accessible credit and loan programs by financing institutions							LBP, other financial institutions, BFAR FIDSD and Regions and COA
Strengthening of local marketing network								
Facilitate/assist stakeholders in accessing financial assistance especially during calamities (no. of fisherfolk associations facilitated)		10 1,000	10 1,000	10 1,000	10 1,000	10 1,000	50 5,000	BFAR, LGU, LBP, and other financial institutions
Establishment and strengthening of existing fisheries cooperative/ organization/ association (% of small-scale shellfish growers registered in cooperatives/ associations)		25% 500	25% 500	25% 500	25% 500	25% 500	100% 2,500	BFAR CO-FIDSD and Regions
Capacity building on product packaging and labeling	Improvement of mussel and oyster processed products	17 1,700	17 1,700	17 1,700	17 1,700	17 1,700	85 8,500	BFAR, DTI
Establishment of Depuration facilities (no. of depuration facilities)	Ensure/Improve quality and safety of harvested mussel and oyster	2 4,000	2 4,000	2 4,000	2 4,000	2 4,000	10 20,000	RQALs, FPHTD, FPTL, Regional Offices
Capacity building on Depuration and Relaying Technologies			1 350	1 350	1 350	1 350	5 1,750	NIFTDC
Distribution of simple processing package (stainless tables, jet washers)		170 PP 8,500	170 PP 8,500	170 PP 8,500	170 PP 8,500		680 PP 34,000	RQALs, FPHTD, FPTL, Regional Offices

Long-Term Plan (2031-2040)

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)											RESPONSIBLE ENTITY
		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	TOTAL	
Export of TnT products (2% increase in export)	Expand the export potential of TnT products	1	1	1	1	1	1	1	1	1	1	10	BFAR, FIDSSD, Exporters
Assessment and selection of potential sites for the culture of pearl oysters and giant clams (no. of regions assessed)		1 2,000	1 2,000	1 2,000	1 2,000	1 2,000	1 2,000					6 12,000	BFAR, DOST, NFRDI
Provision of technical assistance to potential investors													
Policy formulation and review on the translocation of TnT species (no. of policy reviewed/ formulated)	Strengthen surveillance and monitoring of invasive species	1 1,000		1 1,000		1 1,000						3 3,000	BFAR, LGU, NFRDI
Facilitate certification of processing facilities (no. of certifications facilitated)	Improve traceability and quality assurance												

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)											RESPONSIBLE ENTITY
		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	TOTAL	
Regular price monitoring in key markets for facilitation of implementation of SRP for TnT (no. of monitorings conducted)	Price monitoring and standard-ization	12 120	12 120	12 120	12 120	12 120	12 120	12 120	12 120	12 120	12 120	120 1,200	BFAR, LGUs
Facilitate market matching between growers, processors, and exporters (no. of assistance conducted)	Strengthen market linkage	1 100	1 100	1 100	1 100	1 100	1 100	1 100	1 100	1 100	1 100	10 1,000	BFAR, DTI, LGU, Private
Conduct of entrepreneurial training (no. of training conducted)	Strengthen-ing of capac-ity of MSMEs on TnT	1 100	1 100	1 100	1 100	1 100	1 100	1 100	1 100	1 100	1 100	10 1,000	BFAR, DA-ATI, LGU, Private
Skills capacity training of shuckers on local and international food safety standards conducted		17 1,700	17 1,700	17 1,700	17 1,700	17 1,700						85 8,500	BFAR, DA-ATI, LGU, Private

ACTION / STRATEGY / DESCRIPTION	PROGRAM / ACTIVITY / PROJECT	PHYSICAL AND FINANCIAL TARGETS ('000)											RESPONSIBLE ENTITY
		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	TOTAL	
Policies, procedures, and work instructions that are compliant with food safety standards of the domestic and international markets developed													BFAR, DTI
Participation of Philippine exporters to International fairs and fora (no. of facilitation conducted)	Promotion and support to TnT export			1 1,000			1 1,000			1 1,000		3 3,000	Private
Conduct training on the shell craft industry		1 50		1 50		1 50		1 50		1 50		5 250	BFAR, NFRDI

APPENDIX 3 INSTITUTIONAL ARRANGEMENT

DA-BFAR shall directly supervise the implementation of the roadmap. The following stakeholders shall be involved in the implementation:

Production-related/Production and Livelihood Development

- BFAR Central and Regional Offices
- Schools, Universities and Colleges
- Local Government Units

Training Program

- DA-Agricultural Training Institute
- BFAR-National Integrated Fisheries Technology Development Center
- BFAR Regional Offices, Regional Fisheries Training Centers

Marketing and Credit Program

- BFAR Fisheries Industry Development Services and Support Division
- BFAR Regional Offices
- Landbank/ACPC/Rural Banks and Fishery Cooperatives
- Local Government Units
- Private Sector

Product Development

- BFAR Post Harvest Division and regional Offices
- Private Sector
- SUCs

Research and Development

- BFAR
- NFRDI
- SUCs
- SEAFDEC

Regulatory Requirements

- BFAR Regulatory Division and Fisheries Quarantine Unit
- BFAR Central and Regional Offices
- Private Sector
- Schools, Universities, and Colleges
- Local Government Units

Trade and Marketing

- BFAR Fisheries Industry Development Services and Support Division
- Department of Trade and Industry
- Schools, Universities, and Colleges
- Local Government Units
- Department of Trade and Industry

APPENDIX 4 MONITORING AND EVALUATION

Monitoring and evaluation (M&E) are tools that both aim at providing information that can help inform decisions, improve project performance, and achieve planned results. M&E shall be conducted to determine program performance and, if needed, to recommend policy adjustment for more effective program implementation. Program activities shall be regularly monitored by the BFAR Regional Office, through its Regional Shellfish Coordinator who shall prepare a quarterly report of the progress of program activities. The BFAR Regional Office shall be required to provide the BFAR National Office progress reports at six months, annually, and a final report at the end of the program. Evaluation of the overall program shall be the responsibility of the National Shellfish Development Team.

OTHER ATTACHMENTS

Shellfish resources have long been exploited for food and had generally promoted in the past only small-scale fisheries in various localities throughout the country, catering mostly to the domestic trade. Shellfish culture as livelihood only requires minimal capital investments compared to other aquaculture commodities such as tilapia and milkfish (Samonte-Tan and Davis 1998; Yap et al. 2007; El-Sayed 2006). And is, therefore, more accessible either as a major or supplemental source of income.

The industry thus played a significant role in the country's economy, in terms of providing employment and livelihoods in rural areas and generating income from domestic trade and exports.

The country's shellfish industry now comprises the cultivation of a few molluscan species, harvesting of shellfish species from natural populations, and the shell craft industry. However, unlike in other countries such as Japan, France, and China where the mariculture of mollusks is popularly practiced, shellfish production in the Philippines still depends mainly on natural harvests, rather than on mariculture of commercially important species.

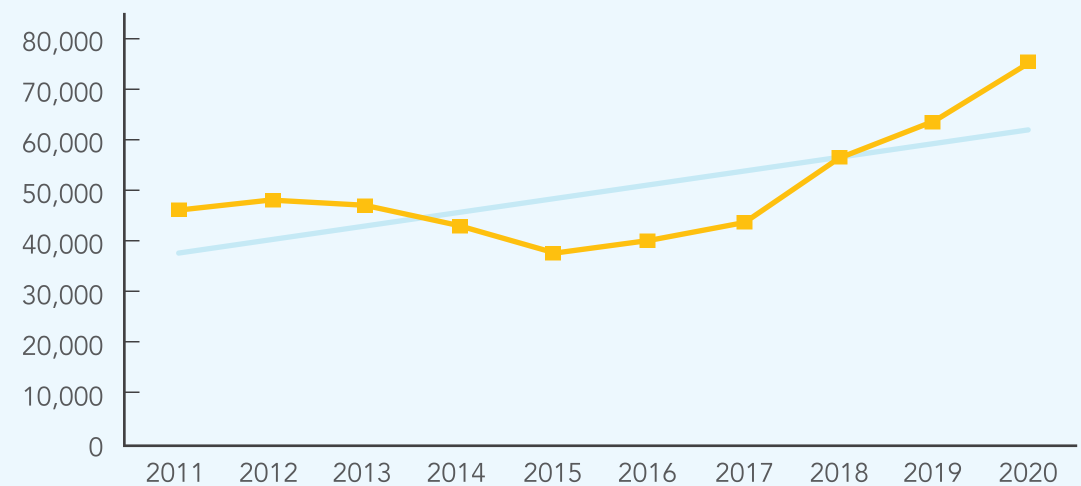
For oysters, there are four species cultivated: *Crassostrea iredalei*, *C. cucullata*, *C. malabonensis* and *C. palmipes*. Of these four species, *C. iredalei* is the most commercially desirable because it grows at a faster rate to a larger size and has straight shell margins which make them easier to open (FAO, 2012).

In the Philippines, mussels are an important fishery resource with only three species exploited commercially, namely, *Perna viridis* (Linneaus, 1758), *Modiolus metcalfei* (Hanley, 1843), and *Modiolus philippinarum* (Hanley, 1843). The green mussel, *P. viridis*, is commercially farmed with its production entirely sustained by the abundance of wild seeds while the horse mussels, *M. metcalfei* and *M. philippinarum*, are gathered from the wild, as they are not known to attach on substrates other than living adults growing in dense mats on muddy bottoms (Yap, 1978).

According to the 2002 Census of Fisheries of the National Statistics Office, there were a total of 5,463 aquaculture operators engaged in oyster (3,041) and mussel farming (2,422) wherein production came from open coastal waters. Common culture methods for oysters and mussels are broadcast, stake, plot-hanging, longline, and raft methods. Broadcast is usually combined with raft and stake methods and is employed for the culture of small oysters removed during thinning or harvest.

The methods commonly used for oyster culture are bottom, stake, and hanging either from a rack or raft-rack. The stake method is the most used. In terms of productivity, the raft method and hanging methods are the most productive, followed by the stake, then the bottom method. Bottom and stake methods are used in shallow (intertidal) areas, whereas the hanging method is used in deeper areas (Gallardo, 2001).

TOTAL 10-YEAR PRODUCTION DATA (IN MT) FOR MUSSELS AND OYSTERS IN THE PHILIPPINES



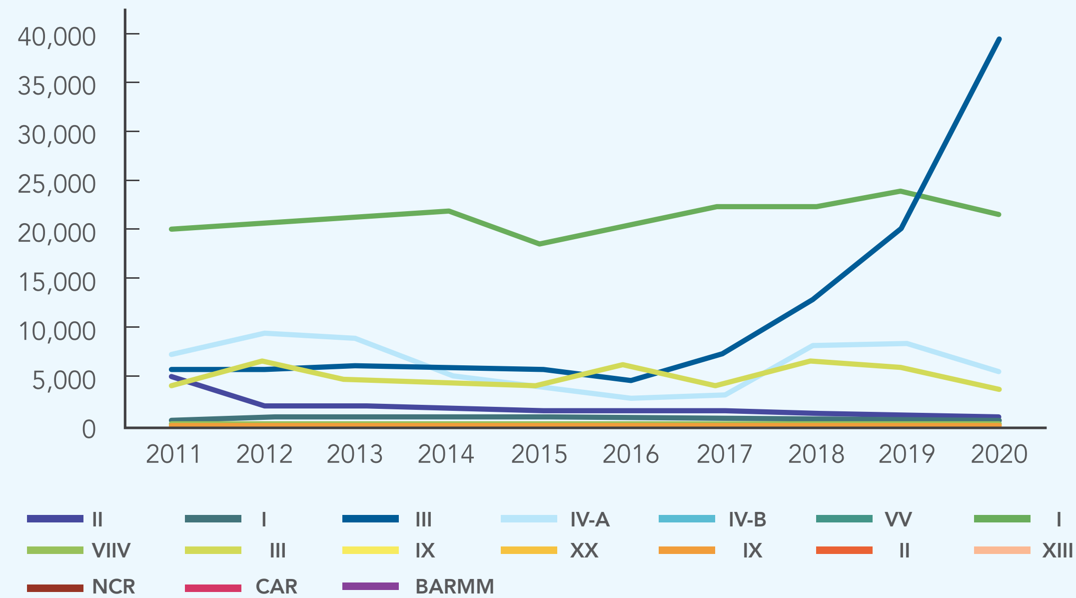
Source: PSA, 2020

In 2020, the total production of tahong and talaba reached 74,993.02 MT valued at PhP 1,551,688,000.00 which showed an estimated 18% increase in production from 2019's data by PSA. A declining trend of production was observed from 2013 to 2015 but eventually recovered for the succeeding years showing an average of 15% annual production from 2016 to 2020.

The 10-year production data showed that the top producing regions are Region VI (21,388.62 MT), Region III (11,425.52 MT), Region IV-A (6,424.42 MT), Region VIII (5,373.93 MT), and Region I (2,049.61 MT). Meanwhile, based on the 2020 PSA data of production alone, Region III (39,004.17 MT) ranked first and switched places with Region

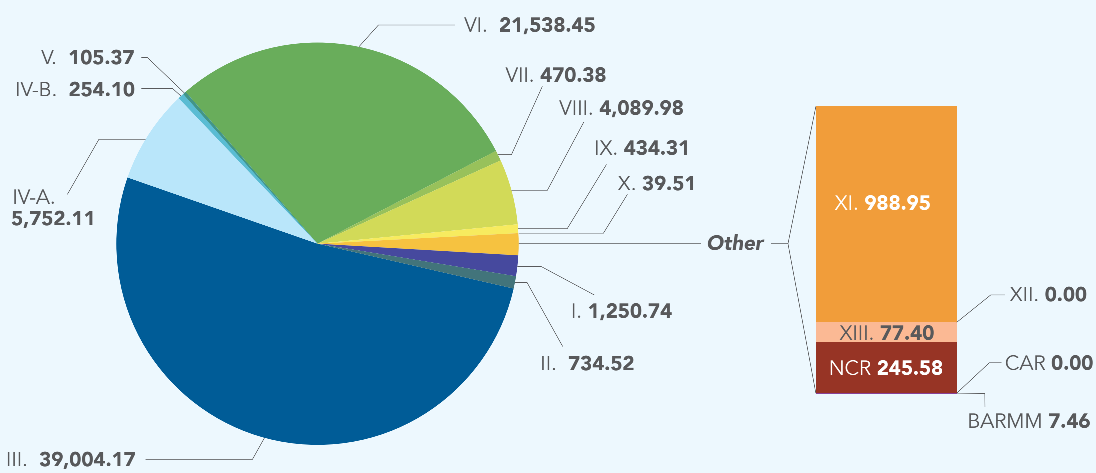
VI (21,538.45 MT). This was followed by Region VIII (4,089.98 MT), Region IV (5,752.11 MT), and Region I (1,250.74 MT), completing the top 5 producing regions. The rest of the regions produced either less than 1,000 mt of oysters/mussels, or nil.

TEN-YEAR MUSSEL AND OYSTER PRODUCTION DATA (IN MT) BY REGION



Source: PSA, 2020

2020 SHELLFISH PRODUCTION DATA (IN MT) BY REGION



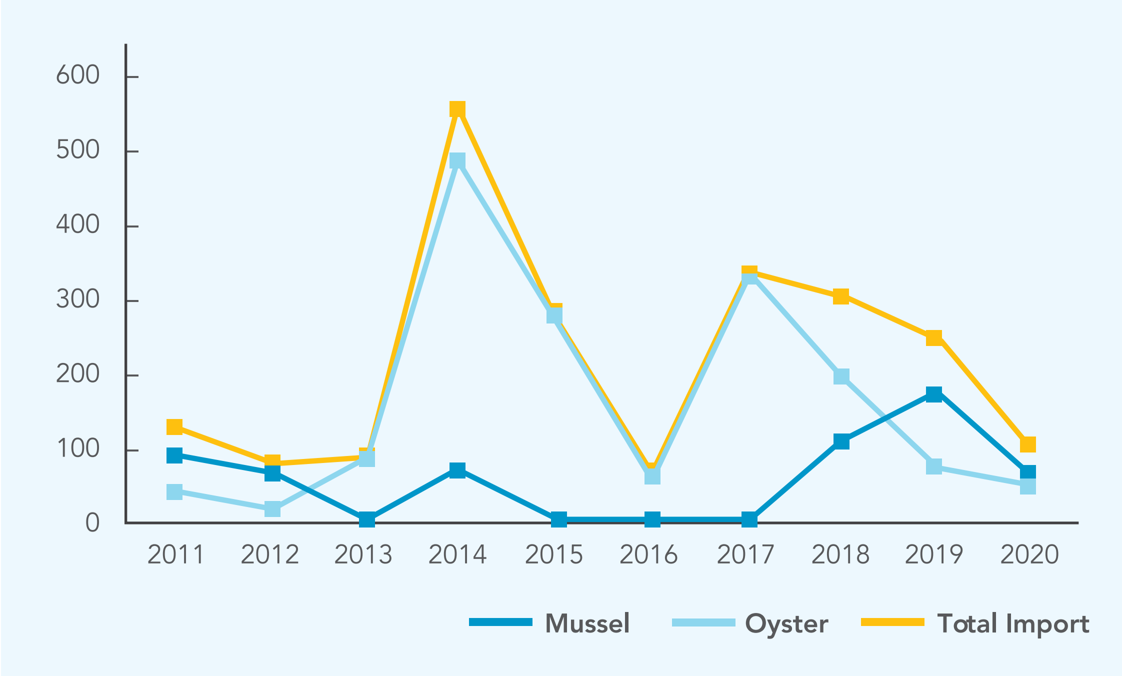
Source: PSA, 2020

Decreasing trends for export from 2018 to 2020 was observed in the country (Figure 4). Meanwhile, dwindling data on importation of mussels and oysters can be seen for the past 10 years where there is a recent drop in importation from 2019 to 2020 at 59%.

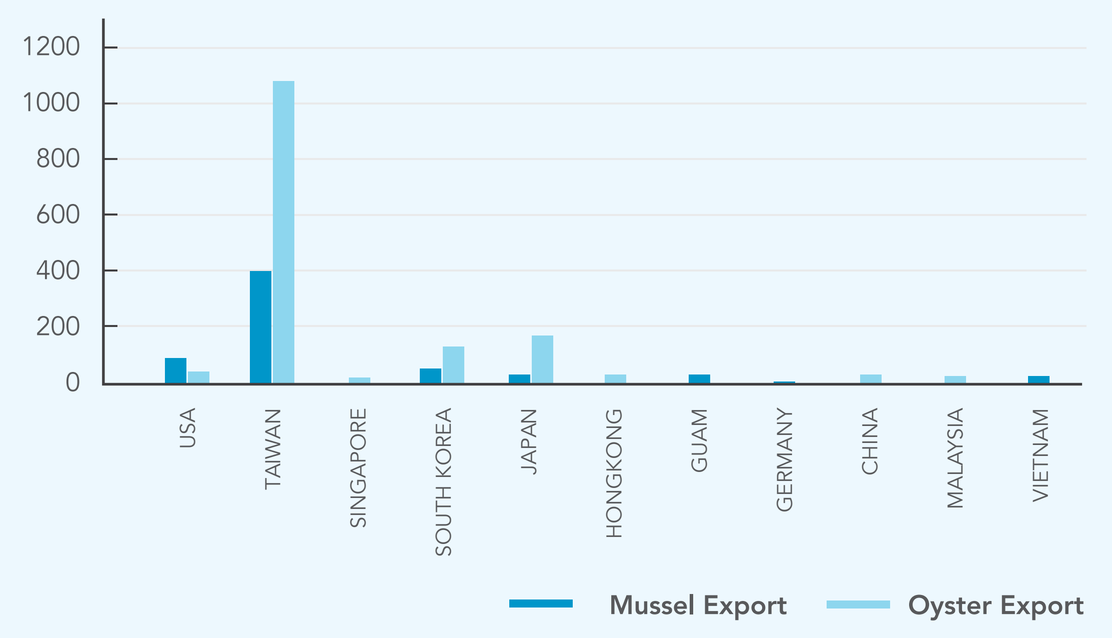
Export data for mussels and oysters declined for the last four years (2017-2020) with a 60% decline last year (2020) from the 2019 export data. A drastic decrease in export was seen in oysters compared to mussel products.

According to PSA data, mussel products of the Philippines are being exported to the United States of America, Taiwan, Singapore, Korea, Japan, Hongkong, Guam, and Germany with an average gross export of 16.62 MT for the last 10 years. Taiwan ranked first in the data of our exportation both for oysters and mussels. This is followed by the USA, Japan, and Korea. Sources of exportation in the Philippines are Iloilo City, Zamboanga City, and Metro Manila. For oysters, data for export is recorded for Vietnam, the USA, Taiwan, Singapore, Korea, China, Malaysia, Japan, and Hongkong with an average gross of 19.21 MT for the last 10 years (2011-2020). This comes from Cebu City, Metro Manila, Region VII, and NCR.

TEN-YEAR TNT EXPORTATION IN THE PHILIPPINES (IN MT)

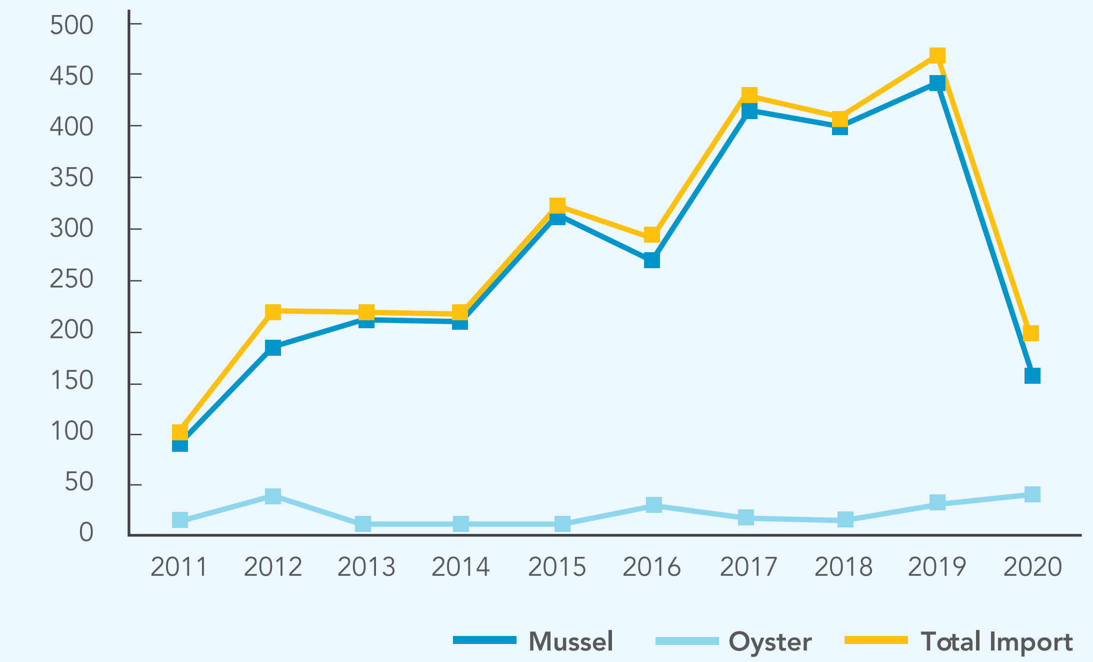


DESTINATION COUNTRIES WHERE THE PHILIPPINES EXPORTED TNT FOR THE LAST 10 YEARS (IN MT).

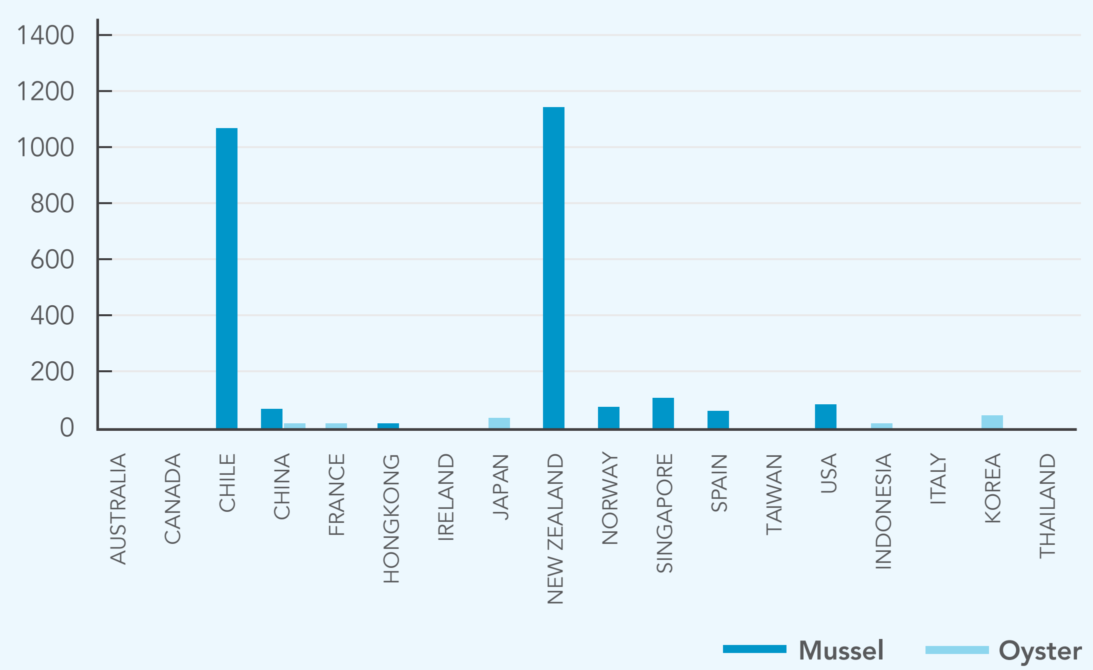


Meanwhile, importation data for shellfish showed an increasing trend from 2011 to 2019 with a sudden drop of 59% in 2020. Importation is dominated by mussels with an average gross volume of 267 MT from 2011-2020 which we imported from Australia, Canada, Chile, China, France, Hongkong, Ireland, Japan, New Zealand, Norway, Singapore, Spain, Taiwan, and the USA. For oysters, we also have a minimal importation average gross volume of 17.22 MT which we imported from Australia, Canada, Chile, France, Hongkong, Indonesia, Italy, Japan, Korea, New Zealand, China, Thailand, and the USA. The bulk of our importation data comes from New Zealand and Chile where the highest imports for mussels were recorded. For oysters, the majority of imports come from Korea and Japan.

TEN-YEAR TNT IMPORTATION IN THE PHILIPPINES (IN MT).



COUNTRIES WHERE THE PHILIPPINES IMPORT SHELLFISH (OYSTER AND MUSSELS) FOR THE LAST 10 YEARS



The per capita consumption for mussels by region can be seen in Table 4. SThe per capita consumption is based on the average of 2015-2016 data from the Philippine Statistics Authority.. The data shows that the Davao Region, Eastern Visayas, and the National Capital Region, have the highest consumption requirements for mussels. For oysters, PSA 2012 data on the per capita consumption was recorded at 0.60 grams per day.

AVERAGE PER CAPITA CONSUMPTION DATA FOR MUSSELS IN 2015-2016 BY REGION (KG/YR)

REGION	TAHONG (MUSSELS)
PHILIPPINES	0.383
NCR	0.792
CAR	0.402
I	0.0406
II	0.294
III	0.555
IV-A	0.162
MIMAROPA	0.787
V	0.141
VI	0.234
VII	0.213
VIII	0.881
IX	0.082
X	0.190
XI	0.887
XII	0.321
XIII	0.512
BARMM	0.088

The value chain is non-complex and straightforward. Shellfish seeds are usually sourced out from the wild which remains largely dependent on environmental and biological factors. Factors affecting spat collection include the state of the technology and socio-political factors. Collected spats are transferred to grow-out areas. Growing shellfish as done in open-access areas is subjected to external factors like in oyster/mussel spat collection. After harvest, the product is either marketed directly or underwent post-harvest processing before reaching the consumers. Harvest is conducted with assistance from the family or hired labor. Shellfish farmers practice sorting of live and dead shellfish, sorting by size and species, and to some extent cleaning of fouling organisms. Harvested oysters are transported in baskets, plastic containers, and sacks. The average shelf-life of raw oysters is around 3 days (Tanay, unpublished).

A whole household can be involved in the trading aspect. Men usually collect the shellfish while women and children participate in processing the product. Both men and women may also perform the marketing. This is consistent with the observations of other studies where men are typically engaged in strenuous activities while women are in activities needing patience and meticulous attention (Ferrer et al., 2014; Sumagaysay, 2014). Meanwhile, in the Gender role profiling and value chain analysis of raw oysters in Capiz and Bulacan conducted by Tanay (unpublished), among the identified stages in oyster production, female participation was limited at selling and marketing of raw oysters. However, in areas where the market for shucked oysters is available, the majority of workers involved are women. It was also reported that in the absence of mechanization and reliance on manual labor, women's participation is limited to marketing and to some extent, processing. Moreover, the problem of intensive labor required in oyster farming is also a complaint among male farmers.

Being a male-dominated industry, the participation of women is minimal except in processing and trading. According to the Gender Activity Profile conducted by Sumagaysay (2014), the productive-reproductive-community work mix showed that the workspaces for women include the extension of household work for which they have been best prepared by conventions, norms, and traditional socio-economic institutions. The utilization of members of the household as unpaid workers is a strategy also adopted in the shellfish trade. This is to cope with poverty, as this results in lower operational expenses and additional family income (Silvander, 2013; Roxas et al., 2017).

It can likewise be viewed as a series of institutional arrangements linking and coordinating producers, processors, traders, and distributors of mussels and mussel products. At the micro-level are the businesses that are found in each VC function. They are called the VC operators and the operational service providers; each one with specific activities. At the macro level are VC enablers which are composed of various support services to VC operators. At every VC level, value is added to the product thereby, generating more incomes, more investments, and more employment (Sumagaysay, 2014).

There are three types of supply chains operating on raw oysters or other shellfish industries in the Philippines (SFRDC 1991). The first type of distribution channel involves the farmer operating a stall along the highway or at the market, and directly selling their produce to the consumers. The most common distribution channel is the second type, where the farmer directly transacts with a wholesaler. In the early 1990s when the demand for oysters was still high, wholesalers often purchased the product even before harvest (SFRDC 1991). The third channel involves an operator at the landing sites which facilitates the sale of shellfish to wholesalers through a bidding system. Under this supply chain, the operator collects 3 to 5% commission from the sale of shellfish. Key players in the raw oyster value chain are producers (i.e., spat collectors and growers), processors, sellers, and consumers. The activities comprising the shellfish value chain are mostly performed and shared at the household level.

Marketing of raw oysters is conducted with assistance from family members. Major channels are retailers/vendors and middlemen. The shellfish is mostly marketed live with shell. Total cleaning of oysters from foaling organisms, silts, and other substrates is conducted at the retailer site (stalls or restaurants) (Tanay, unpublished).

Oysters are sold shell-on or shucked. Shucking is done with a sharp knife. The meat is removed from the shells and placed in a container filled with clean water. The meat is weighed and measured by volume. Unshucked oysters are sold by the basket or by kilogram. For green mussels, these are sold shelled-on and unshucked. Like unshucked oysters, these are also sold by basket or by kilogram. The present supply of oysters hardly meets local demand. Many farm operators are hesitant to enter contracts with businessmen from other countries because they are afraid they may not be able to meet the required quantity stipulated in the contract (FAO, 2012). Although oysters can be bought in the local market the whole year round, demand is higher during certain months, usually during summer when oysters are prepared for outings and other gatherings. On the other hand, during stormy weather, the supply is relatively low due to difficulty in harvesting.

The horse mussel value chain (Uba, et.al., 2020) consisted of a sequence of productive processes beginning with the provision of specific inputs for horse mussel collection to processing, trading, and finally, consumption. The horse mussel value chain can be viewed as a series of institutional arrangements linking collectors, processors, traders, and consumers. Every actor in the value chain had specific activities supported by the enablers. At every node, the value was added, thereby generating more incomes, investments, and employment.

It is imperative for operators in all VC functions to be competitive if the VC is to become the driver of economic development by its ability to create jobs and generate incomes. Table 1 provides an overview of the strengths and weaknesses of the industry as well as the opportunities and threats that have been observed.

Sub-system	Strengths	Weaknesses	Opportunities	Threats
Inputs	Locally available materials	Disorganized fisherfolk	Potential areas for the expansion of shellfish seed collection areas Potential adoption of shellfish seed hatchery by the private sector Supply of inputs	
Production	Rich shellfish resources Potential areas for expansion	Unpredicted spatfall Premature harvesting1	Potential for poverty reduction Source of employment Spatfall monitoring Adoption of seed hatchery breeding for shellfish	Overexploitation Typhoons Pollution
Handling and Processing	Potential for business Longer shelf-life	Poor sanitation packaging, and labeling Lack of post-harvest structure	Many products can be developed from shellfish	Inadequate supply of raw materials for processing
Trading	Potential high profits and rates of returns Employs women	Prices are not standardized Price reduction due to undersized products2	Standardize prices Aggressive marketing	Monopoly of production
Consumption	Healthy food option Flavor can be enhanced	Small local market	Higher demand especially for mussel products	Harmful algal blooms Food poisoning

1,2. Banocod et al. (in Press)

The opportunities for the improvement of the shellfish industry can be targeted from the support of the local government as the main enabler and the academe as the research arm. The country has a rich shellfish resource with a high potential for profits. The opportunities emanate from the government programs for the expansion of the industry, which boasts of wide areas for farming, a large potential market for fresh and processed shellfish products, as well as the presence of well-organized shellfish operators' associations.

Sumagaysay (2014) also emphasized opportunities on workspaces for women in the shellfish value chain could include: ownership of poles, managing production, supervising sorting, cleaning and packing; providing storage and similar post-harvest facilities for rent; innovating flavors for mussel cracker production; to go for value-addition e.g. mussel fritters, mussel paste and mussel powder for seasoning; producing shell craft; and to function as brokers, retailers, or wholesalers using social networks/information technology. The business prospects for the woman-entrepreneur are promising. However, these can only succeed if the enabling environment is created and is made accessible and friendly to the woman entrepreneur.

On the other hand, there are constraints to contend with such as the need to provide a sustained supply of inputs, to improve the shelf-life and quality of processed shellfish products, and to undertake more aggressive marketing. All of these serve as indicators for identifying investment opportunities for women (Sumagaysay, 2014). Constraints to the industry also included inadequate law enforcement, lack of support from the enablers, lack of post-harvest infrastructure, and disorganized fisherfolk. The threats to the industry can be anthropogenic and natural.

The industry in general is faced with several issues such as the occurrence of harmful algal bloom (HAB), food safety, and poor consumer acceptance (Montojo et al. 2006; Azanza et al. 2010). Anthropogenic threats included pollution, overexploitation, and food safety concerns which can be avoided if adequate measures were taken while natural threats included the occurrence of harmful algal blooms and the prevalence of bad weather conditions, mainly typhoons. Spat fall predictability and quantity are also critical in the sustainability of shellfish farming operations. Deploying the collectors too early or after the peak of spat fall results in decreased production due to the occurrence of bio-fouling and low recruitment, respectively (Tanay, unpublished). In addressing the problem of oyster spat fall, two interventions were recommended. First is the conduct of spat fall monitoring in traditional and potential oyster grounds. Spat fall monitoring will address the problem of unpredictability, as farmers will be advised when to deploy their oyster spat collectors. Integrating the collection of environmental factors (e.g., salinity and temperature) during the spat fall monitoring will enable forecasting which will be valuable information among farmers to determine when to culminate the farming activities. The second recommendation is to institutionalize the production of hatchery-bred oyster seeds. Hatchery production of oyster spats, aside from reducing the effect of climate on seed availability, also provides an avenue for improving the quality of oysters. Simple chromosome manipulations, such as the development of tetraploid breeders for the production of triploid oyster seeds, will result in large oysters which are preferred in the export market.

Indications of a deteriorating habitat condition were also reported by Uba et al. (2019). Thus, management measures should be adapted in the area. Harvest control regulations such as size limit, the maximum volume of harvest, and frequency of harvesting must be implemented through an ordinance. Moreover, given the small-scale nature of some of the shellfish species such as horse mussels, there were no proper records of other shellfish species' volume of production (Decastillo Jr., pers. comm.). The lack of adequate enforcement of the laws, minor support from the enablers, and lack of infrastructure on post-harvest can also hinder the full potential of the shellfish industry. The same problems were reported by Brown et al. (2010), Roxas et al. (2017), Rosales et al. (2017), and Jontila et al. (2018) on their study of the value chains of small-scale fisheries in the country.

The role and current state of Research and Development (R & D) in the revival of the country's fisheries sector was reviewed by Israel (1999). The main role of R & D is to generate new information and technologies that can increase the output above the current low levels. Also, the results obtained will serve as a baseline for the development of effective policies and management approaches for the rehabilitation, protection, enhancement, and long–term sustainable exploitation of resources and alleviation of poverty. However, this scheme is still confronted with institutional, capability, and management issues.

In 1987, the Philippine Council for Aquatic and Marine Research and Development (PCAMRD), which is under the Department of Science and Technology (DOST), was established to specifically mandate planning, monitoring, and evaluation of fisheries. The council established the National Aquatic Resources Research and Development System (NARRDS) made up of networks of national centers, zonal centers, and over 30 public and private fisheries R & D member institutions that will serve as the implementing arm of fisheries R&D by conducting basic and applied research and technology transfer activities. Aside from the individual institutions, the PCAMRD links up with international institutions involved in fisheries research such as the International Center for Living Aquatic Resources Management (ICLARM) and the Southeast Asian Fisheries Development Center – Aquaculture Department (SEAFDEC AQD) and vertically interacts with the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA) and the Ecosystem Research and Development Bureau (ERDB) of the Department of Environment and Natural Resources (DENR) whose scope covers the fisheries sector. Furthermore, the Council and the NARRDS cooperate with the local government units (LGUs), non-governmental organizations (NGOs), private organizations (POs), and government organizations (GOs) in technology dissemination and adoption.

Aquaculture technologies for some economically–important shellfishes were developed by SEAFDEC/AQD.

On the other hand, the Department of Agriculture – National Fisheries Research and Development Institute (DA – NFRDI) is the lead agency for fisheries research and development in the country under section 85 of RA 8550 as amended by RA 10654. In line with the directives of DA Secretary William Dar, the institution implements its twenty- two refocused projects for the fiscal year 2020. Fifteen of these projects are under the collaborative agreement of NFRDI and BFAR. The project entitled: Slipper oyster (*Crassostrea iredalei*) fattening and quality improvement in ponds using Skeletonema spp. Diatoms that are currently being instigated in the BFAR – NIFTDC at Dagupan City aims to determine the viability of oysters fattened with Skeletonema spp. diatom to improve its bacteriological, organoleptic, and chemical quality that would be safe for human consumption

ATTACHMENT 2. DIRECTORY OF STAKEHOLDERS

Name	Position/Designation	Institution	Contact Information
Dr. Dennis D. Tanay	Officer-in-Charge	BFAR- National Fisheries Development Center (NFDC)	dennistanay@gmail.com
Ms. Nerafe C. Muyalde	Senior Aquaculturist	BFAR- National Integrated Fisheries Technology Development Center (NIFTDC)	nerafe12@yahoo.com
Dr. Westly R. Rosario	Chairman	PRC Board for Fisheries	westlyrosario@ymail.com
Dr. Jocelyn M. Ladja	Scientist	Southeast Asian Fisheries Development Center	abotnegosyo@seafdec.org.ph
Dr. Ma. Junemie Hazel Lebata-Ramos	Scientist	Southeast Asian Fisheries Development Center	jlebata@seafdec.org.ph
Nonita Cabacaba	Center Chief	Guian Marine Fisheries Development Center	nonette55@gmail.com
Ms. Sandra Victoria Arcamo	Division Chief, Fisheries Resources Management Division (FRMD)	Bureau of Fisheries and Aquatic Resources	sandyarcamo@yahoo.com frmd@bfar.da.gov.ph
Mr. Marc Lawrence Romero	Section Chief, Aquatic Toxicology Laboratory	Bureau of Fisheries and Aquatic Resources	mromero@bfar.da.gov.ph, marclawrence503@gmail.com
Mr. Juan R. Relox Jr.	Supervising Aquaculturist, Conservation and Environmental Protection (RED TIDE)	Bureau of Fisheries and Aquatic Resources	reloxj@gmail.com
Mr. Roy C. Ortega	Center Chief	National Brackishwater Fisheries Technology Center	rortega@bfar.da.gov.ph
Milagros dela Pena	Researcher, Mollusks and Natural Food	Southeast Asian Fisheries Development Center	miladp@seafdec.org.ph
Mr. Christopher Baterina	Chairman on Committee for Environment/ Oyster hatchery/ farm owner	Province of Ilocos Sur	chrisbaterina@gmail.com
Mr. Raymond S. Rodolfo	Environmental Officer	Agriculture Sustainability Initiatives for Nature (ASIN)	rrodolfo@asin.com.ph
Neon Tomas B. Rosell II	President	Agriculture Sustainability Initiatives for Nature (ASIN)	nrosell@asin.com.ph

Name	Position/Designation	Institution	Contact Information
Hillel B. Cabria		Agriculture Sustainability Initiatives for Nature (ASIN)	hcabria@asin.com.ph
Jose B. Gamboa III	Senior Aquaculturist	BFAR NIFTDC	j37861@yahoo.com
Ulysses Montojo	Chief, Postharvest Research and Development Division	NFRDI	ulyssesmontojo@gmail.com
Marites Chiuco		NFRDI	mariteschiuco@gmail.com
Ma. Theresa Oclos		NFRDI	matheresa.tarampi@gmail.com
Evangeline Tayag	IPD	Marigold Manufacturing Corporation / Mama Sitas	etayag@msita.com
Ms. Amor Diaz	Chief	BFAR-FIDSSD	adiaz@bfar.da.gov.ph
Ms. Racquel A. Ferrer	Lab Technician II/ Shellfish Production Head	BFAR-NIFTDC	fidsdchief@gmail.com
Ms. Cordelia B. Nipales	Supervising Aquaculturist	BFAR-NFDC	racquelferrer494@gmail.com
Ms. Editha C. Roxas	Senior Aquaculturist	BFAR-NFDC	delnipales@yahoo.com
Mr. Regino R. Regpala	Aquaculturist II	BFAR-NFDC	ecroxas05@yahoo.com
Ms. Mary Joy G. Agustin	Aquaculturist II	BFAR-NFDC	rrregpala@gmail.com
Mr. Francisco Reyes Jr.	Science Research Specialist I	BFAR-NFDC	agustinmaryjoy08@yahoo.com
Ms. Rogelyn V. Laban	Science Research Specialist I	BFAR-NFDC	isko.reyes31@gmail.com
Ms. Ashley D. Salinas	Executive Assistant I	BFAR-NFDC	labanrogelyn@gmail.com
Ms. Ana Marie Magallanes	Technical Staff	Guian Marine Fisheries Development Center	salinashang@gmail.com / adsalinas@slu.edu.ph
Sandra Macasojot	Technical Staff	Guian Marine Fisheries Development Center	nonette55@gmail.com
Benjie Oboza	Regional Focal Person	BFAR Region 1	benjoboza@gmail.com / 09062444939
John Figuracion	Regional Focal Person	BFAR Region 2	john_figuracion67@yahoo.com / 09657229856
Jennete Cataluna	Regional Focal Person	BFAR Region 3	jennycataluna1@gmail.com / 09177930484
Amparo Fang	Regional Focal Person	BFAR Region 4A	0929 198 5370 / 0945 133 3698

Name	Position/Designation	Institution	Contact Information
Dutchlyne Grace Mangaring	Regional Focal Person	BFAR Region 4b	ardfpssdmimaropa@gmail.com / 09162351243
Jerlinda Cruz	Regional Focal Person	BFAR Region 5	arleneanchetacruz@gmail.com / 09551709795
Riza Chua	Regional Focal Person	BFAR Region 6	rcjchua@gmail.com
Felmar Pacurib	Regional Focal Person	BFAR Region 7	felmar_pacurib@yahoo.com.ph / 09771803208
Maria Lourdes Quero	Regional Focal Person	BFAR Region 8	queromarialourdes@gmail.com / 09301733563
Ronnie Omandam	Regional Focal Person	BFAR Region 9	ronieomandam10@gmail.com
Ronald Escobido	Regional Focal Person	BFAR Region 10	ronalescobido@gmail.com
Mark Alphonse Buniel	Regional Focal Person	BFAR Region 10	markabuniel27@gmail.com
Vilma Montojo	Regional Focal Person	BFAR Region 11	vingmontojo01@gmail.com
Energito Balaba	Regional Focal Person	BFAR Region 12	enerjhetz@gmail.com
Miyomg Biaca	Regional Focal Person	BFAR Region 13	
Lorence Ognasi	Regional Focal Person	BFAR CAR	lorencebognasi@gmail.com
Norhainie Pendulat	Regional Focal Person	BFAR BARMM	norhainie.pen.abdulrahman@gmail.com/09354123287

ATTACHMENT 3. RESOLUTION ADOPTING THE ROADMAP

A RESOLUTION ADOPTING THE TnT COMMODITY INDUSTRY ROADMAP PLAN FOR 2021-2040

WHEREAS, on (date of roadmap approval), the (approving body) approved the Tahong and Talaba Commodity Roadmap Plan for 2021-2040 which included an industry status, mission, vision and goals statement, and strategies for goal attainment centered around sustainable farming, quality, and safe mussels and oysters, strengthened postharvest and marketing channels, and resource management and conservation;

WHEREAS, the approved roadmap was crafted to implement strategies that seek for a sustainable mussel and oyster industry by promoting farming, with an integrated approach to uplift the socio-economic condition of fishing communities dependent on coastal fisheries for livelihood;

WHEREAS, the industry made great progress towards achieving its goals targeted from the Comprehensive National Fisheries Industry Development Program of 2016-2020;

WHEREAS, the Bureau of Fisheries and Aquatic Resources recognized the value of adopting a new Strategic Plan to (i) frame and assess current policy choices, (ii) achieve efficient resource utilization, and (iii) catalyze strategic action;

WHEREAS, after a careful review and consideration of the stakeholders' feedback regarding the Tahong and Talaba Commodity Roadmap Plan,

NOW, THEREFORE, BE IT RESOLVED, that the ______________________ hereby approves and adopts the Tahong and Talaba Commodity Roadmap Plan, attached hereto and incorporated herein by reference; and be it further

RESOLVED, that the Roadmap Plan is to be considered as a non-static, viable template for future deliberative processes and actions; and be it further

RESOLVED, the ___________________________ is directed to post the Roadmap Plan on the ____________________ and place a copy of same at the _______________________ and make copies available for the public upon request.

APPROVED this ___ day of __________________, _______. while the horse mussels, *M. metcalfei* and *M. philippinarum*, are gathered from the wild, as they are not known to attach on substrates other than living adults growing in dense mats on muddy bottoms (Yap, 1978).

APPROVED this ___ day of __________________, _______.

____

Name

ATTEST:

____

Name


PLANT. PLANT. PLANT.
PROGRAM
Masaganang ANI
Mataas na KITA