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DERLEME MAKALESİ **REVIEW PAPER**

An Overview of Fisheries and Aquaculture in the Philippines

Albaris B. TAHILUDDIN[1,2], Ertugrul TERZI[3]*

[1] *College of Fisheries, Mindanao State University-Tawi-Tawi College of Technology and oceanography, Sanga-Sanga, Bongao, Tawi-Tawi, Philippines*
[2] *Department of Aquaculture, Institute of Science, Kastamonu University, Kastamonu, Turkey*
[3*] *Faculty of Fisheries, Kastamonu University, Kastamonu, Turkey*

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: https://orcid.org/0000-0002-3237-3552
: https://orcid.org/0000-0003-2811-6497

***Corresponding author:**
Ertuğrul TERZİ
Kastamonu University, Faculty of Fisheries, Kastamonu, Turkey
✉: ertugrulterzi@gmail.com

Abstract: The Philippines is one of the significant contributors to world fisheries. In 2018, the total production from three sectors, e.g., aquaculture, municipal, and commercial fisheries, was about 4.36 million MT. With this, the Philippines ranked 13th as the top fish-producing country and placed 4th as the major seaweed producer worldwide. The total export earnings of the country from the fisheries sector was US$1.6 billion. The Philippine fisheries sector is an essential contributor to the national economy, providing income from foreign exchange and livelihood sources to almost 2 million Filipino fisherfolks. This review aimed to provide an overview of fisheries and aquaculture in the Philippines. Challenges faced in Philippine fisheries and aquaculture sectors were identified. Response to the challenges and some recommendations were also discussed.

Keywords: Aquaculture, commercial fisheries, fisheries sector, municipal fisheries, Philippines.

Filipinler'deki Balıkçılık ve Su Ürünleri Yetiştiriciliğine Genel Bir Bakış

***Sorumlu yazar:**
Ertuğrul TERZİ
Kastamonu Üniversitesi, Su Ürünleri Fakültesi, Kastamonu, Türkiye
✉: ertugrulterzi@gmail.com

Öz: Filipinler dünya su ürünleri sektörüne önemli katkı sağlayan ülkelerden birisidir. 2018 yılında, su ürünleri yetiştiriciliği, yerel ve ticari balıkçılık gibi üç sektörden toplam üretim yaklaşık 4,36 milyon ton olmuştur. Bununla birlikte Filipinler, en çok su ürünleri üreten ülkeler arasında 13. sırada ve dünya çapında deniz yosunu üreten ülkeler arasında 4. sırada yer almıştır. Ülkenin su ürünleri sektöründen elde ettiği toplam ihracat kazancı 1,6 milyar Amerika doları olmuştur. Filipinler su ürünleri sektörü ulusal ekonomiye önemli katkı ve geçimini su ürünleri ile sağlayan yaklaşık 2 milyon Filipinli balıkçıya gelir sağlayan bir sektördür. Bu derleme, Filipinler'deki balıkçılık ve su ürünleri yetiştiriciliğine genel bir bakış sunmayı amaçlamaktadır. Filipin balıkçılık ve su ürünleri sektörlerinde karşılaşılan zorluklar belirlendi. Ayrıca, karşılaşılan zorluklara cevaplar ve bazı çözüm önerileri de tartışıldı.

Anahtar kelimeler: Su ürünleri yetiştiriciliği, ticari balıkçılık, su ürünleri sektörü, yerel balıkçılık, Filipinler.

INTRODUCTION

The Philippines, situated in Southeast Asia, is an archipelagic country consisting of 7 641 islands divided into three Luzon, Visayas, and Mindanao Island groups, where Luzon and Mindanao are the two biggest islands. The Philippines is bordered by the Pacific Ocean in the east, the West Philippine Sea (formerly called the South China Sea) in the west, Taiwan in the North, and Malaysia, Brunei, and Indonesia in the South. It has a total territorial water area of 2 200 000 km^2, including an exclusive economic zone (EEZ), with a coastline length of 36 289 km

(BFAR, 2019). It is seated within the Coral Triangle – a significant hotspot for coral reef biodiversity (Carpenter & Springer, 2005; Muallil et al., 2014).

Philippine Fisheries is acknowledged in world fisheries as one of the major producing countries. In 2018, the Philippines contributed to world fish production, amounting to 1.89 million MT (2% of the marine capture production), and ranked 13th worldwide. Similarly, the Philippines is the 4th major seaweed producer globally (FAO, 2020).

There are three fisheries sectors in the Philippines: aquaculture, municipal fisheries, and commercial fisheries. In 2018, aquaculture accounted for about 53% of the total production with 2.3 million MT, where seaweeds, milkfish, tilapia, and shrimps/prawns were the major cultured species. Municipal fisheries constituted 25% of the total production with 1.1 million MT, while the commercial fisheries sector contributed about 946 thousand MT of production comprised 22% of the overall fisheries production (BFAR, 2019; PSA, 2019).

According to the Philippine Statistics Authority, the country has a population of about 101 million in 2015. Fish and fishery products are the principal protein source for every Filipino consuming 37 kg year^{-1} comprising about 12% of the total protein intake (BFAR, 2019).

Fisheries provides a livelihood to almost 2 million coastal dwellers. Fisherfolks were engaged in different fishing activities such as capture fishing, aquaculture, vending, gleaning, fishing processing, and others. Of these, capture fishing and aquaculture employ the most with 49% and 11%, respectively (BFAR, 2019). Fisheries activity is not only carried out by men Filipinos but also women . Gender participation plays a crucial role in the fisheries sector. For instance, in Taal Lake, Luzon, fisherfolks were represented by 54% male and 46% female consisted of fishers, processors, helpers, and fish cage or fishpond owners, managers, and caretakers (Mutia et al., 2020).

Fisheries is crucial to the export earnings of the country. In 2018, the Philippines earned about US$1.6 billion. The country's major fishery exports were tuna, seaweeds, shrimps/prawns, crabs, octopus, grouper, round scad, cuttlefish and squid, sea cucumber, and ornamental fish (BFAR, 2019).

FISHERIES RESOURCES OF THE PHILIPPINES

The Philippines, being an archipelagic country, is fortunate to be endowed with rich fisheries resources (Table 1). Table 2 and Figure 1 show the location and areas of major fishing grounds in the Philippines.

Table 1. Fisheries resources of the Philippines.

A. Marine Resources		
1.	Total Territorial water area (including EEZ)	2 200 000 km^2
a.	Coastal	266 000 km^2
b.	Oceanic	1 934 000 km^2
2.	Shelf Area (depth 200 m)	184 600 km^2
3.	Coral Reef Area (within the 10-20 fathoms where the reef fisheries occur)	27 000 km^2
4.	Coastline (length)	36 289 km
B. Inland Resources		
1.	Swamplands	246 063 ha
a.	Freshwater	106 328 ha
b.	Brackish water	139 735 ha
2.	Existing Fishpond	253 323 ha
a.	Freshwater	14 531 ha
b.	Brackish water	239 323 ha
3.	Other Inland Resources	250 000 ha
a.	Lakes	200 000 ha
b.	Rivers	31 000 ha
c.	Reservoirs	19 000 ha

Source: BFAR (2019).

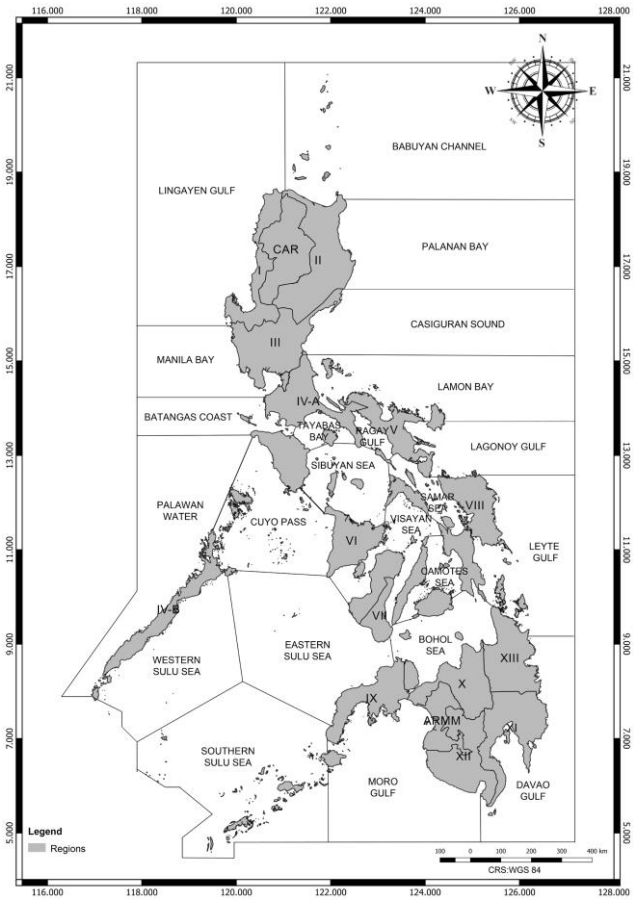

Figure 1. Philippine fishing grounds (Santos et al., 2017).

Table 2. Areas and location of the major Philippine fishing grounds (BFAR, 2019).

Fishing Grounds	Area (km^2)	Location
SEAS		
West Sulu Sea	29 992.5	Palawan
South Sulu Sea	112 642	Zamboanga del Sur/Sulu/Tawi-Tawi
East Sulu sea	9 288	Zamboanga del Norte/Negros
Sibuyan Sea	8 127	Aklan/Masbate/Romblon
Bohol Sea	7 946	Bohol
Samar Sea	3 870	Samar/Masbate/Leyte
Visayan Sea	3 096	Panay/Negros/Cebu/Masbate
Camotes Sea	2 476.8	Cebu/Leyte/Bohol
BAYS		
Lamon Bay	2 838	Quezon/Camarines Norte
Tayabas Bay	2 213	Quezon
Illana Bay	2 128.5	Lanao del Sur/Maguindanao
Manila Bay	1 935	Manila/Bataan/Cavite
Sibugay Bay	1 935	Zamboanga del Sur
Iligan Bay	1 811.16	Misamis Occidental/Lanao del Norte
Imuruan Bay	1 087.8	Palawan
San Miguel bay	774	Camarines Sur
Tawi-Tawi Bay	592.4	Tawi-Tawi
Butuan Bay	516	Agusan del Norte
GULFS		
Moro Gulf	2 900	Zamboanga del Sur/Maguindanao/Sultan Kudarat
Davao Gulf	4 024	Davao del Sur/Davao del Norte/Davao Oriental
Ragay Gulf	3 225	Camarines Sur/Quezon
Leyte Gulf	2 724	Leyte Island/Samar Island
Panay Gulf	2 311	Iloilo/Negros Occidental
Lingayen Gulf	2 064	Pangasinan
Lagonoy Gulf	1 935	Albay/Camarines Sur/Catanduanes
Asid Gulf	619	Masbate
Albay Gulf	412.8	Albay
CHANNELS		
Babuyan Channel	3 612	Cagayan/Babuyan Island
Jintotolo Channel	280	Capiz/Masbate
Maqueda Channel	129	Camarines Sur/Catanduanes
STRAITS		
Tablas Strait	3 870	Tablas Island/Mindoro Oriental
Mindoro Strait	3 426.2	Palawan/Mindoro Occidental
Tañon Strait	2 786.4	Cebu/Negros
Cebu Strait	1 818.9	Cebu/Boho
Iloilo Strait	1 006	Iloilo/Guimaras
PASSAGES		
Burias Pass	1 393.2	Burias Island/Camarines Sur
Ticao Pass	804.75	Ticao Island/Sorsogon

PRODUCTION TRENDS

Five-year (2014 to 2018) Philippine production from the three fisheries sectors is shown in Table 3 and Figure 2. Aquaculture production is consistent with more than 2 million MT and remains the primary Philippine production source compared to municipal and commercial fisheries in 5 consecutive years. Municipal fisheries production is more or less unchanged throughout the years, with more than 1 million MT. However, commercial fisheries production gradually declined from more than 1 million MT to more than 900 thousand MT in the same years (PSA, 2019).

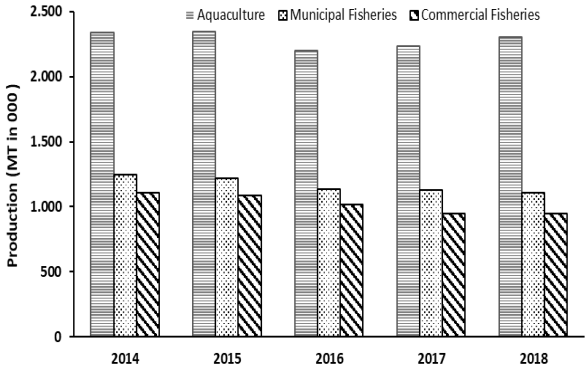

Figure 2. Fisheries production of the Philippines between 2014 and 2018 (PSA, 2019).

SECTORS OF PHILIPPINE FISHERIES

Aquaculture

Aquaculture is a significant contributor to the country's total fishery production. It is the lone sector where continuous development has been achieved compared to the municipal and commercial fisheries sectors (Aypa & Baconguis, 2000; BFAR, 2019). Seaweeds (mainly *Kappaphycus* and *Eucheuma* spp.), milkfish (*Chanos chanos*), tilapia (mainly *Oreochromis* spp.), and shrimps/prawns (*Peneaus* spp., *Metapenaeus* sp., and *Macrobrachium* sp. *)* are the top cultured species produced from the aquaculture sector, comprising 91.38% of the total production in 2018 (Table 4) (BFAR, 2019; PSA, 2019).

Table 4. Top Aquaculture-produced species, 2018.

Species	Amount (MT)	Rate (%)
Seaweeds (*Kappaphycus* & *Eucheuma* spp.)	1 478 301	64.15
Milkfish (*Chanos chanos*)	303 402	13.17
Tilapia (mainly *Oreochromis* spp.)	277 006	12.02
Shrimps/Prawns (*Peneaus*, *Metapenaeus*, *Macrobrachium* spp.)	47 060	2.04
Others	198 597	8.62
Total	2 304 365	100

Source: BFAR (2019)

Table 3. Fisheries production of the Philippines from 2014 – 2018 (MT).

Sector	Year				
	2014	2015	2016	2017	2018
Aquaculture	2 337 604.96	2 348 161.21	2 200 913.34	2 237 790.36	2 304 365.31
Municipal Fisheries	1 244 258.95	1 216 526.72	1 137 931.03	1 126 017.30	1 106 071.84
Commercial Fisheries	1 107 220.80	1 084 624.70	1 016 948.05	948 281.45	946 437.62
Total	4 689 064.71	4 649 312.63	4 355 792.42	4 312 098.51	4 356 874.77

Source: PSA (2019)

Major Cultured Species

Seaweeds: Seaweeds are a vital marine ecosystem component alongside the mangrove and coral reefs. They can be seen in two viewpoints, from their ecological value as well as their economic benefits. Among the flora in Asia Pacific Regions, the Philippine seaweed is exceptionally diverse (BFAR, 2010). As compiled and published by Silva et al. (1987), seaweeds recorded to be up to more than 800 species. The Philippines' seaweed sources have been extensively reviewed by Trono & Largo (2019), emphasizing that *Kappaphycus*, *Eucheuma*, *Gracilaria*, and *Caulerpa* as major cultured seaweed species. Additionally, *Codium*, *Gelidiela acerosa*, *Halymenia*, *Porphyra*, and *Sargassum* spp. are other seaweeds with economic significance (BFAR, 2010).

Seaweeds are the top aquaculture species cultivated from all regions (excluding National Capital Region and Cordillera Administrative Region), with 1.48 million MT comprising about 64% of the total production in 2018, where BARMM (Bangsamoro Autonomous in Muslim Mindanao) is a significant producer (BFAR, 2019; PSA, 2019). Philippines ranked 4th in seaweed production next to China, Indonesia, and the Republic of Korea (FAO, 2020).

Seaweeds are exported in both processed (semi-refined chips/carrageenan and refined carrageenan) and raw (fresh or dried seaweeds) forms. The Philippines exported carrageenan in both semi-refined and refined form, mainly to the USA, Mexico, Belgium, Thailand, Denmark, Australia, Russia, Spain, France, and Brazil, with about US$185 million in 2018. At the same time, the major importing countries of the raw forms were Spain, Argentina, China, the USA, and Brazil, with a value of about US$16 million (BFAR, 2019).

Seaweed farming is the primary livelihood source for coastal villagers, particularly in the BARMM, Southern Philippines (BFAR, 2010; Romero, 2002). It is considered a family venture involving nearly all family members, including children (Romero, 2002). Seaweed farming utilizes between 100 000-120 000 labors, where 90% are seaweed farmers, and the rest are seaweed processors and traders (BFAR, 2010). There are several culture methods practiced in the country. These include fixed off-bottom or bottom stake, bamboo raft, floating monoline, raft longline, and hanging longline (Hurtado, 2003; Romero, 2002; Sabdani, 2002). The harvesting period varies from region to region, ranging from 20 to 60 days (Mundo et al., 2002; Romero, 2002) or usually after 45 days (Samonte, 2017). Philippine seaweed production in 2018 is shown in Table 5, where BARMM was the major seaweed-producing region.

Milkfish: Milkfish (*Chanos chanos*) or locally called *Bangus*, is considered the Philippines' official national fish (Bagarinao, 1998). Farming of this fish species has been carried out in Southeast Asia for over 50 decades and is now considered the most important farmed fish (Sumagaysay-chavoso, 2003; Yap et al., 2007). Milkfish is the 2nd aquaculture production species comprising 13% of the total production (BFAR, 2019; PSA, 2019). Milkfish is cultured in brackish water, freshwater lakes, estuarine areas, and coastal marine waters using various culture systems like ponds, cages, and pens (Yap et al., 2007).

Table 5. Philippine seaweed production, 2018.

Region	Production (MT)
NCR (National Capital Region)	-
CAR (Cordillera Administrative Region)	-
I (Ilocos Region)	8.38
II (Cagayan Valley)	90.63
III (Central Luzon)	763.11
IV-A (Calabarzon)	3 303.97
IV-B (Mimaropa)	344 606.77
V (Bicol Region)	52 607.77
VI (Western Visayas)	82 503.42
VII (Central Visayas)	62 936.73
VIII (Eastern Visayas)	17 487.43
IX (Zamboanga Peninsula)	196 638.56
X (Northern Mindanao)	32 179.84
XI (Davao Region)	6 928.13
XII (Soccsksargen)	32.88
XIII (Caraga)	9 200.45
BARMM (Bangsamoro Autonomous Region in Muslim Mindanao)	669 013.44
Total	1 478 300.84

Source: BFAR (2019)

Tilapia: Before tilapia deemed as the second popular cultivated fish in the Philippines, tilapia (mainly the dark "Java" tilapia, *Oreochromis mossambicus*) was a disliked fish: bothersome to consumers who favored marine and brackish water species and disdained by fishpond operators who perceived the fish as a pest. All of that has changed with acknowledging that Nile tilapia (*O. niloticus*) is a far prevalent species for cultivation (Smith & Pullin, 1984). The six farmed tilapia species in the country are Nile tilapia *Oreochromis niloticus* together with its genetic strains, Mozambique tilapia (*O. mossambicus*), Blue tilapia (*O. aureus*), and Redbelly tilapia (*Coptodon zilli*), Blackchin tilapia (*Sarotherodon melanotheron*), and Red tilapia (*Oreochromis* spp. hybrids) (Guerrero, 1979; Romana-Eguia et al., 2020). These tilapia species are all introduced species. The first tilapia species introduced in the country from Thailand in 1950 was *O. mossambicus*. It was then followed by *O. niloticus* in 1972 and other species (*O. hornorum*, *O. aureus*, *Coptodon zilli*, and *S. melanotheron*) (Guerrero, 2019). Tilapias are considered so versatile in various environments that it has been referred to as "aquatic chicken" (Acosta & Gupta, 2010). Tilapias are typically grown using semi-intensive or intensive culture techniques under various cultivation and environmental factors, stocking rates, and management approach (El-Sayed,

2019). Romana-Eguia et al. (2020) detailed the basic concepts of tilapia cultivation in the Philippines in various farming techniques such as cage cultivation, pond cultivation, monosex male tilapia cultivation, saltwater cultivation, rice-fish (tilapia) cultivation, and aquaponics.

Shrimps/Prawns: Shrimps/Prawns are the 4th important species cultivated in the Philippines, with 47 060 MT contributing about 2% of the total aquaculture production in 2018 (BFAR, 2019; PSA, 2019). The main cultured shrimp/prawn species in brackish water ponds are *Peneaus monodon*, *P. vannamei*, *P. indicus*, *P. setiferus*, and *Metapenaeus ensis*. Another species of prawn, freshwater prawn *Macrobrachium rosenbergii*, is also recently cultivated around 2001 (Rosario & Tayamen, 2007), but its production is negligible compared to the above shrimp/prawn species (PSA, 2019).

Tiger prawn (*Peneaus monodon*) is an essential export species cultured throughout the Philippines. This species' cultivation was regarded as a minor species harvested along with the milkfish. It became the predominant species in 1951 propagated in brackish water pond in which the source of seed stocks came from the wild. In the 1980s, when SEAFDEC promoted the hatchery technology, farming of this species became successful and commercially practiced nationwide (Rosario & Lopez, 2005).

Culture System

The culture system varies according to species as well as environments. In the Philippines, fishpond, fish cage, fish pen, and mariculture are the major culture systems practiced in brackish water, freshwater, and marine environments. In 2018, mariculture had the highest production (nearly 1.5 million MT), where seaweeds, oysters, and mussels were the primary cultured species. Almost 0.5 million MT was produced from the fishpond in freshwater and brackish water environment. The fish cage production was about 0.2 million MT, while fish pen production was about 70 000 MT produced from the fish pen in all environments. Farm reservoir and rice-fish productions were 83 and 3 MT, respectively (BFAR, 2019) (Table 6).

In brackish water, the most popular cultured fish are milkfish, tilapia, grouper, siganid, and crustaceans such as tiger prawn, white shrimp, endeavor prawn, and mud crab. In the freshwater environment, major cultured species are milkfish, carp, catfish, mudfish, gourami, and freshwater prawn. In the marine environment, species with high production mostly come from seaweeds, oysters, mussels, milkfish, grouper, siganid, mud crab, spiny lobster, and tiger prawn. Farming of fish in the rice field and farm reservoir is also done of which tilapia, carp, catfish, mudfish, and gourami are the species cultivated (BFAR, 2019).

Table 6. Aquaculture production, by culture system & environment, 2018 (in MT)

Environment	Culture System					
	Fishpond	*Fish cage*	*Fish pen*	*Mariculture*	*Small Farm Reservoir*	*Rice-Fish*
Brackish water	325 504.03	1 248.79	2 877.07			
Freshwater	161 519.70	103 348.99	57 644.10		83.27	3.47
Marine water		108 951.71	9 866.9	1 533 311.76		
Total	487 023.73	213 549.49	70 388.07	1 533 311.76	83.27	3.47

Source: BFAR (2019).

Marine Fisheries

Marine fisheries are defined as the extraction of wild living resources in coastal and open sea for human sustenance or markets. Marine Fisheries resources include various fishes as well as invertebrates like mollusks, crustaceans, and sea cucumbers. In the Philippines, marine fisheries is composed of two sectors, municipal fisheries or small-scale fisheries and commercial fisheries or large-scale fisheries (Luna et al., 2004). Marine fisheries are a significant protein source, sustenance, and export earning of the Philippines (Barut et al., 1997).

From municipal and commercial sectors, marine fisheries constituted about 47% or approximately 2 million MT of Philippine production in 2018 (BFAR, 2019). In the Philippines, the most productive fishing grounds are the West Palawan Sea, South Sulu Sea, Visayan Sea, Moro Gulf, and Bohol Sea (BFAR, 2000). The most common types of fishing gears used in the Philippines are drift gillnet, purse seine, bag net, ring net, trawl, beach seine, Danish seine, handline, multiple handline, longline, and bottom set longline (Santos et al., 2017).

Municipal Fisheries

Municipal fisheries is marine fisheries where fishing is carried out along coastal and inland waters with or without the use of vessels of 3 gross tons or less (BFAR, 2019).

Municipal production: In 2018, the municipal production both from marine and inland waters was mainly contributed by Region IX-B, Region V, BARMM, Region IX, and Region VI, as shown in Table 7. Production from marine waters was about 942 000 MT, primarily composed of big-eyed scad, Indian sardines, frigate tuna, round scad, fimbriated sardines, slipmouth, squid, Indian mackerel, yellowfin tuna, and anchovies (Table 8). On the other hand, production from inland waters was about 164 000 MT, mainly comprising tilapia, carp, mudfish, freshwater catfish, milkfish, gourami, freshwater shrimp, big-head carp, freshwater goby, silver perch, mullet, and freshwater sardines (Table 9) (BFAR, 2019).

Table 7. Municipal fisheries production, by region, 2018 (in MT).

Region	Marine	Inland	Total
NCR (National Capital Region)	8 206.63		8 206.63
CAR (Cordillera Administrative Region)	-	1 111.20	1 111.20
I (Ilocos Region)	24 236.02	1 761.98	25 998.00
II (Cagayan Valley)	19 693.70	8 378.99	28 072.69
III (Central Luzon)	38 112.39	16 364.85	54 477.24
IV-A (Calabarzon)	33 336.80	67 352.12	100 688.92
IV-B (Mimaropa)	124 905.62	2 048.85	126 954.47
V (Bicol Region)	122 076.66	4 694.68	126 771.34
VI (Western Visayas)	103 635.37	7 902.06	111 537.43
VII (Central Visayas)	63 668.73	194.06	63 863.49
VIII (Eastern Visayas)	69 550.93	560.76	70 111.64
IX (Zamboanga Peninsula)	116 123.36	942.02	117 065.38
X (Northern Mindanao)	40 242.85	4 490.03	44 732.88
XI (Davao Region)	22 876.92	243.94	23 120.86
XII (Soccsksargen)	11 547.66	19 676.84	31 224.50
XIII (Caraga)	47 178.25	4 685.31	51 863.56
BARMM (Bangsamoro Autonomous Region in Muslim Mindanao)	96 478.97	23 792.64	120 271.61
Total	941 870.86	164 200.98	1 106 071.84

Source: BFAR (2019)

Table 8. Marine municipal fish catch, by major fish species, 2018.

Species	Total (MT)	% Total
Big-eyed Scad (*Selar crumenophthalmus*)	69 556.00	7.4
Bali Sardinella (*Sardinella lemuru*)	65 298.70	6.9
Frigate Tuna (*Auxis thazard*)	53 961.30	5.7
Round scad (*Decapterus maruadsi*)	50 941.61	5.4
Fimbriated Sardines (*Sardinella fimbriata*)	42 446.43	4.5
Slipmouth (*Leiognathus*)	37 331.94	4.0
Squid (Teuthoidea)	36 089.04	3.8
Indian Mackerel (*Rastrelliger kanagurta*)	35 703.42	3.8
Yellowfin tuna (*Thunnus albacares*)	34 523.77	3.7
Anchovies (*Engraulidae*)	34 220.70	3.6
Others	481 797.95	51.2
Total	941 870.86	100.0

Source: BFAR (2019).

Table 9. Inland municipal fish catch, by major species, 2018.

Species	Total (MT)	% Total
Tilapia (*Oreochromis spp.)*	44 070.89	26.84
Carp (*Cyprinus carpio*)	14 659.10	8.93
Mudfish (*Channa striata*)	9 666.04	5.89
Freshwater catfish (*Clarias batrachus*)	5 814.51	3.54
Milkfish (*Chanos chanos*)	4 988.47	3.04
Gourami (*Osphronemidae*)	4 033.14	2.46
Freshwater prawn (*Macrobrachium rosenbergii*)	3 373.52	2.05
Big-head carp (*Hypophthalmichthys nobilis*)	3 011.90	1.83
Freshwater goby (*Glossogobius celebius*)	2 892.24	1.76
Silver perch (*Leiopotherapon plumbeus*)	1 407.87	0.86
Mullet (*Mugilidae*)	1 413.74	0.86
Freshwater sardines (*Sardinella tawilis*)	993.88	0.57
Others	67 935.68	41.37
Total	164 200.98	100.0

Source: BFAR (2019).

Municipal fishing vessels: The total number of municipal fishing vessels in the country was about 259 000, dominated mainly by regions VIII, VI, VII, IV-B, and BARMM (Table 10) (BFAR, 2019).

Municipal fishing gears: The municipal fisheries in Lingayen Gulf mostly used line gears like handline, multiple handline, bottom longline, spear guns, push net, and fish trap/pot (Gaerlan et al., 2018). The fishing gears used in the Scarborough Shoal mainly comprised of variations of gillnets (bottom-set, drift, and ring nets) and hook-and-line (drift, multiple, and simple handlines), as well as speargun and jig of which the catch was dominated mainly by Acanthuridae, Balistidae, Lethrinidae, and Scombridae (Arceo et al., 2020).

Table 10. Number of municipal fishing vessels, by region 2018.

Region	No. of Fishing Vessels
NCR (National Capital Region)	718
CAR (Cordillera Administrative Region)	308
I (Ilocos Region)	8 780
II (Cagayan Valley)	9 895
III (Central Luzon)	8 684
IV-A (Calabarzon)	13 166
IV-B (Mimaropa)	29 201
V (Bicol Region)	21 555
VI (Western Visayas)	29 227
VII (Central Visayas)	29 075
VIII (Eastern Visayas)	31 548
IX (Zamboanga Peninsula)	17 061
X (Northern Mindanao)	10 184
XI (Davao Region)	10 680
XII (Soccsksargen)	9 708
XIII (Caraga)	7 862
BARMM (Bangsamoro Autonomous Region in Muslim Mindanao)	21 304
Total	258 956

Source: BFAR (2019).

Commercial Fisheries

The Philippine Fisheries Code of 1998 defines commercial fishing as taking fishery species by passive or active fishing gears for trade, business, or profit beyond subsistence or sports fishing. Fishing is done using vessels of more than 3 gross tons (BFAR, 2019; Luna et al., 2004).

Commercial production: In 2018, commercial production was about 946 000 MT. The major fish species were primarily represented by skipjack, Indian sardines, yellowfin tuna, frigate tuna, fimbriated sardines, big-eyed scad, eastern little tuna, Indian mackerel, slipmouth, and indo-pacific mackerel (BFAR, 2019.)

Tunas, family Scombridae, are being fished throughout the country's waters. A recent study by Nepomuceno et al. (2020) emphasized that Philippine waters, particularly the West Philippine Sea and Batanes-Polillo waters, have the most bountiful tuna species in species diversity.

Table 11. Commercial fish production, by major fish species, 2018.

Species	Total (MT)	% Total
Skipjack (*Katsuwonus pelamis*)	229 348.87	24.2
Bali Sardinella (*Sardinella lemuru*)	193 835.77	20.5
Yellowfin Tuna (*Thunnus albacares*)	120 364.80	6.3
Frigate Tuna (*Auxis thazard*)	57 954.97	6.1
Fimbriated Sardines (*Sardinella fimbriata*)	45 131.38	4.8
Big-eyed Scad (*Selar crumenophthalmus*)	41 368.73	4.4
Eastern Little Tuna (*Euthynnus affinis*)	21 362.01	2.3
Indian Mackerel (*Rastrelliger kanagurta*)	20 071.18	2.1
Slipmouth (*Leiognathus*)	10 619.37	1.1
Indo-pacific Mackerel (*Rastrelliger brachysoma*)	10 614.93	1.1
Other Species	135 852.19	14.4
Total	946 437.62	100.0

Source: BFAR (2019)

Tunas are the top export commodities of the Philippines. In 2018, 39% (approximately 430 000 MT) of the commercial production was composed of tuna species like skipjack (*K. pelamis)*, yellowfin tuna (*T. albacares)*, frigate tuna (*A. thazard)*, and eastern little tuna (*E. affinis*). About 170 000 MT of tuna products, both fresh and preserved, amounting to roughly US$500 million, was exported to the UK, Japan, Germany, Spain, the USA, Netherlands, Italy, Poland, Israel, Portugal, Cyprus, Indonesia, Switzerland, and other countries (BFAR, 2019).

Commercial fishing vessels: Commercial fishing vessels in the Philippines had more than 8 000, with more than 3 000 fishing operators. The NCR had the highest total number of commercial fishing vessel operators (2 362) with 6 422 commercial fishing vessels in 2018 (Table 12) (BFAR, 2019).

Commercial fishing gears: Commercial fishing gears operate across the country's waters are Danish seine, purse seine, trawls (commercial trawl, pair trawl, and midwater trawl), ring net, drift filter net, bag net, handline, multiple hook and line, and troll line (Santos et al., 2017).

Table 12. Number of commercial fishing operators and fishing vessels, by region, 2018.

Region	No. of Operators	No. of Fishing Vessels			
		Large scale (>150 GT)	Medium-scale (20.1 -150 GT)	Small scale (3.1-20 GT)	Subtotal
NCR (National Capital Region)	2 362	524	2 949	2 949	6 422
CAR (Cordillera Administrative Region)	-	-	-	-	-
I (Ilocos Region)	72	18	110	119	247
II (Cagayan Valley)	9	1	4	17	22
III (Central Luzon)	47	1	16	53	70
IV-A (Calabarzon)	146	-	55	183	238
IV-B (Mimaropa)	70	-	39	77	116
V (Bicol Region)	74	2	37	100	139
VI (Western Visayas)	7	-	5	6	11
VII (Central Visayas)	43	3	49	68	120
VIII (Eastern Visayas)	51	-	17	72	89
IX (Zamboanga Peninsula)	66	35	158	109	302
X (Northern Mindanao)	10	-	5	8	13
XI (Davao Region)	7	-	7	11	18
XII (Soccsksargen)	87	18	174	185	377
XIII (Caraga)	6	-	5	4	9
BARMM (Bangsamoro Autonomous Region in Muslim Mindanao)	1	-	4	1	5
Total	3 058	602	3 624	3 962	8 198

Source: BFAR (2019).

CHALLENGES IN THE PHILIPPINE FISHERIES AND AQUACULTURE

Challenges in the Philippine Aquaculture

The aquaculture sector in the Philippines faces many challenges despite large volume of production in recent consecutive years. The most common challenges are pests and diseases, water quality degradation, the occurrence of harmful algal blooms, and lack of capital and government support.

Pests and Diseases: Significant losses in seaweed production have been attributed mainly to pests and diseases (Ward et al. 2020; Faisan et al. 2021). The most common pests and diseases affecting seaweed farms in the country are ice-ice disease and epiphytic filamentous algae (Faisan et al. 2021). Ice-ice disease is generally caused by biotic (pathogenic bacteria and marine-derived fungi) and abiotic (light, temperature, salinity, nutrients) factors, where the infected branches of the seaweeds appeared as white and soft, which can disintegrate easily, resulting in losses in the farms thereby causing a severe production

decline (Largo et al., 1995a; Largo et al., 1995b; Mendoza et al., 2002; Solis et al. 2010; Tahiluddin and Terzi, 2021). Another problem in seaweed farming is the epiphytic filamentous algae. These pests, which are prevalent in the country, are attached using their holdfast in the host plants; and the infected branches of the seaweeds show epiphytes penetrating the cortex and growing within the medullary (Faisan et al., 2021). Epiphytic filamentous algae are also responsible for a significant decline in carrageenan quality and production biomass of farmed *Kappaphycus* and *Eucheuma* species (Ward et al. 2020).

Tilapias are also affected by diseases, especially bacterial and viral diseases, despite being a nearly hardy fish. The most commonly reported bacterial diseases are streptococcosis, motile *Aeromonas* septicemia, and *Pseudomonas* infections (Duremdez and Lio-Po, 1988; Yambot, 1998; Reyes et al., 2019; Limbauan, 2018; Legario et al., 2020). In addition, Tilapia Lake Virus, a viral disease that emerged recently, threatens tilapia aquaculture in the country as well as worldwide (Aich et al., 2021; OIE, 2017).

Disease outbreaks in shrimp aquaculture have resulted in substantial production decline over the last decades, which has become more challenging for the country to claim back the title as the global shrimp leader. Shrimp diseases can be viral, bacterial, and protozoan. Among the most common diseases which have significant impacts are white spot disease (WSD), white feces disease (WFD), early mortality syndrome (EMS), hepatopancreatic microsporidiosis (HPM), luminous vibriosis, filamentous bacterial disease, shell disease, ciliate Infestation, black gill disease, and chronic soft-shell syndrome (Hays, 2020).

Water quality degradation: Water quality degradation in ecosystems that support aquaculture is still a main issue in the Philippines, especially in Luzon. For example, in Taal Lake, concentrations of phosphates, nitrates, and total dissolved solids were significantly higher in aquaculture cage sites than in areas without aquaculture activities (Querijero & Mercurio, 2016; Cruz et al., 2019). Furthermore, the current status of Manila Bay revealed that the levels of PO_4^{-3} (1.02 mg/L – 2.42 mg/L) and NH_3-N (0.90 mg/L – 2.35 mg/L) were unsuitable for fish culture, although other important parameters like temperature, dissolved oxygen, pH, etc. were within the safe levels (Baldoza et al., 2020). Moreover, high water temperature (>32 °C) was the major challenge that has a significant impact on tilapia aquaculture, particularly in Luzon and Mindanao (Guerrero, 2019).

Harmful algal blooms (HABs): Harmful Algal blooms (HABs) have been a country's problem for the last decades affecting the aquatic environment, aquaculture sites, infected farmed species, country's economy, and even a human's life. For instance, in Laguna de Bay, due to human activity such as disposal of nutrients (nitrate and phosphate), under favorable environmental conditions, algal blooms can be expected degrading water quality like low oxygen and toxin production. This is the main cause of fish kill in most Luzon in recent years (De Vera-Ruiz, 2021).

HABs occurrence also has a great impact on the national economy of the country as well as threatening public health. For example, from 1983 to 2002, there were 2122 cases of paralytic shellfish poisoning with 117 deaths. Moreover, in the same year duration, HABs resulted in; a) economic losses and damages amounting to 2.2 million pesos, b) extensive economic damages, c) problem in the international trades, d) unemployment of many shellfish industries, and e) displacement and losses of livelihood for thousands of fishers (BFAR, 2021).

Lack of capital and government support: Farming of seaweeds is usually dependent on the availability of capital (funds) in order to start farming (Romero, 2002). In Tawi-Tawi, Southern Philippines, one of the problems that hindered farmers from intensifying seaweed farming was the lack of capital and government support, which resulted in low socio-economic status (Tahiluddin and Delasas, unpublished). In tilapia aquaculture, lack of capital and government support has been identified as one of the prime causes of low tilapia production (Guerrero, 2019).

Challenges in Philippine Marine Fisheries

Overfishing, destructive and illegal fishing, and weak law enforcement are among the prevalent challenges in marine fisheries in the Philippines.

Overfishing: Overfishing in the Philippines has been observed in the 1990s and may have been started in the 1980s (Israel & Banzon, 1997; Camacho, 1999). In the 20th century, small pelagic fishes in the country were overfished (Dalzell & Ganaden, 1987), and recently some fisheries officials blamed overfishing in Samar and Bicol for rotting sardines in Bulan, Sorsogon province (Toledo, 2021). Also, sea cucumbers in some provinces are overexploited, evident from previous studies (Olavides et al., 2010; Jontila et al., 2017; Ajik et al., 2021), although the Philippines remains as the second major sea cucumber-producing country in Southeast Asia (Alejandro, 2019). According to the chief of the Fish Right Program in the Philippines of the United States Agency for International Development (USAid), 70% of fishing grounds in the country are currently overfished (Aguirre, 2019).

Destructive and illegal fishing: Dynamite (blast) fishing, cyanide fishing, and using destructive fishing gears are considered damaging to habitats and aquatic resources (Camacho, 1999; Erdmann et al., 2000). In addition, Philippine coral reefs have been damaged by the use of

destructive fishing methods (Alcala & Russ, 2002). Even in this pandemic, illegal fishing was reported to spike during the lockdown from March to May 2020 (Espenilla, 2020). In 2019, illegal fishing from municipal and commercial fisheries comprised 27-40% of the total production amounting to 42-63 billion pesos (BFAR, 2020). In addition, unreported, unregulated, and unregistered fishing are also significant challenges in the marine fisheries sector of the country (BFAR, 2020).

Weak law enforcement: Weak law enforcement has resulted in the rampant use of destructive and illegal fishing in the country, leading to overfishing. For example, in Calamianes Island, Palawan, weak law enforcement prevails, and local fishers are even accused of corruption in fisheries governance, such as a strong link between the law enforcement agent and unscrupulous operators/traders (Fabinyi, 2007).

RESPONSE TO THE CHALLENGES AND RECOMMENDATION

The challenges mentioned above have been a long hindrance to the sustainability of Philippine fisheries and aquaculture. Pests and diseases in aquaculture, particularly in seaweed farming, must be given attention in future research like looking and further understanding the water parameters of the farm as well as the role of pathogenic microorganisms. Our previous paper (Tahiluddin and Terzi, 2021) reviewed the causes, occurrence, and some control measures of ice-ice disease of *Kappaphycus* and *Eucheuma* species may be beneficial to minimize this disease and can be used to further investigate for proper disease management. In general, biosecurity measures and aquatic disease surveillance must be imposed and enhanced to reduce pests and diseases in aquaculture. In addition, future researches may also focus on investigating the potential environmental-friendly and efficient ways of reducing, eliminating, or treating pests and diseases in aquaculture.

To monitor and maintain water quality, there should be a regular assessment or future researches of water quality, especially in aquaculture sites nationwide. In order to attain water quality standards, strict compliance with the Code of Good Aquaculture Practices must be imposed (Baldoza et al., 2020).

Although HABs monitoring in the Philippines is regularly monitored by the Bureau of Fisheries and Aquatic Resources (BFAR), especially in the area where laboratory equipment is available, coverage areas should be expanded to cover more areas where shellfish farming is being practiced and monitoring and surveillance should be improved. The development of a rapid test for detecting HABs would also be helpful for fast detection, early warnings, and avoidance of great losses both HABs-infested species as well as consumers' life. Likewise, researchers must consider and explore HABs through extensive research in many parts of the country.

The government must prioritize farmers and fishers in giving and providing assistance/support to improve the country's fisheries and aquaculture sectors. Overfishing, destructive and illegal fishing are all liked to weak enforcement of existing laws pertaining to proper utilization and management of Philippine fisheries resources. Hence, to boost fish production, there is a need for stronger enforcement measures to attain seafood self-sufficiency and sustainable fisheries in the country.

CONCLUSION

Philippine fisheries comprise three sectors; aquaculture, municipal fisheries, and commercial fisheries. Aquaculture consistently maintained high production for consecutive 5 years from 2014 to 2018, around 2.2 to 2.3 million MT, mainly from the mariculture of seaweeds, fishpond, and the fish cage of milkfish and tilapia. Municipal fisheries contributed nearly 1.1 to 1.2 million MT in the same years, primarily from big-eyed scad, Indian sardines, and frigate tuna. From about 1.1 million MT in 2014 to about 950 000 MT, commercial fisheries production gradually decreased, which may be due to overexploitation. Skipjack, Indian sardines, and yellowfin tuna are the major species from the commercial sector. The fisheries sector provides both foreign exchange and employment to the country despite the existing challenges.

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