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A Sustainable and Inclusive Blue Economy for the Philippine Archipelago

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ABSTRACT

The Philippine Archipelago is surrounded by the West Pacific Ocean region on its eastern seaboard and the West Philippine Sea on the west. It is the apex of a coral-rich area known as the Coral Triangle, the center of marine biodiversity. The Filipino people have a long history of affinity to the sea that has been used as a source of food and means of transport and trade/business, yet the maritime potential of the country has not been fully utilized to propel its overall development using the blue economy platform. The status and potentials of the country in the fields of fisheries and aquaculture, marine biotechnology, ocean energy and transport, and manpower and infrastructure development for an integrated and future responsive development of a sustainable and inclusive blue economy are presented in this paper. The discussions encompass the twin goals of the blue economy, which are the inclusive growth of the people and protection of the marine resources.

Keywords: aquaculture, blue economy, capture fisheries, marine resources, Philippines

Abbreviations: APEC, Asia-Pacific Economic Cooperation; BFAR, Bureau of Fisheries and Aquatic Resources; DA, Department of Agriculture; DENR, Department of Environment and Natural Resources; DOE, Department of Energy; EEZ, Extended Economic Zone; FAO, Food and Agriculture Organization; ICM, Integrated Coastal Management; MGR, Marine Genetic Resource; MPA, Marine Protected Area; NAMRIA, National Mapping and Resource Information Authority; PEMSEA, Partnerships in Environmental Management for the Seas of East Asia; PHILSA, Philippine Space Agency; PPA, Philippine Ports Authority; PSA, Philippine Statistics Authority; RSM, Regional Scientific Meeting; SEAFDEC, Southeast Asian Fisheries Development Center; UNEP, United Nations Environmental Program;

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INTRODUCTION

The Philippine archipelago consists of 7,641 islands and is bound by the Philippine Sea in the East, which is part of the Western North Pacific Ocean, the West Philippine Sea in the West, the Celebes and Sulawesi Seas in the South, and Bashi Channel in the North (Figure 1). Situated at the Coral Triangle, the center of marine biodiversity. The country has about 220 million hectares of marine waters and 29.8 million hectares of land, with a coastline of 36,289 km, the world's 5th longest (NAMRIA 2021).

The Filipinos are mostly coastal inhabitants with about 55.3 million (about 60% of total population) residing in coastal areas (PHILSA 2019) and with a long history of use of the marine environment/resources for food, fodder, and fuel (3 Fs), trade and mobility, and recreation/tourism. These ecosystems' goods and services can be broadly classified as provisioning (3 Fs), supporting (species habitat/biodiversity, genetic diversity), regulating (shoreline protection, climate change/carbon sequestration) and cultural (recreation, aesthetic values, educational values) (UNEP 2010).

Valuation or estimates of the intrinsic values for conservation and decision making for sustainable development purposes of these marine resources have been undertaken in several countries including those in East Asia (PEMSEA 2017). With focus on the valuation and management of the country's blue economy, it is estimated that the intrinsic value of Philippine marine ecosystem goods and services is about USD 6 trillion.

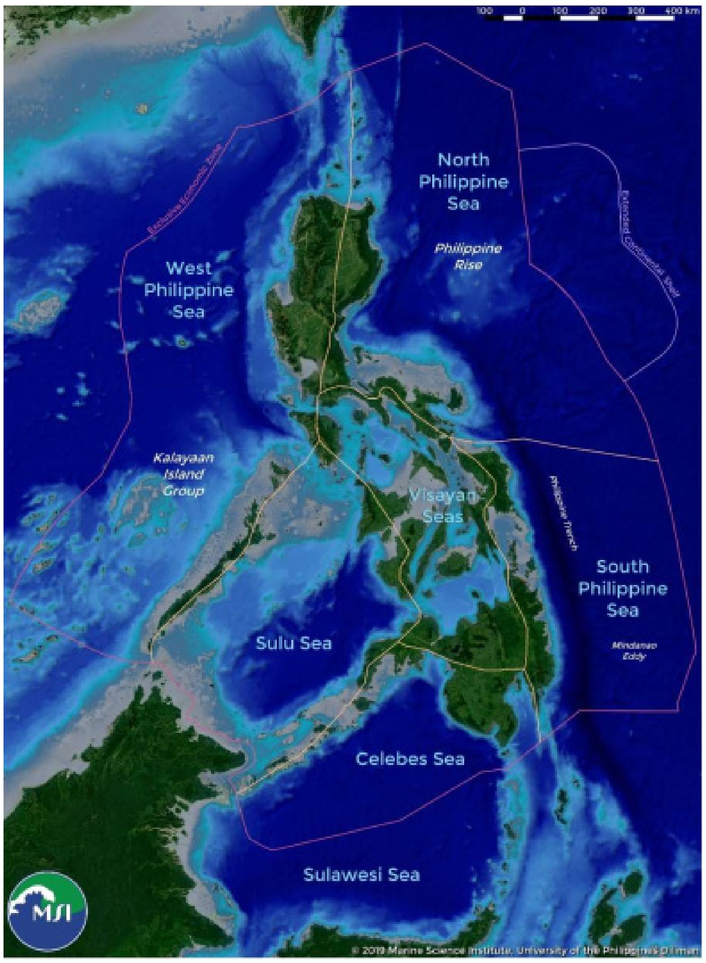

Figure 2. The Philippine archipelago showing the major island groups and the Philippine Rise east of Luzon. (Source: Marine Science Institute, University of the Philippines, Diliman)

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The "Blue Economy" platform or approach has dual objectives of the sustainable use of the marine (living and non-living) resources for improved livelihoods of the people while preserving the health of the marine ecosystems. China, Indonesia, and Vietnam have been aggressively developing their blue economies/ocean economies in support of their overall development plans (APEC Blue Economy Forum 2012) using "blue economic zones and parks".

This is a synthesis of the papers presented on the blue economy potentials of the Philippines during the NAST 2020 Regional Scientific Meeting (RSM) and Annual Scientific Meeting with the theme, "*Science and Technology for Society: Solutions to Long Standing Concerns*". The paper aims to review Philippine marine resource status and potentials and discuss issues and threats (including this very impactive COVID-19 pandemic, where appropriate) with the goal of having a sustainable and inclusive blue economy.

GEOGRAPHICAL CONTEXT OF THE PHILIPPINE BLUE ECONOMY

The Philippines' total marine territorial waters at 2.2 million square kilometers are seven times larger than its total land area (Mendoza and Valenzuela 2017, PSA 2020). Over 12% of the territorial waters is coastal area and would extend 1 kilometer inland from the shoreline at high tide down to 200-meter isobath. The larger 88% of the marine territorial waters is oceanic that also includes exclusive economic zones of the Philippines. In addition to the territorial waters is the 130,000 square kilometers Philippine Rise located about 320 nautical miles off the eastern coast of Northern Luzon (Barreto et al. 2020). The extent of the marine territorial waters of the Philippines clearly defines the archipelagic nature of the country and the need to give value to the affinity of its land and water (DENR et al. 2004). The terrestrial areas are generally divided into "Luzon, Visayas, and Mindanao", with three biggest islands being Luzon, Mindanao, and Samar (in the eastern part of the Visayas with a number of relatively smaller islands).

The archipelagic nature of the county forms unique biodiversity regions parallel to the major island groupings (Figure 1; Ong et al. 2002; Aliño and Gomez 1994). Straits and channels between islands convey water from the Pacific Ocean into the West Philippine Sea and serve as marine biodiversity corridors. Based on reef fish habitat and diversity, the complexity of hydrodynamic factors creates 6 biogeograhic regions. Marine features around Luzon are strategic to biodiversity management and tourism and tourism. The Verde Island Passage between Batangas and Mindoro in Southern Luzon is considered as the center of marine shore fish biodiversity (Carpenter and Springer 2005). The Philippine Rise, a 13,000 square kilometers underwater feature more than 300 nautical miles east of coast of Aurora, is also part of Luzon. The Visayas Region, with narrow straits between islands is the most productive portion of marine waters in the country in terms of fisheries which are also priority areas in cetacean conservation, and host to several large marine protected areas in the country. Mindanao, on the other hand, hosts five of the major fishing grounds of the Philippines where sardines, and tuna, as well as seaweeds, are primarily sourced for local consumption and export market (https://bit.ly/3EcAh1x, downloaded on November 7, 2022).

FISHERIES AND AQUACULTURE PRODUCTION

Fish overexploitation has been observed in the Philippines in the past five decades resulting to the decline in the fish catch of small fishers. Quantitative estimates by Mualil et al. (2014) indicate that catches by small fishers are lower by 24-26% in the preceding four decades and that "the initial signs of severe depletion of fish stocks to the level indicative of biological and economic overfishing occurred in the 1990s". These factors include increase in coastal population, use of destructive fishing methods, commercial fishing in coastal waters, climate change, and siltation/pollution from land-based activities. Even the establishment of MPAs and tourism activities that closed some traditional fishing grounds were included as factors in the diminished harvest of local small fishers (Mualil et al. 2014). Blast fishing, although in a declining trend (Alcala 2000), is still being practiced sporadically in some areas in the Visayas with lax law enforcement and is one of the causes of the rapid deterioration of the reefs and fishing grounds. Remedies, however, have been explored to recover from the dynamite-blasting of reefs using innovative techniques to stimulate natural recovery in fish and coral population (Raymundo et al. 2007). This trend follows that of the world. FAO (2020) estimates that more than 90% of global marine stocks is overfished, with about 59% fished at maximum sustainable levels. Thus, the food organization recommends that wild harvest and culture practices move towards sustainability and conservation-sensitivity to remedy the situation.

The latest statistics update on fisheries and aquaculture production show that the growth rate in this sector was lower in 2020 (i.e., amidst the pandemic) at -0.3% compared to 1.3% in 2019 and 1.0% in 2018. The total volume of production was down at 4,403.71 MT in 2020 compared to 4,415.00 MT in 2019 and 4,356.87 MT in 2018 (PSA 2020). Municipal fisheries and aquaculture recorded decreases at -2.1 and -1.5 % for the period 2019-2020, respectively, while commercial fisheries showed an increase in growth rate at 5.0% for the same period (Table 1). Major decrements were recorded for the production of seaweeds (-2.1%) and tilapia (-5.2%) and harvest of sardines (tunsoy, -33.2%), slipmouth (sapsap, -14%) and Indian mackerel (alumahan, -10.8%) (Table 2). Upturn in production was observed for sardinella/tamban at 37.0%, roundscad/galunggong at 7.2% and culture of milkfish/bangus at 1.9%.

As in other industries/activities, the ongoing pandemic exacerbated the above-mentioned anthropocene consequences on Philippine fishery harvest and aquaculture in 2020. People's mobility was impaired resulting in lessened activities for seafood supply and trade from covid quarantine/lockdowns. Consequently, landings/harvest for 2020 generally showed negative values (PSA 2020). Other undocumented natural and man-made influences such as pollution during the pandemic need to be assessed.

The Philippines used to be number one in the culture of carrageenan-producing seaweeds, a very important export commodity in the 1990s to early 2000s. However, due to a complex of environmental problems and apparent lack of comprehensive development framework, the industry has been experiencing a downward trend as neighboring Indonesia continues to increase its annual seaweed production. In 2018 the country's seaweed production was 1,478.30 MT at 4.4% growth while the values were 1,499.96 MT at 1.5% growth in 2019 and 1,467.82 MT and -2.1 % growth in 2020 (PSA 2020). Trono and Largo (2019) have reported on the production of seaweeds in the Philippines dating back to the early 1980s, peaking in 2011 and declining towards the present. Many problems of this industry have been associated with deteriorating coastal environment from various types of pollution and lack of continued manpower and other support systems. Research and development to enhance cultivation techniques and management practices have been previously recommended (Ask and Azanza 2002).

Fisheries/wild harvest and aquaculture done in municipal waters (mangrove areas, seagrass beds and coral reef areas) are the main sources for survival and livelihood of many coastal communities while

Table 1. Volume of Fisheries Production by Subsector: Philippines, January - December 2018 - 2020[P]

Subsector	Volume of Production (metric tons)			Percent Change		Percent Share to Total Fisheries
	2018	2019	2020[P]	2019/2018	2020[P]/2019	
Fisheries	4,356,874.77	4,415,001.68	4,415,001.68	1.30	-0.30	
Commercial Fisheries	946,437.62	931,451.05	931,451.05	-1.60	5.00	22.20
Municipal Fisheries	1,106,071.84	1,125,217.47	1,125,217.47	1.70	-2.10	25.00
Marine	941,870.86	968,758.60	968,758.60	2.90	-1.80	21.60
Inland	164,200.98	156,458.87	156,458.87	-4.70	-4.10	3.40
Aquaculture	2,304,365.31	2,358,333.16	2,358,333.16	2.30	-1.50	52.80

[P] – Preliminary

Note: Percent change and the percent share may yield different results when computed manually due to rounding

Source: Philippine Statistics Authority

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Table 2. Volume of Fisheries Production by Species: Philippines, January - December 2018 – 2020.

Species	Volume of Production (metric tons)			Percent Change		Percent Share to Total Fisheries
	2018	2019	2020ᴾ	2019/ 2018	2020ᴾ/ 2019	
Fisheries	4,356,874.77	4,415,001.68	4,415,001.68	1.30	-0.30	100.00
Milkfish (Bangus)	400,118.78	414,944.25	414,944.25	3.70	1.90	9.60
Tilapia	321,076.58	321,187.79	321,187.79	0	-5.2	6.9
Tiger prawn (Sugpo)	44,884.45	46,003.56	46,003.56	2.50	-7.70	1.00
Skipjack (Gulyasan)	258,375.05	256,375.66	256,375.66	3.10	-1.60	6.00
Roundscad (Galunggong)	171,306.41	189,003.22	189,003.22	10.30	7.20	4.60
Seaweed	1,478,301.85	1,499,961.25	1,499,961.25	1.50	-2.10	33.30
Yellowfin tuna (Tambakol/ Beriles)	94,437.19	99,351.27	99,351.27	5.20	-3.50	2.20
Mudcrab (Alimango)	21,678.67	22,283.75	22,283.75	2.80	-0.40	0.50
Frigate tuna (Tulingan)	111,916.27	111,511.06	111,511.06	-0.40	-0.90	2.50
Big-eye scad (Matangbaka)	110,924.73	109,439.57	109,439.57	-1.30	-4.00	2.40
Bali sardinelia (Tamban)	259,134.47	247,502.84	247,502.84	-4.50	37.10	7.70
Squid (Pusit)	47,327.48	46,945.50	46,945.50	-0.80	-5.60	1.00
Blue crab (Alimasag)	33,929.60	29,677.14	29,677.14	-12.50	4.70	0.70
Bigeye tuna (Tambakol/ Bariles)	31,134.51	17,756.61	17,756.61	-43.00	12.90	0.50
Grouper (Lapu-lapu)	17,781.66	17,781.66	17,781.66	11.00	-1.00	0.40
Indian mackerel (Alumahan)	55,774.60	60,214.50	60,214.50	8	-10.3	1.20
Threadfin bream (Bisugo)	36,343.42	41,381.23	41,381.23	13.90	-5.00	0.90
Slipmouth (Sapsap)	47,951.31	46,464.14	46,464.14	-3.10	-14.30	0.90
Cavalia (Talakitok)	23,658.82	24,224.34	24,224.34	2.40	7.00	0.60
Fimbriated sardines (Tunsoy)	87,577.81	77,723.36	77,723.36	-11.30	-33.20	1.20
Others	703,242.13	723,319.43	723,319.43	2.90	-2.80	18.00

ᴾ – Preliminary

Note: Percent change and percent share may yield different results when computed manually due to rounding
Source: Philippine Statistics Office

commercial fisheries operate within the Extended Economic Zone (EEZ) and sometimes into the High Seas. The Bureau of Fisheries and Aquatic Resources estimated that the total value of fishery production in 2019 was PhP281,652 billion with aquaculture comprising 42% of production, municipal fisheries at 36%, and commercial fisheries at 22% (DA-BFAR 2019).

Capture fisheries, aquaculture, and related industries have always been vulnerable to the country's seasonal typhoons exacerbated by climate change impacts bringing stronger winds and excessive rainfall and creeping ocean acidification. Accompanying these climate change consequences are coastal physical impairments and salinity and pH changes in the water and aggravated chemical and solid waste pollution (Azanza et al. 2017). Integrated Coastal Management (ICM) and proper maintenance of Marine Protected Areas (MPAs) are extremely potent at increasing 1) the resilience of overfished and climate change impacted areas and 2) the productivity and biodiversity of the protected and adjacent areas (Alcala and Russ 2002; Abesamis 2018). The protection and proper management of the ecological base of our blue economy is paramount for the inclusive and sustainable development of our archipelagic nation.

Sustainable mariculture is an industry that the country needs to focus on to boost fishery production and ensure food security. More opportunities for employment would open and other economic activities would be spurred in the countryside especially using environmentally sustainable production and support systems. Smart/precision mariculture coupled with coastal and marine spatial planning would prevent conflicting utilization of the environment resources and resolve at an early and future stages of socio-economic and environmental problems and issues. Integrated Multi-trophic Aquaculture (IMTA), being practiced in other countries can be tried with R & D support so that ecologically compatible species can be cultured together in the marine environment to avoid the use of pollutive fish feeds (Largo et al. 2016; Melendres and Largo 2021). This could also be tried in deeper waters/ offshore waters of the country where pollution is less which otherwise would affect the quality of the cultured organisms. Support for the development of value-added products for local use and export is also vital in the blue economy development of the country (NAST PHL Foresight Report 2021).

MARINE BIOTECHNOLOGY AND OTHER PRODUCTS FROM THE SEA

The rich marine biodiversity of the Philippines represents our Marine Genetic Resources (MGRs) which is a rich source of biologically active compounds for various purposes in the medical/ pharmaceutical arena (Table 3). MGRs from marine organisms like bacteria, fungi, algae and other plants and animals are being screened, studied and isolated for their anti-pain, anti-infection and anti-cancer properties. Many of these organisms, especially marine algae, may prove to be important sources of functional nutrients including essential elements for brain development, specifically omega-3 and omega-6 fatty acids, taurine, magnesium, iodine, zinc, and vitamin B12 (Mouritsen et al. 2019). Cultured seaweeds can be promoted as a healthy food and a sustainable source of nutrients. The more than a thousand species of Philippine algae awaiting to be harnessed, minus the few species already providing us with important products and services (e.g., carrageenan from *Kappaphycus* and *Eucheuma*; agar from *Gracilaria* and *Gelidiella*; spp.; and fresh salad from *Caulerpa, Eucheuma* and *Gracilaria*), the need for safe and healthy food when agriculture can no longer sustain a population projected to increase at 144 million by 2050, will find seaweeds the most available source of nutritious food that are just around the corner ready to be rolled out by avant-garde chefs. The new trend of seaweed gastronomy (or phycogastronomy, i.e., using seaweed as part of modern cooking), being practiced by some modern culinary artists to produce innovative cuisine, dates back to earlier times when Japanese first used seaweeds rich in glutamate (e.g., the kelp *Saccharina* spp.) as a flavoring (*umami*) in cooked food such as *miso* soup. Known as *dashi* in Japanese, this taste enhancer became an indispensable ingredient in Japanese cooking (Mouritsen et al. 2019). Aside from the culinary arts, cosmetics and medicine from the sea have long been produced in countries like Japan, China and Korea and the continuing search for these novel substances have also been initiated in the Philippines (Concepcion et al. 2017) and other countries (Azanza et al. 2017). The current initiative to build a Virology Institute of the Philippines (VIP) can consider the marine environment as potential sources of bioactive materials for use in the present and anticipated viral and bacterial endemics and epidemics.

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Table 3. Summary of bioactive compounds isolated from marine organisms and their associated bacteria from the Philippines (Source: Concepcion et al., 2014)

Compounds	Structural Class	Bioactivity	Reference
bistramides(38,40)	cyclic peptide	cytotoxic to human colon cancer HCT-116 cells	Foster et al. 1992
adociaquinones and xestoquinones (12-15)	quinone	cytotoxic to HCT-116 cells	Concepcion et al. 1995
makaluvamine N	pyrolloiminoquinone	topoisomerase II-inhibitor	Venables et al. 1997
Bolinaquinone	sesquiterpene hydroxyquinone	cytotoxic to HCT-116 and CHO xrs-6 cells	De Guzman et al. 1998
neoamphimedine (17)	pyridoacridine	cytotoxic to normal CHO AA8 cells cytotoxic to KB tumors and HCT-116 in mice	De Guzman et al. 1999
Agelasine	terpenoid	inhibited M. tuberculosis and drug resistant strains (isoniazid ATCC 358222, ethambutol ATCC 35837, ethionamide ATCC 35830) in vitro	Mangalindan et al. 2000
aldisines (19,20)	alkaloid	cytotoxic to human tumor LoVo cells	Tasdemir et al. 2001
Perophoramidine	alkaloid	cytotoxic to HCT-116 cells	Verbitski et al. 2002
Bromotryptophans	bromoindole	cytotoxic to HCT-116 cells	Tasdemir et al. 2002a
heptylprodigiosin (33)	tripyrrole	anti-malaria activity against chloroquine-sensitive strain	Lazaro et al. 2002
Isomalabaricanes	triterpene	cytotoxic to p21-deficient HCT-116 cells	Tasdemir et al. 2002b
p-sulfooxyphenylpyruvic acid	sulfated	minimal activity to epidermoid carcinoma A431 cells	Bugni et al. 2002
lissoclinotoxins (21,22)	alkaloid	cytotoxic to PTEN-deficient human breast cancer MDA-MB-468 cells	Davis et al. 2003
xestospongin B	macrolide	platelet aggregation inhibitor in vivo	Pimentel et al. 2003
Kalihinols	diterpene	inhibits bacterial folate synthesis	Bugni et al. 2004
microcionamides (31,32)	cyclic peptide	cytotoxic to human breast cancer MCF-7 and SKBR-3 cells	Davis et al. 2004
cribostatin 7 reneirone	isoquinoline quinones	cytotoxic to JHCT-116 cells	Sandoval et al. 2004
crambescidin	guanidine alkaloid	anti-malaria activity against Plasmodium falcifarum 3D7	Lazaro et al. 2006
speciosterol sulfates (23,26)	sterol sulfates	inhibits NF-kB activation in human chondrocytes	Whitson et al. 2008
fibrosterol sulfates (27,28)	sulfated sterols	inhibits PKCζ	Whitson et al. 2009
deoxyamphimedine (18)	pyridoacridine	cytotoxic to human ovarian cancer A2780wt and A2780AD cells	Marshall et al. 2009
chondropsins (¬34,35)	macrolide	cytotoxic to LOX (melanoma) OVCAR-3 (ovarian) human tumor cell lines	Coombs et al. 2010, Cantrell et al. 2000

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A framework for the development and establishment of marine biotechnology research and innovation in the Philippines in key areas/satellites should consider infrastructure and manpower needs, hence, collaboration with Universities/Higher Education Institutions, national and local government units and private partners is vital. The Marine Science Institute, University of the Philippines-Diliman and the Southeast Asian Fisheries Development Center (SEAFDEC) in Iloilo, are two institutions that can assist in this endeavor of tapping our marine resources for novel and value-added products. Capacity building should include manpower development/training in basic sciences like chemistry, molecular biology and taxonomy.

SEAPORTS, SHIPBUILDING, TRANSPORT, AND MANPOWER

There are 1800 ports around the Philippines serving both economic and transport activities (PPA 2020). The major ones are the North and South ports in Manila Bay, Cebu Port in Mactan Channel, Subic Port in Subic Bay, Batangas Port in Batangas Bay and Zamboanga Port in Basilan Channel. The Philippine Ports Authority (PPA) is implementing a project to have all the country's ports become "Disaster Resilient", the country being one of the most exposed to disasters particularly those coming from typhoons and earthquakes. The PPA states that a "disaster resilient port" ensures that logistics continue during and after a disaster (PPA 2019). Relating to the covid disaster, the movement of people, i.e., frontliners, and patients, and delivery of goods should be facilitated and given top priority. The PPA includes a Port Business Recovery action plan so that public and private plans can help in the recovery from any disaster at the most minimal time.

The pandemic has caused the "forced" return of thousands of our overseas workers not only from the maritime industry. Many of them have been struggling to find alternative livelihoods. For those in the coastal villages, which have immediate access to the fishing grounds, the sea offers the opportunity to be engaged not only fishing but also in post-harvest activities with the help of their families. Drying fish, making salted sea products (e.g., bagoong, ginamos, tinabal, dayok), fish and squid balls/tempuras are some of small businesses that could earn income for the displaced workers. For the more gadget-savvy individuals who know how to use their smartphones to their advantage, they can engage in online trading, which is a new trend in delivering goods directly to the doorsteps of consumers. Fresh fish and even vegetables from their backyards are traded this way that has practically reduced the number of middlemen who only jack up the price of commodities (Largo DB, unpublished).

The Philippine Marina, which is in charge of matters relating to ships, seafarers and all systems relating to maritime transport has a 30-year development framework (2019-2050) which gives importance to strengthened national maritime standards, compliance to regional and global maritime agreements and international maritime conventions. The 30-year program includes: 1) Improvement of domestic shipping, 2) Development of services for maritime tourism, 3) Development of coastal and inland waterways transport system, 4) Strengthening of safety standards for Philippine-registered fishing vessels, 5) Development of a Global Maritime Hub, 6) Enhancement of Maritime Safety in the Philippines, 7) Modernization of maritime security in the country and 8) Development of a Maritime Innovation and Knowledge Center (Marina 2018).

The impact of COVID 19 pandemic is unprecedented and extends to many coastal- and ocean-based activities upon, which many people depend for their livelihood, food and raw materials to make useful and profitable products. Disruption in the movements of goods and services due to lockdowns, including intermittent closures of fishports, and the supply chain slowdown especially during the early days of the COVID pandemic allowed us a chance to peek into what could happen if the supply chain is significantly disrupted because of market access or logistical problems related to transportation and border restrictions. It is "business as usual" with transport of food to non-food items (e.g., raw seaweeds for hydrocolloid processing) assumed to be now moving at a slower pace because of the health protocols like social or physical distancing. Part of the domino effect from the quarantine requirements is the additional expense and efforts to ensure freshness and safety of marine raw materials (Largo DB, unpublished).

With a long history of shipbuilding and shipping from the "Balangay Period" (Scott 1985) and coastal and offshore fishery, and other product trading, the Philippines has to revitalize its "blue economy" for the

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sustainable development of this archipelagic nation. A multi-hull boat called "trimaran" has been designed and built in the Philippines for passenger and cargo transport using hybrid sources of energy, i.e., oil and wave energy (DOE 2020). This opportunity to use the vast ocean resource of the country and the boatbuilding skills/capacity for innovation of the Filipinos should be fully harnessed for the blue economy.

DEVELOPMENT AND USE OF OCEAN/MARINE ENERGY

Various types of renewable energy (waves, tidal and thermal) could be derived from our vast marine waters. Ocean wave energy gradient, thermal energy and tidal energy gradient, can be utilized by using technologies/devices, some of which have been developed in other countries. Tidal energy is collected during high tides in embayments where the tide differences are distinctly measured and turbines deliver the energy to the shore/coast where they are stored or directly used. Thermal/solar energy present on the surface and certain depths of the sea can take care of the energy requirements of the coastal communities with proper collection and distribution. Wave energy can be used in sea transportation which is now being considered in the Philippines.

The Philippines has initiated the development of ocean/marine energy and for this purpose has considered the use of areas which are mostly on the Pacific/eastern seaboard of the country. Since ocean energy conversion system basically has the same energy conversion system as the more commonly used wind energy system, there is a considerable opportunity for our local energy innovators and providers. Further, the location of the Philippines is ideal for the usage of our archipelagic coast as source of ocean energy for power generation. According to the Department of Energy (DOE 2020) there are 15 sites that are qualified for this system that may generate an estimated 265 million megawatts of electricity. These potential sites are San Vicente in Ilocos Sur, Agno in Pangasinan, Palauig in Zambales, Agusuhin in Bataan, Mananao in Mindoro, San Jose in Antique, Manukan in Misamis Occidental, Omosmarata in Basilan, Palaui Island in Cagayan, Dijohan Pt. in Bulacan, Mascasco in Masbate, Batag Island in Samar, San Francisco in Surigao del Norte, Lamon Pt. in Surigao del Sur and Lacaron in Davao del Sur.

Investment in algal culture research as a source of renewable biodiesel is also timely. It has been shown that diatom biolipids is the main feedstock of fossil fuels with 15-fold higher yield than corn (Sharma et al. 2021). Technology for commercial-scale production, however, is still in its infancy that needs massive public support (Wang and Seibert 2017).

WAY FORWARD TOWARDS A SUSTAINABLE AND INCLUSIVE BLUE ECONOMY

The Philippines has to harness better inter-agency collaboration and cooperation with a "whole of government" approach in planning and implementing a sustainable and inclusive blue economy (Azanza 2019). Priority should be given to an in-depth but facilitated review of existing laws, procedures and guidelines for gaps, redundancy and disagreements for smoother development of our Philippine blue economy and stimulate innovations and novel business investments. An inter-agency ad hoc committee to perform this review and updating should be representing the maritime industry, fisheries and aquaculture, energy sector, business and trade, science and technology, NGOs, national defense and security, and department of justice (among others), should be urgently convened by the Legislative or the Office of the President. The chair and members of the said ad hoc committee should be selected based on relevant knowledge/qualification and commitment to public service.

The need for the establishment of a separate department to focus on the integration of coastal and ocean issues and concerns and the sustainable development of our archipelagic maritime nation has been earlier recommended by the NAST (2020). The commencement of the blue economic development of the country should also involve mapping out blue economy investment (Escalona 2020). Fragmented development efforts may result in overlapping and incompatible agenda in some sites. Following the mapping of blue economic development areas is building attractive financing portfolios, e.g., blue financing schemes for aquaculture, waste management, and tourism. Debt swap for blue investments may be arranged with creditors that will encourage blue investments by international creditors. Locally, incentives may be granted to coastal industries that are investing in waste treatment plants and other pollution reducing installations (Escalona 2020). Mapping will also allow proper valuation of resources for their intrinsic and commercial values and the environmental and other risks in the area. Valuation studies may also help in the estimate of the carrying capacities of the areas to be developed and put a limit to the pressure that can be exerted to make the resource more profitable and sustainable (Azanza et al. 2017, Azanza 2019). More practical is when blue investment areas would consider Programmatic Environmental Impact Studies to mitigate or prevent long term risks.

Likewise, manpower and infrastructure development for the present and anticipated needs of the inclusive and sustainable blue economy which could be hastened by innovative public-private-academe partnerships. Climate change and other hazards and risks should be incorporated in all the action plans for the blue economy. Formal and non-formal education of the Filipinos should emphasize land ocean connectivity and interactions.

With the hope of helping the Philippines evolve into a "one archipelagic maritime nation" that is sustainable and inclusive with healthy and productive citizens on or before 2050 (NAST Foresight Report 2021) these recommendations on the Philippine blue economy are being offered and reiterated.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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