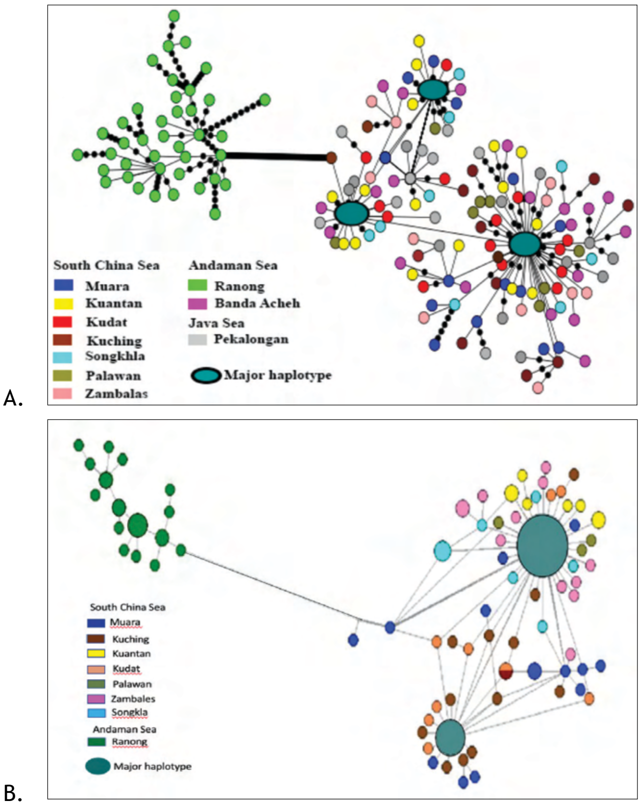

Figure 62. Minimum Spanning Network (MSN) inferred from mtDNA *Cyt b* (A) and *COI* (B) genes

- Misidentification of most common sardine species; thus, there is a need for morphologic, meristic, and molecular genetic tools to identify at the species level

Way Forward

The ongoing project of SEAFDEC/MFRDMD "Fisheries Management Strategy for Pelagic Fish Resources in the Southeast Asian Region" (2020–2024) under the JTF VI Phase II is developing the sustainable management strategy for pelagic fisheries including the fishery of sardines. For the AMSs, the Philippines as the leading sardine producer in the region through its Bureau of Fisheries and Aquatic Resources (BFAR), has initiated the National Sardines Management Plan (NSMP) 2020–2025 which envisions "A sustainable and equitably-shared sardine fishery that contributes to food security and increased income through responsible management." To contribute to this vision, the Plan aims to: 1) establish (reference points) and monitor progress with respect to biomass-based and fishing mortality-based reference points for the top three sardine species by 2023; 2) reduce juvenile catch by 10 % by 2025 in five priority sardine fishing areas by 2022; and 3) reduce poverty incidence of sardines fishers by 5 % (BFAR, 2020).

1.1.6 Marine Shrimps

In the Southeast Asian region, the economically important marine shrimps from capture fisheries include the tropical spiny lobsters *nei*, flathead lobster, slipper lobsters *nei*, banana prawn, giant tiger prawn, western king prawn, green tiger prawn, *Penaeus* shrimps *nei*, endeavour shrimp, *Metapenaeus* shrimps *nei*, and sergestid shrimps *nei*. Shrimps are mainly caught by beam trawls with relatively small mesh size, while in Brunei Darussalam and Singapore, *Penaeus* spp. are mainly caught by gill nets and trawls, respectively (SEAFDEC, 2020a).

The average production of marine shrimps from capture fisheries of the region during 2008–2019 was around 288,057 mt per year (**Figure 63**). In Fishing Area 57, the average production between 2008 and 2019 was around 95,815 mt with the highest at 118,445 mt in 2011 and lowest at 74,307 mt in 2019. On the other hand, in Fishing Area 71 production between 2008 and 2019 reached an average of 192,242 mt per year, with the highest in 2018 at 248,170 mt, and the lowest was in 2017 (157,786 mt).

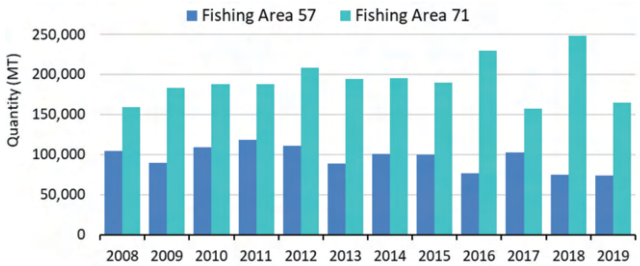

Figure 63. Production of marine shrimps from capture fishery of Southeast Asia from 2008 to 2019 by quantity (mt) (SEAFDEC, 2022)

1.1.7 Seaweeds

Seaweeds are aquatic plants that could be commonly differentiated by the predominant color of its pigments, *i.e.* red (*Rhodophyta*), green (*Chlorophyta*), and brown (*Ochrophyta*). Seaweeds have been traditionally exploited for centuries and generally collected from the wild as a source of food particularly in Asia. However, in the last 50 years, the increased demand for seaweeds and its by-products has led to the commercial exploitation and expansion of farming areas in tropical and temperate countries. The exponential increase in production of the eucheumatoid seaweeds in the Southeast Asian region has been attributed to the increased demand for carrageenan, an extract valued for its hydrocolloid polysaccharides. Carrageen-producing red algal seaweeds of the genera *Kappaphycus* and *Eucheuma* are the leading seaweeds being cultured in the region. Carrageenan is classified into three types, namely: kappa, iota, and lambda carrageenan. Kappa carrageenan is the hard-gelling type and comes from *Kappaphycus* spp; iota-carrageenan is a soft-gelling carrageenan sourced from *E. denticulatum*; and lambda is a non-gelling carrageenan usually used as a thickener in dairy products. Moreover, the red alga *Gracilaria* is known as an important source of agar. The discovery of other uses of seaweeds and its by-products other than food applications, including nutraceuticals, pharmaceuticals, and biofuels, contributed to the high demand for seaweeds.

History of Seaweed Farming in Southeast Asia

The experimental cultivation of *Kappaphycus* (=*Eucheuma*) in the mid-1960s in Tawi-Tawi, Philippines, through the collaboration between Marine Colloids Inc. and *Dr. Maxwell Doty* of the University of Hawaii has become commercial success (Doty & Alvarez, 1975). Red seaweeds with high-yielding carrageenan were identified including the genera *Kappaphycus* and *Eucheuma* which are commercially known as "cottonii" and "'spinosum," respectively. The successful cultivation of tropical eucheumatoid seaweeds was later introduced and expanded to other areas of the Philippines including Luzon, Visayas, and Mindanao. The commercial production technique in the seaweed farms in the Philippines was replicated in neighboring countries such as Indonesia and Malaysia. The simple production technique (*e.g.* vegetative planting), low production costs involved in the eucheumatoid seaweed farming, and high demand for carrageenan resulted in its commercial exploitation and introduction to other counties and regions (Ask *et al*., 2003).

The two dominant genera of red seaweeds being cultured in the Southeast Asian region are the *Kappaphycus* spp. and *E. denticulatum*. *Gracilaria* spp. is another important species of red seaweed being commercially cultivated but at a lesser production volume. The green alga *Caulerpa* spp. (sea grapes) is cultivated mainly for direct human consumption, while *Sargassum* spp. is primarily collected from the wild, thus, the production volume is lower than the cultivated red seaweeds. Factors such as availability of raw materials for seedling purposes, low labor cost, favorable weather conditions, and high acceptability of seaweed as a source of food are the several reasons for the region's emergence as the center of global seaweed production.

Among the thousands of red seaweed species, only a few genera including *Kappaphycus*, *Eucheuma*, and *Gracilaria*, have been successfully introduced to other tropical and subtropical regions (Ask *et al*., 2003). Of these, *Kappaphycus alvarezii*, *K. striatus*, and *Eucheuma denticulatum* have been reportedly farmed in over 20 countries in Southeast Asia, South Pacific, Latin America, and the Indian Ocean (Sulu *et al*., 2004; Pickering, 2006; Hurtado *et al*., 2014b; Msuya *et al*., 2014; Hayashi *et al*., 2017; Shanmugam *et al*., 2017; Alemaña *et al*., 2019). These red seaweeds are important sources of carrageenan and agar. Initially, carrageenan was extracted solely from *Chondrus crispus* (Irish moss) but was collected primarily from the wild. As the demand for carrageenan increases, the search for other sources of carrageenan has led to the exploration of tropical red seaweeds.

Seaweed Production of Southeast Asia

Seaweed farming has been considered the fastest growing industry of the aquaculture sub-sector globally with an annual growth rate of 10 percent. In 2019, FAO (2021) reported that seaweeds and other aquatic plants contributed 34.68 million mt wet weight to the world fishery production, and 96.52 percent of the total seaweed production was concentrated in Asia particularly East Asia and Southeast Asia. For Southeast Asia, the region produced 11.62 million mt or 33.52 percent of the world's seaweed production. During the last two decades, some AMSs, namely: Indonesia, Philippines, and Malaysia contributed significantly to the world production of seaweeds; while Viet Nam, Cambodia, and Myanmar were also seaweed producers (**Figure 64**).

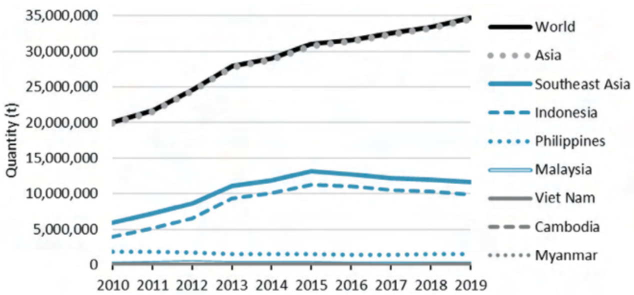

Figure 64. Production of seaweeds (including other aquatic plants) of the world, Asia, Southeast Asia, and ASEAN Member States by quantity (mt, wet weight) from 2010 to 2019 (FAO, 2021b)

Indonesia is the world's most significant contributor of aquatic plants (mostly red seaweeds) producing 9.92 million mt in 2019; and it is the only country besides China that produced over 100,000 mt of farmed *Gracilaria* (FAO, 2021b). Also, Indonesia is the world's largest producer of red seaweeds, including *Kappaphycus* and *Eucheuma*. The major production areas are located in Sulawesi, Maluku, West and East Nusa Tenggara, Northern Kalimantan, and East Java (FAO, 2018). Cai *et al*. (2021) indicated the factors that contributed to the success of the seaweed industry in Indonesia, which include 1) conducive climate conditions for tropical seaweed farming; 2) abundant suitable cultivation sites in the vast archipelago made accessible by effective community-based coastal management; and 3) large labor force in rural fishing communities looking for alternative activities to support livelihoods threatened by overfishing.

The Philippines was the largest producer of farmed eucheumatoid seaweeds from the start of its commercial production in the early 1970s until Indonesia overtook in 2008 (Bixler & Porse, 2011; Hurtado *et al*., 2014a). The seaweed production of the country reached its peak in 2011 with 1.84 million mt; however, there was a notable decline in the production in the succeeding years. Nonetheless, the country's aquaculture production has been dominated by seaweeds in recent years. In 2019, the aquaculture production of the Philippines was 2.36 million mt, and 63 percent (1.49 million mt) of this was from seaweeds amounting to around USD 250 million (BFAR, 2019). The country mainly produced *Kappaphycus* and *Eucheuma* which are processed as alkali-treated chips (ATC), semirefined carrageenan (SRC), and refined carrageenan. Also, the Philippines is the leading producer of *Caulerpa* spp. at 1,090 mt in 2019. Seaweed production has been documented in 15 of the 17 administrative regions of the Philippines. The bulk of production was recorded in the Sulu archipelago including Sulu and Tawi-Tawi Provinces with 0.70 million mt or 46.5 percent of the total seaweed production in 2019 (BFAR, 2019). Also, Region IV-B including Palawan, Zamboanga Peninsula, Western Visayas, and Central Visayas regions contributed significantly to the seaweed production of the country (BFAR, 2019).

After Indonesia and Philippines, Malaysia is the third-largest producer of seaweeds in Southeast Asia producing 0.19 million mt in 2019. The majority of seaweeds produced in the country are *Kappaphycus* and *Eucheuma*. The total area for seaweed cultivation in the country is 9,836 ha (DOF, 2019). Nearly all the seaweed production in Malaysia is concentrated in Sabah particularly in Semporma, Tawau, Kunak, and Lahad Datu as the four major seaweed growing areas.

In Viet Nam, the seaweed industry is still in the developing stage where the production volume is in limited quantity and mostly harvested from the wild. In 2019, the country produced more than 10,000 mt of *Gracilaria* (FAO, 2021b). The two main seaweeds of commercial importance are *Gracilaria* and *Sargassum* for agar and alginate processing, respectively; while *Sargassum* is mainly used as fertilizer (FAO, 2018). Seaweed processing centers are already present in the country, particularly in Haiphong, Ho Chi Minh City, and Danang.

Other AMSs including Cambodia, Myanmar, and Thailand produced seaweeds on a limited production scale (FAO, 2021b). In 2019, Cambodia and Myanmar produced 2,000 mt and 11 mt of seaweeds, respectively (FAO, 2021b). Most of the production was from the wild and mainly for local consumption. In Thailand, FAO (2018) reported that seaweed productions are mainly from *Gracilaria*, *Hypnea*, *Porphyra*, *Acanthopora*, and *Caulerpa*. Most of these seaweeds are wild-caught and in limited volume. Among these, *Gracilaria* is considered the most important species, mainly used for human consumption and agar processing. To fill the requirements for the local needs, raw and processed seaweeds are being imported from China, Japan, and Republic of Korea.

Seaweed Farming

Kappaphycus and *Euchuema* can be grown in shallow and deep-sea areas. In shallow areas, the fixed off-bottom is the most common method used, while hanging long-line, free swing, hanging basket, multiple raft-long lines, single raft long-line, spider web, and triangular are the methods used in deeper waters. The most adopted method in Indonesia, Malaysia, and Philippines are the fixed off-bottom, single floating raft, and hanging long-line (Luxton, 1993; Yasir, 2012; Hurtado *et al*., 2013). In Sabah, Malaysia, the hanging basket method is used in deeper areas. In the Philippines, the methods used to culture *Kappaphycus* that were first introduced were the fixed off-bottom, broadcast, floating bamboo, net system, and tubular net. Particularly in the Zamboanga Peninsula and Sitangkai, Tawi-Tawi, the multiple raft long lines, spider web, and free-swing are the culture methods used in deeper waters.

Problems and Challenges

Seaweeds had been in a bright spot in aquaculture production, benefiting many countries by improving the socioeconomic status of many coastal communities engaged in seaweed cultivation. However, in recent years, several seaweed farming nations, including the AMSs, have experienced a declining trend in production (**Figure 64**). Several factors have been linked to the decline in seaweed production, which include natural calamities, seaweed quality deterioration, seaweed health problems, and biosecurity issues. For the sustainability of the seaweed industry, addressing these problems and challenges should be taken into consideration.

- *Natural calamities*

Seaweed farming is usually done in shallow water areas making the farms vulnerable to fluctuating weather conditions. Natural calamities such as typhoons, earthquakes, volcanic eruptions, and drought, among others could affect the farming areas and, ultimately, loss in biomass production. These natural calamities constituted significant threats to the farming communities that rely on seaweed farming as their source of livelihood. In the last decade, typhoons had frequented the Philippines and were observed to be stronger which destroyed the seaweed farming areas around the country, and losses of income and livelihood opportunities. Unlike Indonesia and Malaysia, Philippines is located in the typhoon belt area where strong winds and storm surges happen regularly, damaging the seaweed farms and preventing production throughout the year (Valderrama *et al*., 2013; Hurtado, 2013). Also, earthquakes and volcanic eruptions can disrupt seaweed farming and operations, thereby affecting production. Moreover, changing weather patterns brought about by climate change (*i.e. El Niño* and *La Niña*) make seaweed farming in the shallow water areas more challenging as the fluctuations of environmental parameters could affect seaweed health.

- *Deterioration of seaweed quality*

Vegetative cutting or the cut and plant is the most commonly used and conventional method in seaweed farming. This method uses healthy thallus of seaweeds which is used as the seedling materials for the subsequent cropping. However, the repetitive use of this method results in the slow growth of seaweeds and makes the seaweeds "less vigor" (Hayashi *et al*., 2010) and more susceptible to diseases and pests because of the changing environment brought about by climate change.

- *Seaweed health problems*

It was reported that diseases and pest outbreaks in farmed seaweeds had resulted in decreases in production, not only in Southeast Asia but also in other major seaweed producing countries including in Zanzibar, Tanzania (Largo *et al*., 2020), and China (Pang *et al*., 2015). In the Philippines, disease and pest outbreaks and other factors resulted in yearly average production losses of 16.8 percent from 2012 to 2018 compared to its peak of production in 2011 at 1.84 million mt (PSA, 2013, 2015, 2019).

Specifically, the ice-ice disease (IID) and epiphyte outbreaks affected the biomass production and carrageenan quality of farmed seaweeds (Uyenco *et al*., 1981; Largo *et al*., 1995; Vairappan *et al*., 2008; Hurtado *et al*., 2019; Ward *et al*., 2020). The IID initially manifests gradual depigmentation or loss of color, from pinkish to whitish, notably at the primary and secondary branches, followed by softening of the thallus; and finally, the breaking off of the infected tissues from the main cultivation line (**Figure 65A**). Such breaking-off of the thallus eventually results in the loss of biomass. The recent survey conducted by Faisan *et al*. (2021) found that IID was prevalent in farms in major seaweed cultivating areas in the Philippines, suggesting that IID already affects many farming areas encompassing different cultivar farming techniques and locations. Several studies suggest that the causative agents of IID, isolated from the diseased seaweeds, are microbes including the gram-negative bacteria (*Vibrio* sp., *Cytophaga-Flavobacterium* complex, *Alteromonas*, *Pseudoalteromonas*, and *Aurantomonas*), and fungi (*Aspergillus*, *Ochraceus*, *A. tereus*, *Phoma* sp.) (Largo *et al*., 1995; Solis *et al*., 2010; Syafitri *et al*., 2017). However, these findings, in addition to the earlier report of Uyenco (1981), suggest that no particular species of microbes were associated with each incidence of IID but instead might be a combination or complex of the abovementioned microbes.

Furthermore, epiphytic filamentous algae (EFA) are red seaweeds that damage the host plant by infiltrating the cortical and medullary cells (**Figure 65B**). EFA-affected seaweeds result in tissue injury, thus allowing pathogenic microbes to infect the host plant. Outbreaks caused by EFA have been recorded in the Philippines since 1975 (Doty & Alvarez, 1975). Hurtado *et al*. (2006) described the EFA outbreaks affecting *K. alvarezii* farm in Camarines Norte, Philippines, resulting in massive losses and stoppage of culture for several years. The same results were also observed in the study of Vairappan (2006), where seasonal occurrences of mostly *Neosiphonia savatiere* infecting *K. alvarezii* farms in Malaysia.

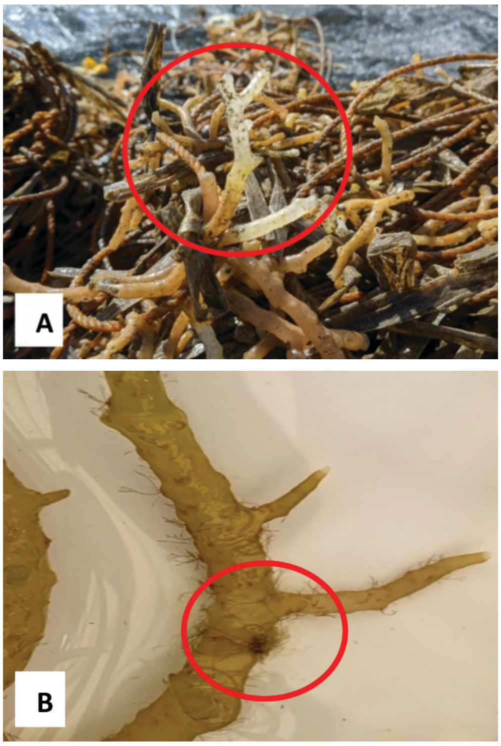

Figure 65. (A) Ice-ice disease (IID) and (B) epiphytic filamentous algae (EFA) affecting farmed eucheumatoid seaweeds (*Kappaphycus*).

Photos by JP Faisan

Seasonal occurrence of other seaweeds, such as the brown algae Sargassum, green algae *Ulva*, and red algae *Gracilaria*, could be observed to grow on the surface of farmed seaweed plants. These macro-epiphyte seaweeds are often observed either loosely attached or entangled on the main cultivating lines. The presence of these macro-epiphytes can potentially affect the growth of farmed seaweeds by competing for light and nutrients. The high prevalence of these macro-epiphyte seaweeds could also be attributed to environmental factors such as slow water movement that prevented these seaweeds from disentangling from the seaweed line or high nutrient availability due to anthropogenic eutrophication (Faisan *et al*., 2021). Certain grazing incidences could also be observed on the soft tissues at the apex of the thallus region of the seaweed plants. Often, signs of grazing are manifested by the absence of tips which is mainly related to the seasonal abundance of juvenile herbivorous fish (*e.g.*, siganids). Mechanical damage on the thallus makes the seaweed tissues susceptible to disease occurrence secondary to microbial infection. Tan *et al*. (2020) found that grazing damage to seaweeds could significantly shift the microbial community structure. Grazing incidence in farms could potentially affect biomass yields, especially on the nursey phase of cultivation where seaweeds are used for seedlings propagation.

Seaweed health problems result in major losses in terms of production yields. However, disease and pest diagnosis in eucheumatoid seaweeds at the farm level remain dependent on personal observation of the farmers, mostly unsupported by scientific knowledge or standardized guidelines (Marino *et al*., 2019; Kambey *et al*., 2020). Research on diagnostic tools to prevent the spread and outbreaks of seaweed health problems should be considered with utmost priority.

- *Biosecurity issues*

The exponential demand for seaweeds (*Kappaphycus* and *Eucheuma*) and its derivatives resulted in the introduction and commercial expansion of seaweed farms in many countries. However, the introduction of non-native seaweeds to other localities or countries inevitably resulted in the introduction of diseases and pests. Compared to other important commodities (both aquatic and terrestrial), biosecurity measures on seaweeds have been absent or not strictly implemented, from the source of the seedlings to the farm (Mateo *et al*., 2020). Policies on seaweed biosecurity have been a major constraint and lacking in many seaweed-producing countries. Although seaweeds had been a major contributor to aquaculture production worldwide, the biosecurity initiatives of the seaweeds industry, particularly in developing countries, remain lagging behind other industries of the aquaculture sub-sector (Cottier-Cook *et al*., 2016).

Concerning the global seaweed industry, Campbell *et al*. (2020) reported the significant challenges in biosecurity policies which include: 1) inconsistent terminology for the inclusion of seaweeds in regulatory frameworks; 2) limited guidance for the responsibility of implementation of biosecurity measures; 3) insufficient evidence to develop disease and pest-specific policies; and 4) lack of coherent approach to seaweed biosecurity risk management in international policies. These issues have also been reflected in the national biosecurity-related regulations and policies in Indonesia and Philippines. Both countries have similar issues in the seaweed industry and there is a need to strengthen the biosecurity policies to ensure the protection of this important commodity. Policies and legislation on seaweeds should be strictly followed and enforced to manage the risk of transboundary transfers of unchecked cultivars and decrease the risks of disease and pest outbreaks.

The inadequate legislation and policies related to seaweed biosecurity issues experienced by the seaweed industry of Indonesia include 1) unspecific allocation of seaweed aquaculture in biosecurity frameworks; 2) limited variety of biosecurity approaches; 3) limited scientific information in seaweed framework; and 4) limited guidance for the use of precautionary principle (Kambey *et al*., 2020). Also, Kambey *et al*. (2020) listed key policy recommendations to improve the national biosecurity frameworks in Indonesia, such as: 1) support further research to develop a strong evidence base, upon which national strategic decisions could be made on the management of the seaweed cultivation; 2) establish seaweed-specific regulations and policies, providing appropriate management strategies that can be effectively enforced; 3) establish national database that reports on the species of seaweeds being produced and where any pest and disease outbreaks occur, and should be followed up with regular evaluation so that the risks could be assessed by the national government and each district, where possible; 4) provide support for farmers to invest in the biosecurity management of seaweed cultivation systems including health monitoring equipment, training on management procedures, regional facilities for farmers to use for quarantine of seedlings or crop stock and surveillance systems; 5) develop risk assessment procedures for the expansion of farms into new and disease-free areas; and 6) make clarifications on the competent authority that is tasked to regulate and support the seaweed industry.

In the Philippines, Mateo (2020) highlighted the key gaps in the legislation and policies governing the seaweed industry, which include: 1) inadequate seaweed specific frameworks; 2) insufficient binding policies for seaweeds aquaculture; 3) limited biosecurity approaches; 4) absence of competent authority; 5) limited involvement of experts in framework development; and 6) insufficient guidance for the use of the precautionary principle. The updating and inclusion of these gaps in the Code of Good Aquaculture Practices for Seaweeds (GAqP-S) by the Philippine National Standards/ Bureau of Fisheries Standards (PNS/BAFS, 2017) including biosecurity protocols on disease prevention and management should be strictly implemented.

Way Forward

The repetitive use of a limited number of cultivars for planting materials in the last several decades has resulted in seaweed biomass quality and quantity deterioration. To improve the quality of seaweed plantlets, micropropagation or in vitro clonal propagation has been developed to produce large numbers of individuals in a short period (Yokoya & Yoneshigue-Valentin, 2011). Aharon Gibor did the first attempt to cultivate seaweed explants under axenic conditions in the 1950s (Polne-Fuller, 1988), while Luhan and Mateo (2017) presented a simple method of producing propagules within a shorter period in media using inorganic nitrogen compared to Grund medium or *Ascophyllum nodosum* only. Several studies in the laboratory were also conducted to renew existing stocks and to culture propagules of *Kappaphycus alvarezii* (Dawes & Koch 1991; Dawes *et al*., 1993). Hurtado and Biter (2007) used smaller sections of seaweeds for tissue culture and then for grow-out farming. The culture of seaweed microcuttings in suspension is a more efficient and cost-effective method to produce clones of *K. alvarezii* for mass production (Luhan & Mateo, 2017). Besides, research on finding seaweed cultivars or strains from the wild populations and their progenies as a new source of planting materials is being developed (Luhan & Sollesta, 2010; Hinaloc & Roleda, 2021).

The full potential of seaweed farming in the AMSs has not been fully tapped as offshore areas of many countries are potentially emerging production sites for farming. Also, the inclusion of seaweeds in the integrated multi-tropic aquaculture (IMTA) system in offshore locations has been explored (Buck *et al*., 2018), potentially maximizing the benefits and production yields. In addition, the use of large-scale seaweed aquaculture as a tool for carbon sequestration to reduce the impacts of climate change has been recently advocated (Duarte *et al*., 2017). The SEAFDEC Aquaculture Department (SEAFDEC/AQD) has been an active partner in supporting the development of seaweed aquaculture by carrying out research and innovation activities. SEAFDEC/AQD is providing quality seaweed plantlets to seaweed growers in the Philippines, and in addition, it also provides technical support through online seminars and on-site training sessions that cater to the needs of seaweed stakeholders.

1.2 Challenges and Future Direction

In the Southeast Asian region, the productivity of the marine fishery resources comes from fishing activities either within or outside the exclusive economic zones (EEZs) of the respective countries or in high sea areas. Although the contribution of the harvests from marine fishery resources from the AMSs overall, has continuously increased during the past decades, the stock status of several commercially exploited marine species has been of major concern. This is especially true for marine pelagic fishery resources that migrate across waters of several countries and into the high sea areas, the management of which requires close cooperation among the concerned countries and with relevant international/regional organizations. In addition to the pelagic species, other important marine fishery resources that are exploited by countries in the region include the demersal fishes, reef fishes, crustaceans, mollusks, and seaweeds, which also require management interventions to ensure their sustainable utilization. Efforts to ensure the sustainable utilization of marine resources should therefore be continued and further intensified by the AMSs to make sure that the productivity of these marine fishery resources would continue to substantially contribute to achieving the target of the UN Sustainable Development Goals (SDGs) in particular the SDG 14: "life below water" which stipulates the ambition to "*conserve and sustainably use the oceans, seas and marine resources*." Therefore, to ensure the sustainable utilization of the marine fishery resources, the following aspects should be considered by the concerned AMSs, and relevant institutions and organizations:

Supporting the management of highly migratory species in cooperation with relevant RFMOs

- Management of oceanic tunas is currently undertaken by relevant RFMOs, *e.g.* the IOTC in the Indian Ocean and the WCPFC in the western and central Pacific Ocean, while the management of neritic tunas and some tuna-like species are also covered by the IOTC. The development of management recommendations for species under the competence of the RFMOs is undertaken through the data collection schemes of the respective organizations. While countries that are members of the respective RFMOs are already complying with their regulations, countries that are non-members have been encouraged to also cooperate as non-contracting parties to ensure sustainable utilization of the marine fishery resources in such RFMO areas.

- Other relevant international/regional organizations and institutions should also consider continuing their support through the conduct of stock and risk assessments of neritic tunas and tuna-like species in the Southeast Asian region. In cases where such organizations do not have specific management mandates, the results of their efforts should be conveyed to the relevant RFMOs, *e.g.* the results of the stock and risk assessments of some neritic tunas and tuna-like species undertaken by SEAFDEC in collaboration with concerned AMSs.

Improving data collection and stock assessment on marine fishery resources

- The AMSs should continue to improve their respective systems of long-term data collection on the status and production trend of major commercially important species, *e.g.* statistics on catch/landings of important marine species including the data from fishing logbooks, statistics on fishing efforts, data on catch per unit effort (CPUE), among others, as these are necessary to support the efforts in carrying out stock and risk assessments of such species.

- Relevant international/regional organizations should also consider enhancing their activities related to the development of appropriate methodologies/models, and extending the capacity building to the AMSs on stock assessment of major species under the data-poor situation of Southeast Asia, the appropriate reference points for multi-species fisheries of the region, as well as the appropriate methodologies and techniques for population genetics study. The results of these efforts are necessary to support the development of appropriate management plans of such resources.

- The AMSs and concerned agencies and institutions should consider establishing collaborative arrangements, especially with respect to undertaking studies on important shared stocks or migratory species, *e.g.* species distribution, life cycle, migration, stock assessment, genetics, among others, considering that one country alone could not come up with the complete information on such particular species.