Box 15. Management strategies employed by some AMSs to reduce food loss and waste *(Cont'd)*
... to recognize the efforts of companies that adopt food waste valorization solutions as well as raise awareness of the concept. Through this award, Singapore seeks to encourage more organizations to adopt and develop similar food waste valorization solutions by recognizing companies that engage in the conversion of food waste, such as homogenous by-products, rejects, and mixed food waste into products that contribute to a sustainable economy. One example of waste valorization in Singapore's fishery supply chain is the use of grey mullet offcuts (head, bones, and trimmings left after processing into fillets) to make soup (Tan & Liu, 2020). In the area of distribution, Singapore minimizes food loss and waste by requiring food establishments to employ appropriate cold chain requirements to ensure food safety, as part of the licensing requirements. To assist the industry, the new Singapore Standards for Cold Chain Management of Chilled and Frozen Food to Assure Food Safety and Quality was published in October 2021 with the intention to strengthen cold chain ecosystem by setting out the General Requirement and Code of Practice for management of chilled and frozen food including seafood. The guide on Good Handling Practices and Cold Chain Guide for Chilled Seafood was also developed by the Singapore Food Agency (SFA) which includes guidelines on temperature control, processing and packaging, transportation, and display for sale to ensure the quality and safety of chilled fish and seafood to minimize losses. An example of this implementation is the e-commerce retailer Redmart which delivers fresh produce to consumers by utilizing normal delivery trucks, but the trucks are lined with reusable insulation and industry-grade ice plates that can be refrozen after each use to maintain the optimum temperature (Neo, 2019). This maintains the cold chain process during delivery and reduces potential food loss when delivered to consumers. For consumption stage, the Food Waste Reduction outreach program in 2015 of NEA aimed at encouraging the adoption of smart food purchase, storage, and preparation habits, helps consumers save money while reducing food wastage at source (NEA, 2020). Educational materials have been publicized on print and social media platforms, and Food Waste Minimisation Guidebooks were published in 2017 for food retail establishments, supermarkets, and food manufacturing establishments to reduce food waste across the supply chain.
Thailand: Majority of fish catch of the country is intended for human consumption, and the remainder is mainly utilized to produce feeds and fertilizer. Higher quality fish are used for human consumption while lower quality fish are used to produce feeds, and fish of the lowest quality are used for fertilizer. Since all parts of fish are utilized to produce either food or non-food products, there is rarely food loss and waste in the fishery supply chain. Nonetheless, the key stage that generates the most food loss is postharvest after production and before processing due to ignorance of low temperature control during handling. To minimize food loss and waste in the fishery supply chain, the country has invested in automation process and use of traceability systems during production stage. For processing, traceability systems are also being implemented. For distribution, better logistics and transportation, packaging, and usage of information technology to monitor temperature during distribution, are meant to reduce food loss. For consumption, educated retailers and consumers, and higher consumer awareness have helped to reduce food waste.
Viet Nam: Under Resolution 48/2009/ NQ-CP, the government set the target of reducing the rate of aquaculture postharvest losses from 20 % to 10 % in 2020 (APEC, 2018). This target would be achieved through building aquaculture ponds equipped with advanced equipment to limit risks caused by environmental impacts such as weather and epidemics, and improvement of freezing preservation technology (Ministry of Agriculture and Rural Development, 2009). In addition, the government has also enacted a policy to provide financial incentives for businesses, farmer cooperatives, and farmers for investment in agricultural facilities such as freezers to reduce postharvest losses.

5.1.3 Food Safety from Marine Biotoxins

Potential hazards in aquaculture can be broadly classified into biological hazards and chemical hazards. Common biological hazards are bacterial pathogens (*e.g. Salmonella* spp., *Shigella* spp., *Vibro* spp., listeria monocytogenes, and pathogenic strains of *Escherichia coli*), parasites (*e.g.* trematodiasis, cestodiasis, and nematodiasis), and viruses (*e.g.* Norovirus, Hepatitis A virus). The primary chemical hazards for aquaculture products include veterinary drug residues, agri-chemicals (*e.g.* pesticides, herbicides, fungicides, disinfectants), heavy metals, persistent environmental contaminants (*e.g.* organochlorine compounds like PCBs and dioxins), and naturally occurring biotoxins (*e.g.* marine biotoxins, scombrotoxins). These hazards are usually associated with the farming system and management, aquaculture habitats and practices, the species being farmed or caught, environmental conditions of the farming sites, and cultural habits of food preparation and consumption. Control measures have been established to address the potential risk from marine biotoxins and scombrotoxins in the context of intensifying climate change, growing population, and wide-spreading environmental pollution.

Over the recent decades, increasing eutrophication, warmer seas, ocean acidification, and food web modifications resulting from overfishing and other factors, have led to increased prevalence of harmful algal blooms (HABs) globally. These algal species can be broadly classified into microalgae (unicellular organisms) and macroalgae (multicellular, also called seaweeds), and together they produce more than half of the oxygen in the earth's atmosphere. The occurrence of algal blooms denotes an increase in the abundance of a single (or more) algal species in each area and the growth reaches bloom proportions when a series of environmental factors occur in synchrony—temperature, salinity, light, turbulence, availability of micro- or macronutrients, availability of trace elements, and in the case of microalgae, interactions with populations of marine bacteria, viruses, and algal grazers. Moreover, a growing interest in increasing aquaculture and mariculture facilities to meet the increasing demand for food has brought with it significant food safety concerns related to phycotoxins caused by the proliferation of HAB species, as consumption of seafood and fish is the primary route for exposure to phycotoxins (algal toxins) in humans. HAB phycotoxins may bioaccumulate in fish and shellfish that can induce toxic syndromes in humans who consume them, with symptoms ranging from skin, eye, or ear irritations to more severe reactions such as liver and kidney damage and gastrointestinal, cardiovascular, respiratory, and neurological conditions.

Another worrying trend is the expansion of several HAB-forming species which have enlarged their geographic ranges over time. A well-known example is that of the causative species of paralytic shellfish poisoning (PSP) *Alexandrium tamarense* and *A. catenella*., which have caused blooms mainly in the temperate coastal regions of Europe, Japan, and North America in the 1970s. In the last 20 years, these species have made their way into the Southern Hemisphere, forming toxic blooms off the coasts of Australia, New Zealand, Papua New Guinea, and South Africa as well as reaching off the coasts of Brunei Darussalam, India, Thailand, and Philippines. Moreover, microplastics have also been implicated as potential carriers of HAB species in the marine environment. With climate change expected to affect the distribution of microplastics in the oceans, how this phenomenon translates into changes in the geographic expansion of HAB species remains to be investigated as it is already a worrying trend.

At present, no routine diagnostic tests are available for HAB-associated poisoning in humans, and clinical diagnosis is based largely on symptoms presented and dietary history. There are also no known antidotes for many of these toxins, making symptom management the only care available to those suffering from the painful toxic effects. In view of this, monitoring seafood for toxicity is essential to manage the risks together with adequate regulations to ensure that the design and implementation of appropriate monitoring and mitigation measures would be able to control HABs and prevent negative health effects and economic losses worldwide. Hence, the monitoring of seafood for marine biotoxins is urgently necessary by adopting surveillance programs to check the levels of toxic phytoplankton. Such a concern reflects the growing urgency of preventing and mitigating HABs occurrences, which is essential to manage possible risks.

Initiatives for Monitoring Marine Biotoxins and Scombrotoxins

In order to better manage the public health risks associated with the consumption of contaminated seafood products in the Southeast Asian region, SEAFDEC/MFRD had launched multiple initiatives to help AMSs to detect, monitor, and share information on marine biotoxins detection. The training sessions organized by SEAFDEC/MFRD (since 2004–2019) had covered a wide range of topics, like the detection of heavy metals, pesticide residues, drug residues, and marine biotoxins and scombrotoxins in aquaculture products. The most recent training activities, that had been customized based on the feedback and requests by the AMSs (2009–2019) focused on marine biotoxins, covering Diarrhetic Shellfish Poisoning (DSP) toxins, Paralytic Shellfish Poisoning (PSP) toxins, Tetradotoxin (TTX), Amnesic Shellfish Poisoning (ASP) toxin (domoic acid), Azaspiracid (AZA) toxin, Brevetoxins (BTX) which causes Neurotoxic Shellfish Poisoning (NSP), as well as algae identification techniques. The overall objectives of these training activities are to equip the AMSs with essential knowledge and laboratory capabilities on aquaculture safety, with which the AMSs would be able to establish monitoring programs to assess the occurrence of the hazards in their countries. As many AMSs are also major exporters of fishery products to the global market, it is therefore essential to enhance the countries' marine biotoxins detection capabilities to facilitate a stable agri-trade and the economic growth of the countries.

Besides the programs mentioned above, the ASEAN community has also established the ASEAN Food Reference Laboratory (AFRL) for Marine Biotoxins and Scombrotoxins under the purview of the ASEAN Food Testing Laboratory Committee (AFTLC), which is under the Prepared Foodstuff Product Working Group (PFPWG) overseen by the Economic Community sector of the ASEAN. The AFRL for Marine Biotoxins and Scombrotoxins is the 10th AFRL established in 2019 and is currently being hosted by the National Centre for Food Science (NCFS) of the Singapore Food Agency (SFA) under the Foodborne and Natural Toxins team, and with a multi-disciplinary team of scientists and advanced analytical facilities. To date, it has established testing capabilities of over 35 marine biotoxins as well as scombrotoxin and is accredited under ISO/IEC 17025, the testing methodologies are benchmarked with the world's leading reference laboratories (*e.g.* EU reference laboratories for marine biotoxins) and through the participation in proficiency tests (PTs) organized by internationally recognized PT providers. Currently, this AFRL is conducting a survey to solicit interest by the AMSs on proficiency and training activities to commence in 2022 in this specialized food safety area.

5.2 Challenges and Future Direction

Fishery resources have been harvested and utilized for human consumption as well as for non-food purposes. Although the proportion of utilization of fish (and other aquatic species) for human consumption has increased over the years, which could be a result of the technologies developed for reducing food losses and wastes, as well as for preservation and processing of fish catch, it is still necessary for the countries in the region to continue developing and improving their fishery products to meet the changing market demand. One of the important issues on the utilization of fishery resources is to ensure the safety and quality of fishery products by enhancing the capacity of countries to comply with quality assurance systems, such as the HACCP, GMP, among others, in processing establishments as appropriate, availability of accredited laboratories to detect contaminants in food products, *e.g.* chemicals, antibiotics, as well as biotoxins that are subjected to trade regulations, and the application of cold chain management throughout the fishery supply chain from catching/harvesting until reaching the consumers.