

the species and/or genetic stock structure and diversity either for conservation, stock management, or selective breeding. At SEAFDEC/AQD, research initiatives on genetics and selective breeding, in particular, began in the mid-1980s, with funds from the International Development Centre of Canada (IDRC) under a regional network, then referred to as the International Network on Genetics in Aquaculture (INGA). SEAFDEC/AQD embarked on a farmer-friendly tilapia mass selection scheme while the other Southeast Asian countries under INGA, conducted family selection and/or combined family and within family selection methods to improve farmed Nile tilapias and Asian carps. No region-wide genetic improvement project has been conducted since thence. Genetics, especially genomics, has been applied extensively in several aquaculture research areas, *e.g.* from nutrition to fish health management and ecological (*e.g.* climate change) studies. Current applications cover nutrigenomics, immunogenetics, molecular marker-based disease diagnosis, and researches that require an understanding of aquatic organisms' resiliency towards environmental stressors through 'omics (transcriptomics, etc.) principles. Recently, interest in gene editing as applied in tropical aquaculture species such as tilapia has been noted. Since such studies require advanced technical/laboratory skills and equipment, major research funds are needed to support infrastructure and capacity building. In the Philippines, several aquaculture genetics/genomics projects have been undertaken with support from the Philippine Department of Science and Technology (DOST) apart from the Department of Agriculture's Biotechnology Program. Several of the DOST projects which started a decade ago were initiated with SEAFDEC/AQD as one of the cooperating agencies, together with major academic institutions such as the University of the Philippines and several private universities. The milkfish genetic diversity studies were part of this program (Romana-Eguia *et al.*, 2019). However, currently, the DOST has prioritized the provision of funding support to the academic institutions which have continued these genetics/genomics-based researches, *e.g.* on mud crab, milkfish, oysters, and seaweeds.

Therefore, SEAFDEC need to reinforce linkages and collaborate or form research networks among its Member Countries as well as come up with comprehensive genetics/genomics programs towards the improvement of priority species in aquaculture, targeting important traits such as fast growth, disease resistance, and climate resilience.

7.1.8 Traceability of Aquaculture Products

The Codex Alimentarius Commission (2004) defines traceability or product tracing as 'the ability to follow the movement of a food through specified stage(s) of production, processing, and distribution.' Traceability has become an important tool to deal with issues that are associated with food safety and quality assurance to prevent risk and gain consumers' support. Traceability has now

become a common feature for the international trade of fish and fishery products. The strengthened ties between countries across the globe have encouraged and facilitated bilateral trade. In trade, records of traceability are used as proof of compliance to food safety, biosecurity, and regulatory requirements. These records also ensure that quality and other contractual requirements are fulfilled. In situations such as a food recall, a robust traceability system will allow efficient tracking of affected products through the supply chain.

The AMSs also export a significant volume of aquaculture fish and fishery products annually to regional and global markets. As traceability becomes a trade requirement for eligibility to export aquaculture products to major markets such as Japan, the European Union (EU), and the United States of America (USA), establishing reliable traceability systems is important for the sustainable development of the aquaculture industry in the Southeast Asian region. To tap into demand for aquaculture fish, several large-scale aquaculture companies in the region can comply with the stringent export requirements. Governments and organizations have also been developing different systems on seafood traceability such as TraceFish of the EU and TraceShrimp of Thailand.

Other than the strict regulatory requirements, stress from the general public has led to businesses implementing traceability systems for aquaculture products. A new generation of educated consumers with a higher level of awareness has driven increasing market demand for food safety, security, and sustainability for aquaculture products. Consumers are also becoming more cautious of the food they eat—whether the food is from a safe and sustainable source, and whether production, transportation, and storage conditions can ensure food safety and quality.

Traceability is a component of a food safety management system and it helps to ensure the safety and quality of aquatic organisms in the aquaculture supply chain and verify that they are farmed in accordance with national or international management requirements or to meet national security and public safety objectives. Traceability should provide the linking of vital information across each stakeholder to ensure that the products can be traced effectively. By implementing a traceability system that includes keeping proper records throughout the supply chain of aquaculture products, transparency of product information is guaranteed for all stakeholders. This allows a greater sense of security to consumers who are at the receiving end of the supply chain. Reliable information and comprehensive documentation also allow timely information sharing as well as prompt and effective intervention by relevant competent authorities should problems arise. In times of massive aquaculture, product recalls, traceability system implemented allows timely identification of batch affected or stakeholder involved along the supply chain. Thus, traceability enables prompt verification of records, and through the effective

identification of the root causes of food recall incidents, the impact could be minimized.

Regional Guidelines on Traceability Systems for Aquaculture Products in ASEAN region

In 2017, the Regional Guidelines on Traceability System for Aquaculture Products in the ASEAN Region was developed in consultation with the AMSs, namely: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam. The Guidelines recommend that the countries should establish/promote and maintain records, both individually and regionally through an integrated approach, that are sufficient to identify the immediate previous sources and immediate subsequent recipients of the aquaculture products (Box 37). The documented information should be archived and kept for at least two years.

National and Regional Initiatives

The implementation of traceability of aquaculture products differs among the AMSs. Some countries are major exporters, like Thailand (shrimps) and Viet Nam (catfish and shrimp), and they have begun the implementation of traceability systems for aquaculture products. Although

traceability implementation is mandatory or voluntary depending on governmental or private sector initiatives or obligations, traceability has now become a common feature in the international trade of fish and fishery products, hence, there is an urgent need for all countries to implement traceability systems in their respective aquaculture industry. Also, some countries already have their traceability systems in place and have established a certain degree of the legal framework as well as computerized or electronic traceability systems to track the aquaculture products from farm to fork. This allows them to export their aquaculture products to countries like those in the EU and USA. The status of implementation of traceability systems of aquaculture products in the AMSs is listed in Box 38.

Issues and Challenges

Among the difficulties faced by the region are the differing traceability systems for aquaculture products among the AMSs. Some countries already have in place a robust traceability system that permits them to export aquaculture products to European Union (EU) or the United States (US) and have established a certain degree of the legal framework as well as advanced computerized traceability systems to track their aquaculture products from farm to fork. However, some AMSs are still in the process of

Box 37. Regional Guidelines on Traceability System for Aquaculture Products in ASEAN region
Feed producer: Member States should establish and maintain effective record-keeping practices as early as from the fish feed used. Regardless of the source of aquaculture products, be it locally reared in fish farms or imported from foreign sources, feed mill-related information should be identifiable upon tracing. The feeds product traded should be identified as the TU.
Distributor: the Member States should adopt an integrated approach to the development, maintenance, and updates of record-keeping pertaining to the distributions and movement of aquaculture products-related activities. Distributors are known to be responsible for the distribution of bulk sales or bulk auctions, particularly with feeds involved as the TU from feed miller down the supply chain.
Hatchery: Member States should recognize the importance of hatcheries, where it involves the receiving of the seeds of aquaculture product and subsequent grow out into fish seedlings or fish fry as a new TU. This could range from a few thousand to several hundred thousand fishes being passed down the supply chain.
Chemical supplier: the Member States should establish and maintain information and records associated with materials used that are from external sources to the main domain of the supply chain. The identified TU could be the supply of the various chemical substances or supplements at the receiving end, <i>i.e.</i> the different stakeholders such as fish farms and fish processing plants.
Farm: Aquaculture products within the region could be raised from fingerlings or seeds bred at the hatchery or through imports from the hatchery for better quality control. Member States should establish legal frameworks, laws, and regulations to ensure farms or hatcheries comply with regional guidelines or global standards in farming activities. Locally reared aquaculture products with commercially acceptable or marketable size are the common TU identified.
Middlemen: the Member States should be aware of a number of tiers of “middlemen” -within the aquaculture supply chain. Reared aquaculture products with commercially acceptable or marketable sizes from the fishermen or farms are the common TU identified.
Processor: the Member States should establish/promote and maintain legal framework and regulations for the processors to follow as the processing of aquaculture products are performed differently in the ASEAN region, either through processing plants and establishments or direct processing at the fish farms. Processed aquaculture products are the common TU identified.
Retailer: Retailers should be recognized as the suppliers to the public or consumers, not to other stakeholders upstream of the supply chain. Member States should establish laws and regulations for retailers to follow, particularly inaccurate record-keeping, since they are likely to break down the TU received, package, label, or modify the nature of the aquaculture products before marketing the products. The immediate TU could be in the form of processed aquaculture products or packaged aquaculture products with appropriate labeling.
Exporter: Exporters trade and sell processed or unprocessed aquaculture products as TU to other businesses where they do not alter the nature of the TU. New TU could be created if other stakeholders are at the receiving end where the TU could be broken down, processed, and modified. Member States should enforce and ensure accurate documentation and communication of information throughout the production chain given that the exporter is either positioned at the end of the chain or the beginning of another chain with their TU exported.

Box 38. Status of traceability systems for aquaculture products in the Southeast Asians region

Brunei Darussalam: Three private companies are engaged in traceability systems in shrimp farming. Each shrimp farmer maintains their records of the date of stocking, feeding, and harvest. The country is also the sole supplier of blue shrimp fry which are cultured in different private companies and harvested and sold to local shrimp buyers for the domestic market or to big processing companies that also operate shrimp hatcheries in the country.

Cambodia: Aquaculture production mainly supplies the local demands. With increasing aquaculture demand and production, the Fisheries Administration (FiA) had introduced the Aquaculture Technical Guideline including the list of banned chemical components for aquaculture activities to improve its effort in adopting good aquaculture practices (GAqP), and to ensure the safety and quality of the country's aquaculture products. Training on GAqP is provided to fish farmers and model farms had been selected for GAqP recognition. Although the implementation of GAqP is tedious and involves high costs, some fish farmers understand that the safety of farmed fish is a priority and is preferred by local customers.

Indonesia: In order to meet market demands related to traceability, the Ministry of Marine Affairs and Fisheries (KKP) is currently developing a National Fish Traceability and Logistics System (STELINA) to ensure the traceability of fish, supply chains, and fishery products electronically by integrating information systems including fishing, cultivation, distribution, processing, and marketing. STELINA is expected to be a link of information from upstream (production) to downstream (processing and market). Testing of the STELINA application prototype has been carried out in several locations, namely in Bitung in 2019, and at 2 (two) UPLs in DKI Jakarta and Bali in 2020. The test was carried out to get a picture of the implementation and testing of the real readiness of STELINA implementation in the field. In general, the trial results recommended the need to formulate the STELINA regulatory regulations and develop applications in accordance with the fisheries business processes in Indonesia. For the aquaculture sector, a pilot project is being implemented with the integration of the Indonesia Good Aquaculture Practices (IndoGAP) into the STELINA application in Banyuwangi Regency, East Java.

Lao PDR: The traceability system for aquaculture in Lao PDR has yet to be implemented, but the focus of such implementation is on import, export, and transit of commodities, as well as inspection at the country's International Checkpoint before the commodities, could enter Lao PDR.

Malaysia: Traceability systems include Traceability Form BP-DJ01 for farmed shrimps in ponds, Certificate of Origin (COO), Health Certificate, and coordination between the MAQS Department and the Royal Malaysian Customs. Apart from the issuance of health and origin certificates, the Department of Fisheries Malaysia is also responsible for issuing the Declaration of Import and Export of Shrimp to the United States (Form DS 2031) which is a mandatory condition for shrimp to enter the United States. The use of this traceability form has been successfully implemented to curb the export of transshipped frozen shrimps from other countries through Malaysia to the United States market. Export control through the declaration of traceability forms has also helped to restructure the local shrimp farming industry from the jeopardized disruption of trade of the Malaysian major shrimp importing countries.

Myanmar: Under the supervision of the Aquaculture Division of DOF Thailand, the Aquatic Animal Health and Disease Control Laboratory apply the PCR technique for testing live aquatic animals and products for export and import. For fish, tests are performed to detect the koi herpes virus, red sea bream iridovirus, viral nervous necrosis, spring viraemia of carp, tilapia lake virus. For crustaceans (shrimp, crab, etc.), the tests are done to detect white spot syndrome virus, taura syndrome virus, yellow head virus, infectious hypodermal and hematopoietic necrosis virus, hepatopancreatic parvo-like virus, infectious myonecrosis virus, early mortality syndrome, *Macrobranchium rosenbergii* nodavirus/extra small virus) following the OIE guideline.

Philippines: Traceability of aquaculture fishery products is being supervised by BFAR which implements programs and activities that enhance and strengthen the said products' traceability systems. BFAR Administrative Circular Order No. 251 of 2014 on traceability system for fish and fishery products requires documentation of traceability for wild-caught, farmed fish, and other aquatic products, in the aquaculture supply chain which is divided into three main groups, namely: 1) pre-production (hatchery/nursery, feedmill/aquatic veterinary products); 2) production (grow-out farm), and 3) post-harvest (auction market, transport, processing establishment, cold storage, shipment). Each of these stages of the supply chain requires a documentation system for traceability.

Singapore The Singapore Food Agency (SFA) is the national authority for aquaculture development including licensing all marine food fish farms and land-based farms. The SS670: 2021 Specification for Good Aquaculture Practice was published in 2021 to provide guidance to local agricultural farms on a holistic approach of farm management in the areas of food safety, produce quality, environmental management, workers and animal health, safety, and welfare as well as traceability of aquaculture products. In response to changes in consumers' preferences, some local farms are value-adding their aquaculture products. Harvested fish are sent to SFA-licensed fish establishments or processors for further processing into fillets before being sold to retailers such as supermarkets. For the processing of RTE fish slices, the SFA-licensed fish processors are required to implement Safety Management System (FSMS) equivalent, e.g. HACCP, ISO which includes traceability systems.

Thailand: An electronic traceability system has been in development for effective tracking of fish and fishery products in the entire supply chain from the origin of harvesting to the end processed products. It is achieved by means of identification and recordkeeping through the certification divisions/traceability system of DOF Thailand, namely: 1) Fisheries Map, 2) GAP Standard Certification, 3) Fishery Product Health Certification, 4) Animal Health Certification, 5) Thai Flagged Catch Certification (TFCC), 6) Movement Document (MD), 7) Purchasing Document of Aquatic Animal (E-APD), and 8) Fisheries Single Window.

Viet Nam: Farmed aquatic animals are managed by three agencies. The stage from stocking to harvest is managed by the Directorate of Fisheries (DoF) under the Ministry of Agriculture and Rural Development, the stage from harvest to processing is managed by National Agro-Forestry-Fisheries Quality Control Department, and lastly, the stage from goods on sale in the market to consumers are managed by Ministry of Industry and Trade. However, there is difficulty in tracing the origin of a product being on sale in the market back to the processing factory, farm, unit/individuals supplying inputs for production, as this requires linkage among several agencies. Moreover, the National Standard on Good Aquaculture Practices in Viet Nam (VietGAP) is a comprehensive solution for controlling the quality of input materials, maintaining the good health of aquatic animals, and ensuring a better life for laborers and farmers, while also ensuring the integrity of the environment and easy traceability to complete profile system. VietGAP is a single aquaculture module that complies with existing legislation and allows the application of VietGAP standards to different species, as well as applying it on the growing stage to postharvest stage. VietGAP documentation includes 5 parts, namely: General requirements on legal documents; Food safety; Animal health and welfare; Environmental integrity; and Socioeconomic aspects.

implementing traceability systems and enhancing their capabilities of building up a legal framework for traceability implementation and introducing traceability systems to the industries through government support such as regulatory enforcement, education, and training. Despite the progress made, the aquaculture industry, particularly its small-scale stakeholders are still facing some concerns and difficulties. With these challenges faced, there are some framework and technological recommendations that could aid in improving the traceability implementation. Some examples of challenges and recommendations are shown in **Box 39**.

7.2 Challenges and Future Direction

Aquaculture production from many countries in Southeast Asia has been increasing during the past decades. Specifically, in 2019, the contribution of aquaculture to the region’s fisheries production was reported to be more than one-half of the region’s total fisheries production. The productivity of the aquaculture sub-sector had been derived from the culture of various commodity groups, e.g. finfishes, shrimps, crustaceans, mollusks, seaweeds, at various scales and levels of intensification. Although aquaculture has provided the necessary inputs that augment the region’s total fisheries production as the contribution

from capture fisheries has decreased after encountering various issues and challenges due to the decline in fishery resources, aquaculture has also been confronted with various challenges, particularly from the emerging disease outbreaks, high cost feeds and continued dependence on fish-based ingredients for aquaculture feeds, limited technologies that are environment-friendly and adoptable by aquafarmers at various levels and scales, as well as the requirements for good quality and safety of aquaculture products, and traceability to comply with requirements of importing countries. It is, therefore, necessary for the AMSs to continue addressing such issues and challenges in order that the aquaculture sub-sector could continue to grow and contribute to food security, income generation, and socioeconomic development in the future. Efforts to ensure the sustainable development of aquaculture would also make substantial contributions towards achieving several SDGs, particularly SDG 1: No Poverty, SDG 2: Zero Hunger, SDG 12: Responsible Consumption and Production; and SDG 14: life below water. Therefore, to ensure the sustainable contribution of the aquaculture sub-sector to the economic development of the Southeast Asian region, the following considerations should be taken into account by the AMSs and relevant institutions and organizations:

Box 39. Issues/challenges and recommendations on traceability system in Southeast Asia

Lack of resources

Issue/challenge: In the region, the aquaculture supply chain is dominated by individual small-scale stakeholders (*i.e.* hatcheries, feed mills, farmers, middlemen). The small size and limited income of these small-scale stakeholders mean that incorporating record keeping (the main component of traceability system) will entail higher operating processes and more manpower, which requires funds that small-scale stakeholders lack.

Recommendation: Local competent authorities may encourage paper documentation by providing templates of records in local language for each stage of the aquaculture supply chain (*i.e.* hatcheries, feed mill, farmers, middlemen, buying stations/ collection centers, processing plants, and retailers). Stakeholders could also jointly purchase simple equipment or technology to assist them in data keeping such as barcode printers and readers which could help to reduce the overall cost of a traceability system for individual stakeholders.

Lack of awareness

Issue/challenge: Limited knowledge of the benefits and advantages of having a traceability system in aquaculture operations. Some operators may also be averse to changes and in implementing new processes and traceability systems for their business operations.

Recommendation: Transfer of knowledge and technology to various stakeholders via relevant competent authorities, such as through a series of workshops, roadshows, and training courses, should be enhanced. The approach should strategically cover each province and the message should be to reiterate the fundamentals of traceability and its importance to their business endeavors. Information, education campaign through flyers and other forms of reading materials written in the local language is also an effective tool.

The complexity of the supply chain

Issue/challenge: The presence of diverse stakeholders throughout the supply chain, as well as the processing and free trading, could result in the mixing of raw materials and end products. The absence of cooperatives to manage these stakeholders will form a complex supply chain framework which makes it more difficult to implement a traceability system.

Recommendation: Government should consider registering and licensing middlemen. Training and dialogue sessions may be arranged to educate middlemen on proper record keeping and handling of aquaculture products.

Legal framework

Issue/challenge: The necessary legal framework to enforce traceability in the aquaculture industry is limited. Without the legal framework, various stakeholders will lack the motivation and incentive to implement a traceability system in their operations. Additionally, the lack of technical guidance and assistance could prevent the successful implementation of a traceability system. Unestablished documents and record details of aquaculture products also make it more difficult for small-scale stakeholders to adopt the traceability system.

Recommendation: Local governments could develop a legal framework complete with guidelines and models to aid the adoption of traceability by the various stakeholders. Under this legal framework, each of the stakeholders must be properly registered and licensed in order to partake in the trade within the aquaculture supply chain. To support the enforcement of the new legal framework, it is important for the government to build up its capabilities (*e.g.* establish a department to be in charge of ensuring proper implementation, as well as conducting audits for traceability systems).