FISH for the PEOPLE

A Special Publication for the Promotion of Sustainable Fisheries for Food Security in the ASEAN Region

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SEAFDEC at 49:

Continuing Support for the Sustainable Development of Inland Fisheries in Southeast Asia

Southeast Asian Fisheries Development Center

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Editorial

In Southeast Asia, inland fisheries which include the inland capture fisheries and aquaculture sub-sectors had been rapidly expanding during the past decades. Generally practiced as backyard or village fisheries and carried out in a traditional way, inland fisheries has always been dubbed as protein source provider for the rural populace and one of the major contributors to national economies, and has been sustaining the livelihoods of peoples in rural communities. Specifically for inland capture fisheries, statistical records during the past 20 years showed that its production had been substantially increasing, although at slower annual average increase rate of about 4% compared with that of marine capture fisheries and aquaculture. Nevertheless, the inland capture fisheries sub-sector needs to be monitored to ensure that inland resources are utilized in a sustainable manner.

While inland capture fisheries utilize the inland resources with open access and where people harvest wild fish stocks, in aquaculture fish farmers have the control over the cultured species and the culture environment. Cutting across these two sub-sectors is culture-based fisheries, which had been substantially developing recently in countries with abundant inland water bodies, and in land-locked countries such as Lao PDR. FAO defines culture-based fisheries as capture fisheries operated in water bodies that have been stocked with seeds from aquaculture operations, and encompasses enhanced fisheries that are operated in water bodies where recruitment of aquatic organisms had been supplemented or sustained in order to enhance production. In many Southeast Asian countries, culture-based and enhanced fisheries also form part in their fisheries production systems, and thus, should also be monitored in terms of resources sustainability. Nonetheless, considering that culture-based and enhanced fisheries require minimal capital investment, these could be easily promoted in the region's remote rural areas. However, development of these systems of fisheries would require thorough study to ensure that biodiversity in water bodies is maintained and

that the introduction of invasive aquatic species in natural water bodies is minimized if not avoided, and should be promoted through the ecosystem-based approach to fisheries management. This is another tall order for SEAFDEC to look into so that the region's inland fisheries are developed in sustainable manner.

Moreover, there is also a need for AMSs to address illegal, unreported and unregulated (IUU) fishing in inland waters, as illegal fishing could also occur in rivers, lakes and other inland water bodies. Curbing IUU fishing in inland fisheries would result in enhanced competitiveness of the region's fish and fishery products from inland fisheries. Therefore, in the process of developing their respective inland fisheries, the AMSs should heed to the provisions stipulated in the *Joint ASEAN-SEAFDEC Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products*, which was adopted during the High-level Consultation on Regional Cooperation in Sustainable Fisheries Development Towards the ASEAN Economic Community: Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products," in Bangkok, Thailand on 3 August 2016.

Another very critical area that needs utmost attention is improvement of the region's fisheries data collection systems, especially in inland fisheries. Many reports have indicated that there is a need to strengthen the expertise of the AMSs in identification and compilation of biological data as well as in species identification. Conduct of human resource development activities in these aspects should therefore be intensified. Furthermore, the capacity of ASEAN Member States in determining the fishing efforts, and stock assessment should also be enhanced so that the countries would be able to establish the necessary fisheries management measures for economically important inland and freshwater aquatic species leading to sustainable inland fisheries development.

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FISH for the PEOPLE is a special publication produced by the Southeast Asian Fisheries Development Center (SEAFDEC) to promote sustainable fisheries for food security in the ASEAN region.

Strengthening Regional Cooperation for Sustainable Fisheries Development in Southeast Asia

Kom Silapajarn, Kaoru Ishii, Virgilia T. Sulit, Somboon Siriraksophon, and *Nualanong Tongdee*

During the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment" organized by SEAFDEC and the ASEAN in June 2011, the Ministers and Senior Officials responsible for fisheries of the ASEAN-SEAFDEC Member Countries adopted the "Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020." A sequel to an instrument adopted during the ASEAN-SEAFDEC Millennium Conference in 2001, this current instrument has also served as policy framework for sustainable development of fisheries and enhancing its contribution to food security and the well-being of peoples in the region. While carrying out various activities in accordance with the provisions stipulated in these series of two instruments that display the Resolution and the Plan of Action, and with technical support from SEAFDEC, countries in the region continue to be confronted with emerging issues that need to be addressed through closer cooperation. The most recent concerns include the stringent measures applied by importing countries both within and outside the region, on fishery export products making sure that these do not come from Illegal, Unreported and Unregulated (IUU) fishing activities, and that such fish and fishery products are derived from responsible fishing activities. Therefore, cooperation among relevant national agencies as well as among countries in the region is necessary in order to come up with practical and harmonized approaches that would ensure that the region's fish and fishery products traded in intra-regional or international markets do not come from IUU fishing thus, enhancing their competitiveness. After five years of promoting the 2011 Resolution and the Plan of Action, SEAFDEC considered that mid-way before reaching 2020 would be an opportune time to conduct an in-depth review of the emerging regional issues that hinder fisheries development and the competitiveness of fish and fishery products from the region. This would facilitate identification and adoption of measures particularly those that require regional cooperation and intervention, and securing the countries' high-level commitment and continued support to address such issues in an efficient manner.

Thus, with support from the SEAFDEC Council of Directors during its 47th Meeting and the 23rd Meeting of the ASWGFi in 2015, the "High-level Consultation on Regional Cooperation in Sustainable Fisheries Development Towards the ASEAN Economic Community: Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products" was convened by SEAFDEC on 3 August 2016. During the said Consultation, High-level Officials of the ASEAN-SEAFDEC Member Countries adopted the "Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products." The Joint Declaration is meant to secure high-level policy support and cooperation from relevant national agencies of the ASEAN-SEAFDEC Member Countries towards sustainable fisheries development in Southeast Asia, and is also intended to provide a framework that would enable SEAFDEC and relevant agencies and donor organizations to continue their support toward enhancing regional cooperation in sustainable fisheries development as the ASEAN Economic Community undergoes unification.

Sustainable Fisheries Development in Southeast Asia: Challenges and Opportunities

The fisheries sector is very crucial for the economic development of Southeast Asia not only by swelling the coffers of the countries but most of all also enhancing the livelihoods and well-beings of peoples, especially the fisherfolks in the region. Notwithstanding such portrayal, the trend of the region's fisheries production had dismally attained slow growth during the 10-year period from 1991 to 2000 although in the subsequent years, production gained an abrupt upswing (**Fig. 1**). It could also be deduced that the average growth rate of the fisheries production during the 10-year period from 1991 to 2000 was 5%, increasing to 6% in the next 10 years from 2001 to 2010, then to 7% from 2011 to 2014. However, the prospects for the region's fisheries production to increase in the next ten years remain high.

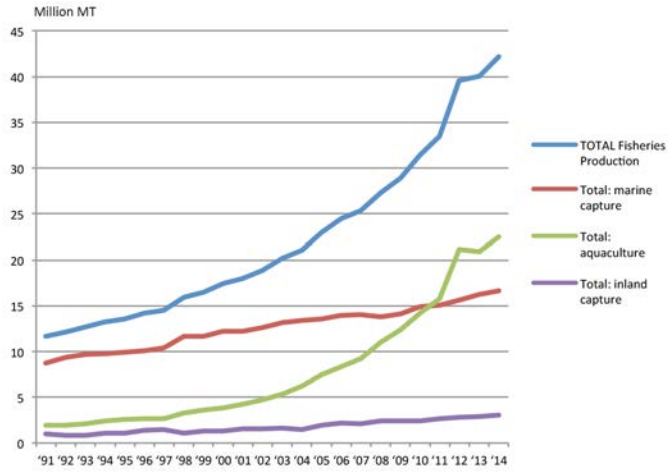

Fig. 1. Trend of Southeast Asia's total fisheries production (in million metric tons) from 1991 to 2014

Sources: *SEAFDEC (1997), SEAFDEC (2005), SEAFDEC (2006), SEAFDEC (2010), SEAFDEC (2015), SEAFDEC (2016a)*

Table 1. Total fisheries production of Southeast Asia from 1991 to 2014 (in million metric tons)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL Fisheries Production	**11.67**	**12.16**	**12.68**	**13.26**	**13.53**	**14.16**	**14.48**	**15.92**	**16.52**	**17.45**	**17.97**	**18.85**
Total: marine capture	8.73	9.40	9.70	9.75	9.90	10.06	10.39	11.63	11.64	12.25	12.20	12.58
Total: aquaculture	1.92	1.93	2.13	2.41	2.56	2.67	2.63	3.25	3.60	3.87	4.21	4.75
Total: inland capture	1.02	0.83	0.85	1.10	1.07	1.43	1.46	1.04	1.28	1.33	1.56	1.52
(Cont'd)												
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
TOTAL Fisheries Production	**20.20**	**21.09**	**22.94**	**24.45**	**25.31**	**27.29**	**28.94**	**31.45**	**33.49**	**39.60**	**40.06**	**42.22**
Total: marine capture	13.19	13.38	13.59	13.94	14.06	13.82	14.14	14.88	15.10	15.59	16.26	16.66
Total: aquaculture	5.38	6.25	7.44	8.35	9.18	11.07	12.38	14.19	15.75	21.16	20.90	22.53
Total: inland capture	1.63	1.46	1.91	2.16	2.07	2.40	2.42	2.38	2.64	2.85	2.90	3.03

Sources: *SEAFDEC (1997), SEAFDEC (2005), SEAFDEC (2006), SEAFDEC (2010), SEAFDEC (2015), SEAFDEC (2016a)*

This is considering the region's resources which have potentials for further development. Nevertheless, such developments must proceed in a sustainable manner. Specifically, the trend by ten-year periods has increments that almost doubled, for example in 2014, the total fisheries production was about 42.22 million metric tons while it was about 21.09 million metric tons a decade ago in 2004. Moreover, the 2013 production of 40.06 million metric tons in 2013 entails an increase of almost 50% from that of 2003 (**Table 1**). Nonetheless, the increments come mainly from the aquaculture sub-sector, the production of which had been gaining an average annual growth rate of about 10% during the past 25 years, *i.e.* about 8% during the 10-year period from 1991 to 2000; about 13% from 2001 to 2010; and about 11% from 2011 to 2014.

Meanwhile, capture fisheries (marine and inland) had very slow annual average growth rate from 1991 to 2014 of about 3%, although the growth had been steadily increasing. With bountiful natural resources available in the region, especially the vast inland freshwater bodies that could be tapped sustainably for inland capture fisheries development, production from capture fisheries could increase in the future.

Both capture fisheries and aquaculture are of fundamental importance to the Southeast Asian region in terms of ensuring food security, enhancing revenue generation, improving economies, and creating employment. In many Southeast Asian countries, catching of and/or farming aquatic resources have always been vital part of people's livelihoods, most particularly the fisherfolks and fish farmers in rural areas. It should be noted that in the cultures of peoples in the region, aquatic resources are not only source of income or food supply but also as raw materials for traditional fish products such as fish sauce and other fish-based condiments which form part of the region's daily diet.

Moreover, fisheries and aquaculture are also crucial in improving the livelihoods of peoples, especially in terms of employment generation, as more than 10 million fishers and fish farmers are reported to be involved in both capture and culture that secure their employment especially for those in rural and coastal communities. It is therefore important that the fishery resources are exploited and utilized in a sustainable manner as these are important not only in securing food stability but also in ensuring nutritional security of the rural and coastal populations.

For such reason, the Southeast Asian countries have been exerting efforts to sustain their fisheries production through the adoption and adaptation of various instruments as well as through cooperation not only with other countries in the region but also with various regional and international organizations involved in fisheries development. As a result, there have been drastic increases in the total fisheries production of the Southeast Asian region from the early 2000s (**Fig. 2**, **Table 2**). While Indonesia has always been the leader being the highest total producer of fish during the last 14-year period, the

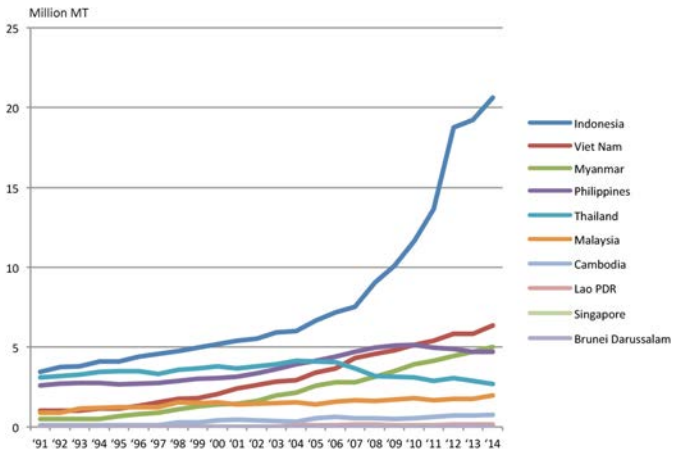

Fig. 2. Trend of total fisheries production of Southeast Asian countries (in million metric tons) from 1991 to 2014

Sources: *SEAFDEC (1997), SEAFDEC (2005), SEAFDEC (2006), SEAFDEC (2010), SEAFDEC (2015), SEAFDEC (2016a)*

Table 2. Total fisheries production of the Southeast Asian countries from 1991 to 2014 (in million metric tons)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL Fisheries Production	**11.67**	**12.16**	**12.68**	**13.26**	**13.53**	**14.16**	**14.48**	**15.92**	**16.52**	**17.45**	**17.97**	**18.85**
Indonesia	3.44	3.75	3.81	4.09	4.12	4.41	4.56	4.73	4.97	5.20	5.40	5.52
Viet Nam	1.02	1.02	1.04	1.14	1.15	1.33	1.55	1.76	1.78	2.04	2.43	2.64
Myanmar	0.50	0.50	0.50	0.50	0.68	0.81	0.90	1.10	1.27	1.39	1.47	1.61
Philippines	2.60	2.70	2.76	2.75	2.69	2.72	2.76	2.88	3.02	3.07	3.16	3.37
Thailand	3.10	3.17	3.28	3.45	3.50	3.51	3.33	3.60	3.68	3.79	3.65	3.80
Malaysia	0.87	0.87	1.16	1.20	1.25	1.24	1.24	1.54	1.50	1.55	1.41	1.47
Cambodia	0.11	0.12	0.11	0.11	0.11	0.11	0.12	0.30	0.28	0.40	0.44	0.43
Lao PDR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Singapore	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Brunei Darussalam	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00

(Cont'd)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
TOTAL Fisheries Production	**20.20**	**21.09**	**22.94**	**24.45**	**25.31**	**27.29**	**28.94**	**31.45**	**33.49**	**39.60**	**40.06**	**42.22**
Indonesia	5.92	6.00	6.64	7.18	7.51	9.06	10.07	11.66	13.63	18.76	19.24	20.60
Viet Nam	2.86	2.93	3.39	3.65	4.32	4.56	4.78	5.13	5.42	5.82	5.83	6.32
Myanmar	1.99	2.13	2.57	2.80	2.81	3.15	3.50	3.91	4.15	4.43	4.72	5.04
Philippines	3.63	3.91	4.15	4.40	4.71	4.97	5.08	5.16	4.98	4.87	4.70	4.68
Thailand	3.92	4.13	4.12	4.04	3.68	3.21	3.14	3.11	2.87	3.07	2.90	2.67
Malaysia	1.48	1.53	1.39	1.59	1.66	1.64	1.73	1.81	1.67	1.76	1.75	1.99
Cambodia	0.39	0.34	0.55	0.65	0.53	0.54	0.52	0.55	0.63	0.73	0.73	0.75
Lao PDR	0.00	0.10	0.11	0.11	0.14	0.15	0.11	0.11	0.13	0.14	0.17	0.15
Singapore	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Brunei Darussalam	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01

Sources: *SEAFDEC (1997), SEAFDEC (2005), SEAFDEC (2006), SEAFDEC (2010), SEAFDEC (2015), SEAFDEC (2016a)*

country's supremacy in fisheries became much more obvious starting in 2014 (**Fig. 3**).

In 2014, the total fisheries production of Indonesia accounted for about 48.80% of the region's total fisheries production, followed by Viet Nam at 15.15%, Myanmar by 11.90%, Philippines by 11.20%, and Thailand by 6.35%. Malaysia contributed about 4.50%, Cambodia about 1.75% and Lao PDR about 0.30%. Singapore and Brunei Darussalam accounted for the remaining 0.05% contributing 0.03% and 0.02%, respectively. While most countries either indicated increases or maintained their respective total fisheries production during the last five years from 2010 to 2014 (**Table 2**), drastic decreases in the total fisheries production were experienced by Thailand and the Philippines (**Fig. 4**). This has been mainly due to decreases in total production not only from aquaculture but also from capture which encompasses marine and inland capture fisheries (**Fig. 5**).

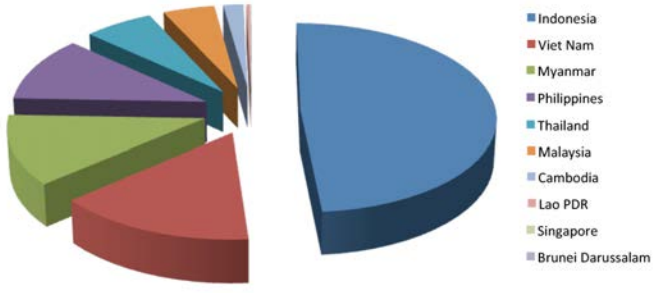

Fig. 3. Contribution of the Southeast Asian countries to the region's total fisheries production (in million metric tons) in 2014

Source: *SEAFDEC (2016)*

As shown in **Table 2** and **Fig. 4**, the total fisheries production of Thailand has been noticeably decreasing during the past five years. Findings from FAO (2014) suggested that this was brought about by the country's depleted marine resources mainly due to overfishing and environmental degradation in the Gulf of Thailand. Moreover, the stoppage of fishing operations by Thai vessels in Indonesian waters since 2008 also exacerbated the already decreasing catches from the country's marine capture fisheries.

Nevertheless, for the whole Southeast region, capture fisheries had been beset by severe environmental concerns that led to the degradation of the resources, as well as illegal, unreported and unregulated (IUU) fishing that brought about drawbacks to the sustainable development of the region's fisheries sector risking the socio-economic stability of coastal communities especially in developing countries. As defined, IUU fishing is a

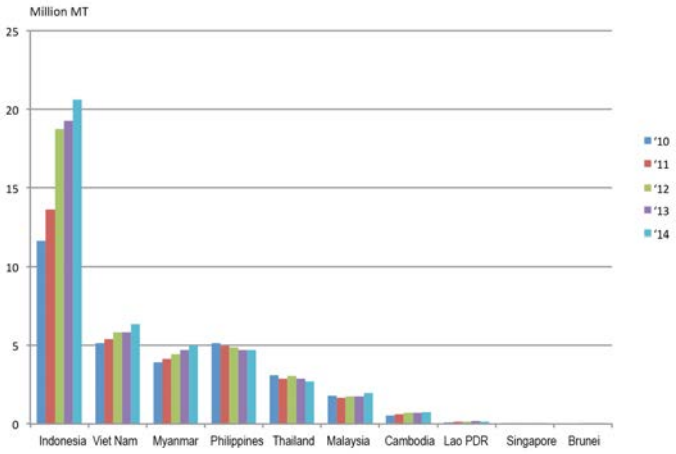

Fig. 4. Changes in the five-year trend of the total fisheries production of Southeast Asian countries (in million metric tons) from 2010 to 2014

*(**Sources:** SEAFDEC (2015), SEAFDEC (2016a))*

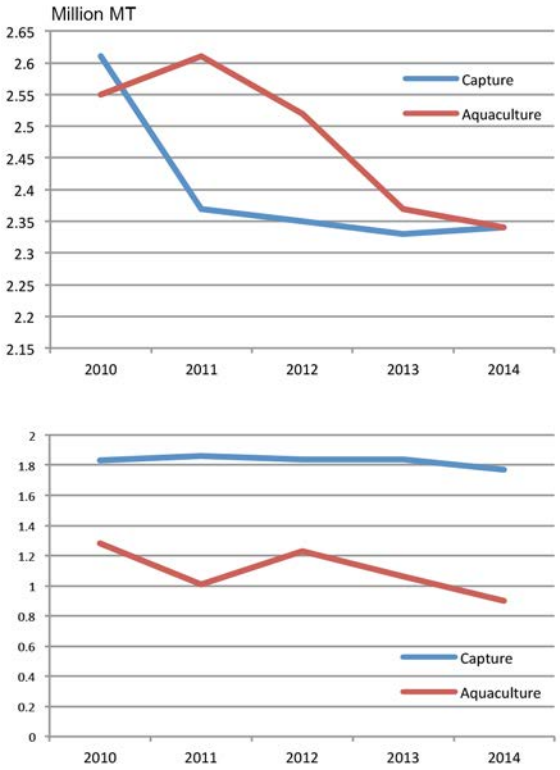

Fig. 5. Production from capture and aquaculture (in million metric tons) from 2010 to 2014: Philippines *(above)*, Thailand *(below)*

*(**Sources:** SEAFDEC (2015), SEAFDEC (2016a))*

fishing activity conducted contradictory to legal conservation and management measures that are currently in place. The rampant practice of IUU fishing worldwide has led to the development of instruments that aim to combat IUU fishing, *e.g.* the FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU); European Union's EC Regulation 1005/2008 to Prevent, Deter and Eliminate IUU Fishing (EC IUU Regulation) which was based on the IPOA-IUU and meant to crack down IUU fishing problems by requiring fisheries products exported to EU fish markets to comply with the EC IUU Regulation; and the US Presidential Task Force on Combating IUU Fishing and Seafood Fraud that enforces risk-based traceability of seafood that enters the US markets.

IUU fishing occurs not only in high seas fisheries but is also generally taking place in small-scale fisheries notably in marine capture as well as in inland capture fisheries, where it could be found in the exclusive economic zones (EEZs) of countries as well as in rivers and other inland water bodies. Specifically in the Southeast Asian region, IUU fishing is multi-pronged and includes numerous facets as shown in **Box 1**.

Meanwhile, the region's aquaculture sector continues to be one of the biggest contributors to the world's total aquaculture production, contributing an average of about 20% annually and increased to 22% in 2014 (FAO, 2016; SEAFDEC, 2016a). Specifically, six of the world's top 15 producers of cultured species in 2014 are Southeast Asian countries, namely: Indonesia (second highest producer contributing about 14.3%), Viet Nam (fourth, contributing 3.4%), Philippines (fifth, 2.3%), Myanmar (twelfth, about 1%), Thailand (thirteenth, about 1%), and Malaysia (fifteenth, about 0.5%). However, the region's aquaculture sector, specifically the shrimp industry, had been challenged during the past ten

Box 1. The various facets of IUU fishing activities occurring in Southeast Asian waters

- illegal fishing within the countries, *i.e.* fishing with fake or without license and registration
- use of vessel with fishing license but with specifications different from those indicated in the license
- use of dynamite and other explosives and poisons to catch fish
- use of prohibited fishing gears, practices and methods, *e.g.* small mesh-sized nets and other destructive gears
- landing of fish in informal and unofficial ports
- transferring of catch at sea
- landing of catch across borders and double flagging
- poaching in other countries' EEZs
- collecting and trading of live reef food fish (LRFF), ornamental and endangered aquatic species by direct shipping of LRFF from producers to importers bypassing in-country exporters
- unscrupulous practices of various stakeholders along the value chain
- fishing in the high seas and Regional Fisheries Management Organization (RFMO) areas but landing the catch in the ASEAN Member States
- fishing without permits or during the out-of-season
- fishing without regard on any catch quotas
- non-reporting or under-reporting of catch and the species caught
- trading of fish coming from illegal fishing in the high seas and RFMO areas

years by the outbreaks of aquatic diseases. Pakingking and de Jesus-Ayson (2016) indicated that the shrimp industry of Southeast Asia had suffered severe brunt since the early 1990s due to the occurrence of the epizootic white spot disease caused by the white spot syndrome virus (WSSV). This was followed by the taura syndrome caused by the taura syndrome virus (TSV) which devastated the shrimp production of Thailand and Indonesia. Most recently, the shrimp industry was again affected by the occurrence of acute hepatopancreatic necrosis disease (AHPND), earlier known as early mortality syndrome (EMS) which first appeared in Viet Nam, spreading later to Thailand, Philippines and Malaysia.

Coping with the issues and concerns

Worldwide, the fishery resources have been declining or to some extent at the verge of total collapse due to over-exploitation and un-controlled fishing operations within

Box 2. Management tools developed by AMSs and SEAFDEC to combat IUU fishing in Southeast Asia and enhance the competitiveness of ASEAN fish and fishery products

Tools for Combating IUU fishing: Main features	
ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain	The **ASEAN Guidelines** ensures that fish and fishery products in the supply chain do not come from IUU fishing activities through the promotion of strategies and measures to prevent the entry of fish and fishery products from IUU activities into the supply chain; development and implementation of effective fisheries management; and enhancing regional cooperation in strengthening MCS systems. Strategies include: Managing Fishing Activities within a ASEAN Member States, Regulating Transshipment and Landing of Fish/ Catch across Borders; Preventing Poaching in the EEZs of ASEAN Member States; Controlling Illegal Fishing and Trading Practices of Live Reef Food Fish, Reef-based Ornamentals and Endangered Aquatic Species; Strengthening the Management of Fishing in the High Seas and RFMO Areas.
Regional Fishing Vessels Record for Vessels 24 Meters in Length and Over (RFVR-24 m)	**RFVR Database System** was developed for fishing vessels 24 meters and over in length to defy IUU fishing in the Southeast Asian region as well as monitor IUU fishing vessels through sharing of information on fishing vessels among the AMSs. Maintained at SEAFDEC Training Department, the Database includes information on 28 items, namely: 1) Name of Vessel, 2) Vessel Registration Number, 3) Owner's Name, 4) Type of Fishing Method/Gear, 5) Fishing License Number, 6) Expiration Date of Fishing License, 7) Port of Registry, 8) Gross Tonnage (GRT/GT), 9) Length (L), 10) Breadth (B), 11) Depth (D), 12) Engine Power, 13) Shipyard/ Ship Builder, 14) Date of Launching/Year Built, 15) International Radio Call Sign, 16) Engine Brand, 17) Serial Number of Engine, 18) Hull Material, 19) Date of Registration, 20) Area (Country) of Fishing Operation, 21) Nationality of Vessel (Flag), 22) Previous Name (if any), 23) Previous Flag (if any), 24) Name of Captain/Master, 25) Nationality of Captain/Master, 26) Number of Crew (maximum/minimum), 27) Nationality of Crew, 28) IMO Number (if available).
Regional Plan of Action for Management of Fishing Capacity	Development of the **Regional Plan of Action for the Management of Fishing Capacity** is meant to match fishing effort with the resources available and safeguard the interest of fishers. This is also intended to serve as guide for the ASEAN Member States to develop their respective National Plans of Action for the Management of Fishing Capacity or NPOA Fishing Capacity.
Implementation of the Port State Measures in the ASEAN Region	**Regional Cooperation to Support the Implementation of the Port State Measures Agreement in the ASEAN Region** is aimed at preventing the entry of illegally caught fish in international markets through the countries' ports. This means that the ASEAN Member States have to take Actions on: restriction of entry into ports, use of ports, access to port services, as well as inspection and other enforcement activities of foreign vessels, as stipulated in the Post State Measures Agreement or PSMA, which has been ratified recently.
Addressing Trans-Boundary Issues through Bi-Lateral/Multi-lateral Dialogues	To effectively and efficiently promote management measures to combat IUU fishing in the whole Southeast Asian region, relevant activities are carried out in sub-regional areas considering that the region's fishery resources are characterized as migratory in nature, fishing licenses are granted to foreign vessels, domestic fisheries are unregulated, high concentration of small-scale fishers that continue to provide significant contribution to the national economies, and high mobility of fishing crew. The sub-regional approach for improving fisheries management to control illegal and destructive fishing practices in the region is promoted through **bi/multi-lateral dialogues** in the Gulf of Thailand (Cambodia, Malaysia, Thailand, Viet Nam); Andaman Sea (Indonesia, Malaysia, Myanmar, Thailand); Southern South China Sea and Sulu-Sulawesi Sea (Brunei Darussalam, Indonesia, Malaysia, Philippines, Viet Nam); and Lower Mekong Basin (Cambodia, Lao PDR, Thailand, Viet Nam).
Measures for enhancing the competitiveness of ASEAN fish and fishery products: Main features	
ASEAN Catch Documentation Scheme (ACDS) for Marine Capture Fisheries	The development of **ASEAN Catch Documentation Scheme (ACDS) for Marine Capture Fisheries** is being carried out by SEAFDEC with the cooperation of the AMSs in order to secure the niche of ASEAN fish and fishery products in the global market. Specifically, the ACDS is meant to provide unified framework that will enhance traceability of fish and fishery products for effective marine fisheries management in AMS; enhance the credibility of fish and fishery products for intra-regional and international trade; and prevent entry of fish and fishery products from IUU fishing activities into the supply chain.

Box 2. Management tools developed by AMSs and SEAFDEC to combat IUU fishing in Southeast Asia and enhance the competitiveness of ASEAN fish and fishery products (Cont'd)	
Regional Guidelines on Traceability System for ASEAN Aquaculture Products	Also with the goal of securing the niche of ASEAN fish and fishery products in the global market, the **Regional Guidelines on Traceability System for ASEAN Aquaculture Products** is being developed by SEAFDEC in collaboration with the AMSs to serve as useful resource and common reference in implementing traceability systems for aquaculture products and in formulating and developing national programs and activities promoting traceability. In order to address difficulties on the part of the AMSs in implementing the Guidelines due to inadequate resources, complexity of the supply chain, and weak enforcement of regulations, compliance with the best practices in aquaculture is encouraged.
Promotion of Good Aquaculture Practices (GAP): Preventing the Spread of Transboundary Aquatic Animal Diseases	The aquaculture industry must comply with good aquaculture practices, one of the most important aspects of which is on preventing the spread of transboundary aquatic animal diseases, as healthy and disease-free aquaculture products would surely secure their niche in the global market. Many aquatic animal diseases occurred in the Southeast Asian region and had impacted the region's aquaculture production resulting in economic damages especially to the exporting countries. The spread of these diseases could be monitored and stopped through effective disease prevention and control as well as by complying with good aquaculture practices such as maintaining the necessary optimal environmental conditions during the culture period.
Other Measures: Main features	
Promotion of GAP: Utilization of Alternative Protein Sources for Aquafeeds to Minimize Pressure on Fishery Resources	Part and parcel of promoting best aquaculture practices is the need to utilize alternative protein sources for aquafeeds to get out from the fishmeal trap and minimize pressure on fishery resources that might have already been depleted due to IUU fishing activities. Some ingredients that had been identified as fishmeal substitutes include plant protein, terrestrial animal protein, fisheries co-products, microbes and unconventional protein sources. Using these ingredients would allow the depleted fishery resources to recover, while the regions' aquaculture stocks would continue to be less-fishmeal dependent. However, there are issues and gaps in the use of these alternative dietary ingredients that need to be addressed.
Addressing Labor Issues in Fisheries	The fisheries sector has been charged with exploitative labor practices, however, there are general labor issues that also need to be addressed, such as: insufficiency in regulating the movement of migrants to the fisheries sector; absence of Good Labor Practices, especially those that involve working and living conditions of migrant labor in fisheries; rampant practice of human trafficking onboard fishing vessels as well as in fish processing plants and factories; national legislations are inadequate to be able to align with international standards and instruments; and weaknesses in the implementation of sustainable management of fisheries. Nevertheless, these issues would need to be discussed collaboratively at the regional level.
Strengthening Fishery Resources Rehabilitation Strategies to Mitigate the Impacts of IUU Fishing	IUU fishing activities impede fish stock recovery, degrade fishery resources, and increase competition among resource users affecting the socio-economic well-being of fishing communities. It is therefore necessary to mitigate the impacts of IUU fishing on the fishery resources by improving critical fish habitats and enhancing the fishery resources, which could be done by identifying the appropriate strategies for rehabilitating the degraded fishery resources. The AMSs and SEAFDEC with support from donors and partners therefore, came up with the Strategic Plans for Fishery Resources Enhancement in the Southeast Asian Region in order to address the looming issues and challenges. To facilitate adoption, the Strategic Plans had been grouped into two aspects, namely: Fishery Resources Enhancement through Habitat Improvement and Management, and Fishery Resources Enhancement through Artificial Propagation and Stock Release.

national jurisdictions or in sub-regional/regional areas or in the high seas. With such backdrop, the tall order is for aquaculture sector to increase production to fill the gap in fish supply as production from capture fisheries would decline if IUU fishing remains uncontrolled. The region's fisheries sector would also have to address the issues on labor in fisheries as it continues to loom the sector. This concern came about because of the allegedly exploitative labor practices of some fishing operators on migrant workers, which in a way has been associated with IUU fishing. Many migrant workers are working in fishing vessels of the region's major fishing countries, *e.g.* workers from Cambodia and Myanmar working in Thai fishing vessels that operate in other coastal States.

Migrant fishers could be vulnerable to abuse because of the nature of work in fishing, *i.e.* long working hours and periods away from home, tough living and work conditions and the risks and hazards that go with fishing. Moreover, there is limited inspection of conditions; and migrants have limited access to grievance procedures or complaint mechanisms.

Such issues and concerns that continue to confront the region's fisheries sector could not be addressed singly by one country alone, but through enhanced regional cooperation. Therefore, SEAFDEC with support from donors notably the Government of Japan through the Japanese Trust Fund and the Government of Sweden through the SEAFDEC-Sweden Project, has been assisting the ASEAN Member States (AMSs) in their efforts

to combat IUU fishing in their respective waters through the development of measures as fisheries management tools to combat IUU fishing that would eventually enhance the competitiveness of the ASEAN fish and fishery products in the global market. Such collaborative efforts led to the creation of opportunities for relevant stakeholders to readily adopt and adapt, as the case may be. These include management tools and measures that had been developed to combat IUU fishing and enhance the competitiveness of the region's fish and fishery products (**Box 2**).

The challenges that confront the fisheries and aquaculture sectors of the Southeast Asian region, especially with regards to the sustainability of fisheries could be mitigated through the engagement of AMSs in the opportunities that had been created through collaborative mechanisms (Silapajarn, 2016a). In addition, the commitment of AMSs to implement the aforementioned management measures and tools could be manifested through the implementation of the provisions stipulated in the **Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating IUU Fishing and Enhancing the Competiveness of ASEAN Fish and Fishery Products**.

Development of Joint ASEAN-SEAFDEC Declaration

As mentioned above, the AMSs have been confronted with emerging issues that seem to slow down the sustainable development of their respective fisheries risking the incomes and livelihoods of peoples. The issues include among others, market driven measures from importing countries, IUU fishing, food safety and traceability system of fish and fishery products, and the labor aspects. The impacts of these emerging issues are not only on the fisheries sector but also on the economies of the countries. Many AMSs have exerted efforts to improve their fisheries management and address the impacts through cooperation among relevant national agencies. However, since these issues could not be addressed by the countries individually, cooperation among countries in the region is necessary by coming up with practical and harmonized approaches, especially on combating IUU fishing and enhancing the competitiveness of fish and fishery products traded in intra-regional or international markets.

The ASEAN-SEAFDEC Member Countries therefore agreed to develop the *Joint ASEAN-SEAFDEC Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products* with the main objective of enhancing regional cooperation in sustainable fisheries development in the light of the unification of the ASEAN Economic Community. At the ASEAN level, the development of the Joint Declaration was supported by the Special SOM-36th AMAF in August 2015. On the part of SEAFDEC, preparatory processes were undertaken through regional experts meeting, technical consultations, and multi-stakeholders consultations in cooperation with the AMSs. Such fora reviewed the fisheries situation and the emerging issues that hinder the sustainable development of fisheries in the region, and assessed the progress of the actions taken by the countries to address the emerging issues while practical steps were recommended toward addressing such issues.

The *Joint ASEAN-SEAFDEC Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products* covers key issues reflecting the current fisheries situation of the ASEAN Member States. These include: preventing the entry of IUU fish products into the supply chain; improving of fishing vessel registration, licensing, and development of the Regional Fishing Vessels Record (RFVR) initially for vessels 24 meters in length and over; promoting the implementation of Port State Measures Agreement; management of fishing capacity under the framework of the Regional Plan of Action for Management of Fishing Capacity in the ASEAN Region; and supporting the bilateral dialogues among the ASEAN Member States. Moreover, in order to enhance the competitiveness of ASEAN fish and fishery products, the key issues also include: enhancing the traceability of capture fisheries through the adoption of the ASEAN Catch Documentation Scheme; promoting the traceability of aquaculture products; addressing labor issues including the migratory workforce and working conditions and safety at sea. Each key issue was discussed among the experts groups as well as through regional consultations resulting in policy recommendations and provisions for implementation by the AMSs. In a span of more than one year, SEAFDEC with the support from the Governments of Japan and Sweden organized series of meetings and consultations to come up with approaches that would address the key issues/areas at hand. Specifically, through such stakeholders' consultations organized by SEAFDEC, the 1st draft of the **Joint ASEAN-SEAFDEC Declaration** was developed. The Draft was submitted and subsequently considered by the SEAFDEC Council of Directors and endorsed by high-level officials of the AMSs prior to the High-level Consultation (Silapajarn, 2016b). The 47th Meeting of the SEAFDEC Council and the 23rd Meeting of the ASWGFi and Special SOM-36th AMAF in 2015 also supported the conduct of the High-level Consultation as a forum where the "Joint Declaration" could be pushed forward.

Adoption of the Joint ASEAN-SEAFDEC Declaration

While articulating its support to the Draft Joint Declaration, the Government of Thailand through the Permanent Secretary of the Ministry of Agriculture and Cooperatives of Thailand *Dr. Theerapat Prayurasiddhi* reiterated the seriousness of the issues on IUU fishing that require not only attention but also commitment from the countries to deal with the issues (SEAFDEC, 2016b). After recalling that in 2011, the Ministers and Senior Officials responsible for Fisheries adopted the

Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region toward 2020, which specified the need to combat IUU fishing and enhance the competitiveness of the ASEAN fish and fishery products, he declared that the High-level Consultation is the most opportune time to put into practice the provisions of the said Resolution and Plan of Action (SEAFDEC, 2016b). He then sought the endorsement of the Joint Declaration by the senior Officials of the ASEAN-SEAFDEC Member Countries. In response, the aforementioned Senior Officials of the ASEAN-SEAFDEC Member Countries signified their concurrence of

Representatives from the Member Countries, ASEAN, SEAFDEC and international/regional organizations attending the Consultation

Box 3. Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating Illegal, Unreported and Unregulated (IUU) Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products (adopted by the Senior Officials of ASEAN-SEAFDEC Member Countries on 3 August 2016)

WE, the Senior Officials of ASEAN-SEAFDEC Member Countries met on the occasion of the "High-level Consultation on Regional Cooperation in Sustainable Fisheries Development Towards the ASEAN Economic Community: Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products," in Bangkok, Thailand on 3 August 2016;

Recognizing the provisions in international instruments such as the United Nations Convention on the Law of the Sea (UNCLOS, 1982), Agenda 21, which was adopted at the UN Conference on Environment and Development (UNCED, 1992), the FAO Code of Conduct for Responsible Fisheries (CCRF, 1995), and the Regional Plan of Action to Promote Responsible Fishing Practices including Combating IUU Fishing in the Region (RPOA-IUU, 2007);

Guided by the ASEAN Charter, which aims to ensure sustainable development for the benefit of present and future generations and to place the well-being, livelihood and welfare of the people at the center of the ASEAN community building process;
Bearing in mind that fisheries in the Southeast Asian region had developed rapidly during the last decade contributing significantly to the improved economy and food security of the region, however, IUU fishing is a serious concern and threatens the sustainability of the region's fisheries management and conservation measures, fishery resources and aquatic ecosystems, as well as economic viability and food security;

Aware of the existing national, regional and international initiatives in combating IUU fishing undertaken by the ASEAN Member States (AMSs), relevant Regional Fisheries Management Organizations (RFMOs), and other regional and international organizations;
Recalling the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region adopted by the ASEAN-SEAFDEC Ministers and Senior Officials responsible for fisheries during the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment" held in June 2011;

Conscious of the need to meet food safety and quality requirements; such as through implementing the ASEAN Guidelines for the Use of Chemicals in Aquaculture and Measures to Eliminate the Use of Harmful Chemicals, ASEAN Good Aquaculture Practice (GAqP), ASEAN Shrimp GAP, and continue developing ASEAN standards in line with relevant regional and international instruments such as the Codex Alimentarius Commission and the Agreement of Sanitary and Phytosanitary (SPS) Measures;

Taking into consideration the importance of working conditions of labor in fisheries sector as outlined in the International Labour Organization (ILO), International Maritime Organization (IMO), Food and Agriculture Organization of the United Nations (FAO), and the ASEAN Declaration on the Protection and Promotion of the Rights of Migrant Workers;

HEREBY DECLARE OUR INTENT, without prejudice to the sovereign rights, obligations, and responsibilities of ASEAN-SEAFDEC Member Countries under relevant international laws and arrangements, to combat IUU fishing in the Southeast Asian region and enhance the competitiveness of ASEAN fish and fishery products by:

1. Strengthening Monitoring, Control and Surveillance (MCS) programs under national laws and regulations for combating IUU fishing and enhancing cooperation among relevant national agencies within the country for effective implementation of laws and regulations for combating IUU fishing;

2. Intensifying capacity building and awareness-raising programs, including information, education and communication campaigns;

3. Enhancing traceability of fish and fishery products from capture fisheries through the implementation of the "ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain," and "ASEAN Catch Documentation Scheme for Marine Capture Fisheries";

4. Enhancing traceability of aquaculture products, through the implementation of all ASEAN GAPs with certification scheme based on regulations of respective countries, and traceability systems that are harmonized with those of major importing countries;

5. Managing fishing capacity with a view to balance fishing efforts taking into account the declining status of the fishery resources in the Southeast Asian region, and establishing conservation measures based on scientific evidence;

Box 3. Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating Illegal, Unreported and Unregulated (IUU) Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products (adopted by the Senior Officials of ASEAN-SEAFDEC Member Countries on 3 August 2016) (Cont'd)

6. Promoting the implementation of port State measures through enhanced inter-agencies and regional cooperation in preventing the landing of fish and fishery products from IUU fishing activities from all foreign fishing vessels, and encouraging the use of the "Regional Fishing Vessels Record (RFVR)";

7. Enhancing regional cooperation in managing trans-boundary fisheries resources through regional, sub-regional, and bilateral arrangements in combating IUU fishing, particularly poaching by fishing vessels, transshipment and transportation of fish and fishery products across borders of respective countries;

8. Regulating the quality and safety of ASEAN fish and fishery products all throughout the supply chain to meet standards and market requirements as well as acceptability by importing countries, and development and promotion of ASEAN seal of excellence/label;

9. Addressing issues on labor (safe, legal and equitable practices) in the fisheries sector in the Southeast Asian region through strengthened cooperation among relevant national agencies within the country as well as establishing regional, sub-regional and bilateral cooperation and collaboration via relevant ASEAN platforms, and helping to support the development and implementation of relevant labor guidelines for the fisheries sector;

10. Enhancing close collaboration between the AMSs and relevant RFMOs in combating IUU fishing; and

11. Undertaking collective efforts in developing preventive and supportive measures to strengthen rehabilitation of resources and recovery of fish stocks to mitigate the impacts of IUU fishing.

WE HEREBY DECLARE AND ENCOURAGE THAT

This Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products be implemented by the ASEAN-SEAFDEC Member Countries; and that AMSs and SEAFDEC with support from donors and collaborating partners, strengthen their efforts to implement programs to combat IUU fishing and enhancing the competitiveness of ASEAN fish and fishery products.

This Joint Declaration is adopted on 3 August 2016. In attendance during the adoption are:

1) *Pg. Kamalrudzaman bin Pg. Haji Md Ishak*, Senior Special Duties Officer, Policy and Planning Division, Ministry of Primary Resources and Tourism, Brunei Darussalam
2) *Dr. Kao Sochivi*, Deputy Director General, Fisheries Administration, Kingdom of Cambodia
3) *Dr. Achmad Poernomo*, Senior Advisor to the Minister for Public Policy, Ministry of Marine Affairs and Fisheries, Republic of Indonesia
4) *Mr. Hideki Moronuki*, Senior Fisheries Negotiator, Fisheries Agency, Japan
5) *Mr. Xaypladeth Choulamany*, Director General, Department of Planning and Cooperation, Ministry of Agriculture and Forestry, Lao People's Democratic Republic
6) *Datuk Hj. Ismail bin Abu Hassan*, Director General, Department of Fisheries, Malaysia
7) *Mr. Khin Maung Maw*, Director General, Department of Fisheries, Republic of the Union of Myanmar
8) *Mr. Sammy A. Malvas*, Regional Director, Bureau of Fisheries and Aquatic Resources, Republic of the Philippines
9) *Dr. Tan Lee Kim*, Deputy Chief Executive Officer (Corporate and Technology), Agri-Food & Veterinary Authority, Republic of Singapore
10) *Dr. Theerapat Prayurasiddhi*, Permanent Secretary, Ministry of Agriculture and Cooperatives, Kingdom of Thailand
11) *Mrs. Nguyen Thi Trang Nhung*, Deputy Director, Department of Science, Technology and International Cooperation, Fisheries Administration, Socialist Republic of Viet Nam

Senior Officials from the ASEAN-SEAFDEC Member Countries, as well as from the ASEAN and SEAFDEC during the High-level Consultation on 3 August 2016, expressing their commitment to enhance cooperation for the sustainability of fisheries in the Southeast Asian region by combating IUU fishing in their respective waters

the "Joint ASEAN-SEAFDEC Declaration for Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products" which was then declared adopted (**Box 3**).

Way Forward

The "Joint Declaration" is another milestone that signifies the Southeast Asian countries' commitment to work together in addressing the issues on IUU fishing which ultimately leads to enhancing the competitiveness of the region's fish and fishery products, including the need to ensure the quality, and safety of such products, as well as addressing issues on labor in fisheries which have recently received much attention of the global community. By adopting the Joint Declaration, the Southeast Asian countries also agreed to implement the provisions and gave the assurance that their respective fishing activities would be conducted in ways that lead to sustainable development that encompasses not only resource sustainability but also food safety and fair treatment to people engaged in the fishing activities. The Joint Declaration is expected to remain a working instrument in all Southeast Asian countries especially that the fisheries sector is considered one of the priorities in the ASEAN Economic Community's Plans and Strategies.

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Development of Fish Passage Design in Cross-river Obstacles for Sustainable Inland Capture Fisheries in Southeast Asia

Chumnarn Pongsri, Suthipong Thanasarnsakorn, Nualanong Tongdee, and *Saivason Klinsukhon*

In Southeast Asia, inland capture fisheries has always been recognized as an economically important sub-sector of the region's fisheries in view of its contribution to livelihood generation and food security of peoples, particularly the poor and marginalized groups in rural areas. Activities in inland capture fisheries are characterized by large numbers of fishers involved, mostly working part-time, and fishing only for subsistence. Inland fishing activities are also seasonal where composition of the catch is highly diverse in terms of species that rely heavily on the resources available in various habitats for their life cycles, *i.e.* breeding, nursing to grow-out stages. This implies the need for the inter-connectivity of habitats to be maintained so that survival of the species is ensured and biodiversity in the ecosystems is preserved, and as a consequence, for the sustainability of inland capture fisheries. While noting that inland capture fisheries are operated in waters shared by other sectors, *e.g.* irrigation, power-generation, etc., such fisheries could be impacted by the activities of these sectors and *vice versa*. Large numbers of development projects such as construction of cross-river barriers, *e.g.* dams, barrages and weirs that are meant for irrigation, hydro-power generation, and domestic water supply, rarely take into consideration their possible impacts to the fishery resources, especially on the inter-connectivity of fish habitats. Construction of fish passage in those cross-river barriers could address such concern as it maintains the necessary habitats' inter-connectivity. Therefore, with the goal of developing a fish passage design appropriate for the Southeast Asian region, SEAFDEC with financial and technical support from the Australian Centre for International Agricultural Research, embarked on a one-year research study on the "Application of Fish Passage Design Principles to Enhance Sustainability of Inland Fishery Resources in the Southeast Asian Region" in 2015-2016.

Status of Inland Capture Fisheries in Southeast Asia

The Southeast Asian countries recognize the importance of inland capture fisheries to food security for their peoples. In expressing an incessant drumbeat of such concern, the ASEAN Member States (AMSs) had resolved to promote the importance of inland capture fisheries and aquaculture in planning and policy formulations as this could pave the way for improving food security and ensuring stable livelihoods of the rural populace (SEAFDEC, 2001). As a follow-through, the AMSs later agreed that awareness of relevant stakeholders on the contribution of inland fisheries to food security and sustainable livelihoods should be heightened, while the priority actions for the region were recognized to "*Ensure the sustainability of inland fisheries by maintaining ecological health of the ecosystem, particularly the inter-connectivity of habitats and the specific management needs during the dry season; and develop mitigating measures for the adverse impacts on inland fisheries that may be caused by the construction of water infrastructure and alteration of water ways*" (SEAFDEC, 2011).

Inland fisheries that include inland capture fisheries and aquaculture, is a fast growing sector, especially in terms of production, *e.g.* aquaculture production. However, while the region's aquaculture production had been increasing rapidly during the past 13 years as shown in **Fig. 1**, that of inland capture fisheries had lagged behind (**Table 1**). This scenario needs a second look considering that inland fishery resources are bountiful in the region and have the potentials for sustainable fisheries development (Pongsri *et al*., 2015). Specifically, the region's freshwater resources could easily include: more than 3.7 million km of rivers; 2.4 million ha of lakes; 56.0 million ha of floodplains; 3.1 million ha of reservoirs; 26.5 million ha of dams; 29.7 million ha of wetlands; and more than 66.3 million ha of other water bodies.

There are several issues that need to be addressed with respect to the development of inland capture fisheries in the Southeast Asian region. The first and foremost of which is on the need to improve the system for collecting production data and related statistics. As mentioned earlier, the region abounds large areas

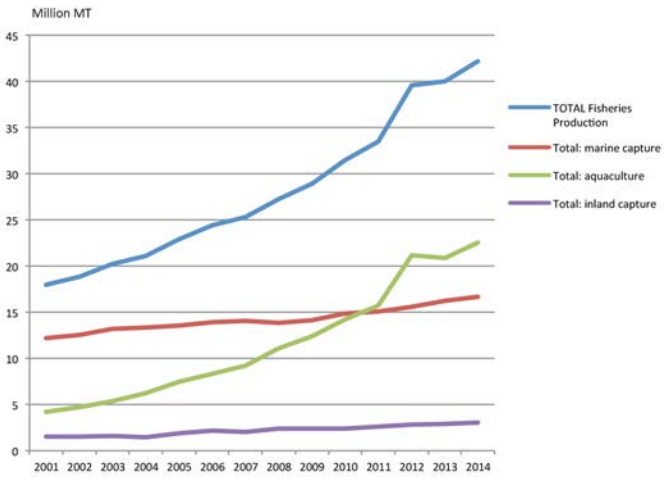


Fig. 1. Trend of fisheries production in Southeast Asia (2001-2013)
Sources: SEAFDEC (2008); SEAFDEC (2010); SEAFDEC (2015); SEAFDEC (2016b)

Table 1. Total production from inland capture fisheries of Southeast Asia from 2001 to 2014 (in million metric tons (MT))

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Brunei Darussalam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cambodia	0.39	0.36	0.31	0.25	0.45	0.56	0.42	0.43	0.39	0.40	0.45	0.53	0.53	0.51
Indonesia	0.31	0.30	0.31	0.33	0.30	0.30	0.31	0.50	0.50	0.35	0.37	0.40	0.39	0.44
Lao PDR	0.00	0.00	0.00	0.03	0.03	0.03	0.08	0.08	0.03	0.03	0.03	0.04	0.04	0.06
Malaysia	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Myanmar	0.26	0.29	0.46	0.50	0.63	0.72	0.72	0.82	0.90	1.00	1.16	1.25	1.30	1.38
Philippines	0.14	0.13	0.13	0.14	0.15	0.17	0.17	0.18	0.19	0.19	0.19	0.20	0.20	0.21
Singapore	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thailand	0.20	0.20	0.20	0.20	0.20	0.22	0.23	0.23	0.25	0.21	0.23	0.22	0.22	0.21
Viet Nam	0.25	0.23	0.21	0.00	0.14	0.15	0.13	0.15	0.15	0.19	0.20	0.20	0.21	0.21
Total: inland capture	**1.56**	**1.52**	**1.63**	**1.46**	**1.91**	**2.16**	**2.07**	**2.40**	**2.42**	**2.38**	**2.64**	**2.85**	**2.90**	**3.03**
Total: marine capture	**12.20**	**12.58**	**13.19**	**13.38**	**13.59**	**13.94**	**14.06**	**13.82**	**14.14**	**14.88**	**15.10**	**15.59**	**16.26**	**16.66**
Total: aquaculture	**4.21**	**4.75**	**5.38**	**6.25**	**7.44**	**8.35**	**9.18**	**11.07**	**12.38**	**14.19**	**15.75**	**21.16**	**20.90**	**22.53**
TOTAL Fisheries Production	**17.97**	**18.85**	**20.20**	**21.09**	**22.94**	**24.45**	**25.31**	**27.29**	**28.94**	**31.45**	**33.49**	**39.60**	**40.06**	**42.22**

Sources: *SEAFDEC (2008); SEAFDEC (2010); SEAFDEC (2015); SEAFDEC (2016b)*

of freshwater bodies. Granting that of the total stretch of 3.7 million km of rivers, every 1,000 km produces 0.5 metric tons of fish per year, this could yield about 1,850 metric tons of fish annually. Moreover, for the total of more than 184.0 million ha of water bodies and if for every ha, 0.5 metric tons of fish is produced annually, this would yield 92.0 million metric tons of fish annually compared to only 2.9 million metric tons in 2013 (**Table 1**). In some cases, such trend could be true considering that based on studies conducted by FAO (2016), alternative information and data on habitats, socio-economic among others, indicate that inland capture fisheries substantially contribute to livelihoods and food security of peoples, but the status of fish populations in inland waters could not be easily determined due to insufficient information.

In Southeast Asia, the compilation and reporting of production data from inland capture fisheries had not been efficient in spite of the efforts of SEAFDEC to promote the improvement of the respective countries' fishery data and statistics collection systems (SEAFDEC, 2015). As a result, production data reported by the countries could be insufficient not only in terms of quantity but also in species composition. Specifically, data on production quantity could be very much under-estimated considering that catch of community members as main users of inland freshwater bodies are usually not recorded as these are meant only for domestic consumption. In addition, the source of fish, fishing methods used, gear used, etc. are also not monitored. These issues should be addressed in order to improve the compilation of data and statistics on inland capture fisheries.

Another equally important issue that could impact on fishery resources and habitats, and subsequently on food security in rural areas is on the need to balance water development programs with management of inland capture fisheries and maintaining aquatic biodiversity. This implies promoting fair sharing of the utilization of freshwater resources by all sectors, *e.g.* agriculture, hydro-power generation, domestic water supply, inland fisheries (capture and aquaculture), to address conflicts among multi-users. FAO (2014) suggested that in addressing such concern, changes could take place not only in the management of water resources and ecosystem but also in development and management of infrastructures and adoption of technologies which should allow the aquatic ecosystem to continue producing fish, maintain biodiversity, and provide electricity, water for irrigation and domestic use, and flood control in the midst of climate change. Taking into account the large areas of dams and reservoirs found in the Southeast Asian region, embracing about 30.0 million ha, which are mostly constructed on river systems with potentials for inland capture fisheries development, FAO (2014) suggested that management options for the operations of existing dams and reservoirs as well as future development constructions, should consider the migration needs of economically important freshwater fishes.

Considering that construction of obstacles on river systems tends to disrupt fish migration routes, such infrastructures or plans for construction of similar infrastructures should include facilities that would allow fish to pass in or through the dams and other barriers during migration which is critical

Box 1. Status of fish passage construction in Southeast Asia (Adapted from FAO and SEAFDEC (2013))

Country	No. of dams/weirs		Purpose(s)	Fish Passage		Remarks
	Existing	Planned/ under construction		Existing	Planned/ under construction	
Cambodia	12	8	Irrigation, hydro-power generation, domestic water supply	1	0	Construction of cross-river obstacles complies with national laws, regulations and guidelines, but inclusion of fish passage in such constructions is not compulsory by law as it depends on the EIA of concerned project.
Indonesia	9	1	Multi-purpose including hydro-power generation	1	1	National regulations related to construction of fish passage do not exist, but the environmental management plan in the EIA process could include fish passage construction to sustain the water flow used for fish migration, and that the technology is still unknown especially taking into account the hydrological conditions in each area.
Lao PDR	14	1	Multi-purpose, hydro-power generation	0	1	No specific compulsory legislation related to the construction of fish passage for hydropower and irrigation facilities, however, in planning for water resources development under the Mekong River Commission (MRC), mitigation measures such as construction of fish passage should be promoted.
Malaysia	5	0	Hydro-power generation, irrigation, domestic water supply	0	0	No fish passage constructed due to inadequate knowledge in designing fish passage and lack of awareness on the part of stakeholders on the significance of having fish passage facilities in weirs, barrage, dams, etc. in maintaining fish population and the river ecosystem.
Myanmar	11	6	Hydro-power generation, irrigation	0	0	No fish passage constructed due to inadequate knowledge on design of fish passage and lack of awareness among stakeholders on the necessity of fish passage.
Philippines	7	n/a	Hydro-power generation, irrigation, flood control	0	n/a	No fish passage constructed as this is not usually included in design and plans for construction of cross-river obstacles, and that priority of projects is power generation and irrigation, however, conservation of biodiversity should be included as one of the criteria in designing cross-river obstacles.
Thailand	35	3	Hydro-power generation, irrigation, flood control	1	n/a	Fisheries Act 1947 includes a provision that prohibits a person from erecting, setting up or building dike, dam, screen fence, fishing nets or other implements that obstruct the passage of aquatic animals.
Viet Nam	8	n/a	Hydro-power generation	0	n/a	No fish passage constructed to protect ecosystem and fishery resources, due to insufficient administrative support and many national agencies involved, and fish passage is not a priority concern in the construction of dams.

Source: *Report of the Workshop on Principles of Improved Fish Passage at Cross-River Obstacles, with Relevance to Southeast Asia (FAO and SEAFDEC, 2013)*

to complete their life cycle. This situation has prompted SEAFDEC to carry out a project that would promote the development of fish passage design appropriate for the Southeast Asian region.

Status of Development of Fish Passage in Southeast Asia

As mentioned earlier, there could be not less than 30 million ha of dams and reservoirs constructed in the Southeast Asian region for multiple uses. During the Workshop on Principles of Improved Fish Passage at Cross-river Obstacles with Relevance to Southeast Asia organized by FAO and SEAFDEC in March 2013, it was noted that construction of fish pass or fish passage is not practiced by many countries in the region (**Box 1**). However, the representatives from the countries attending the Workshop were of the view that fish passage to be constructed at dams, weirs or barrages should take into consideration the hydrological and environmental aspects of the water areas, including the characteristics of migrating fish species in the river systems, *e.g.* Mekong River.

The important recommendations from the workshop included the need to collect/compile biological information on important fish species to be used as basis for designing appropriate fish passage, and that construction of fish passages should be incorporated into any dam project at the initial phase of its planning and construction. Methodologies to evaluate the benefits from fish passage are therefore necessary, while relevant information, *e.g.* on potential impacts of cross-river obstacles, and mitigation of impacts through fish passages, should be packaged and publicized to raise awareness on such issues. In addition, it was also emphasized that there are very large numbers of low-head weirs, which created accumulated impacts particularly to the upstream-downstream migration of fish. Thus, appropriate solution(s) should be explored to address and mitigate the impacts of such types of common construction.

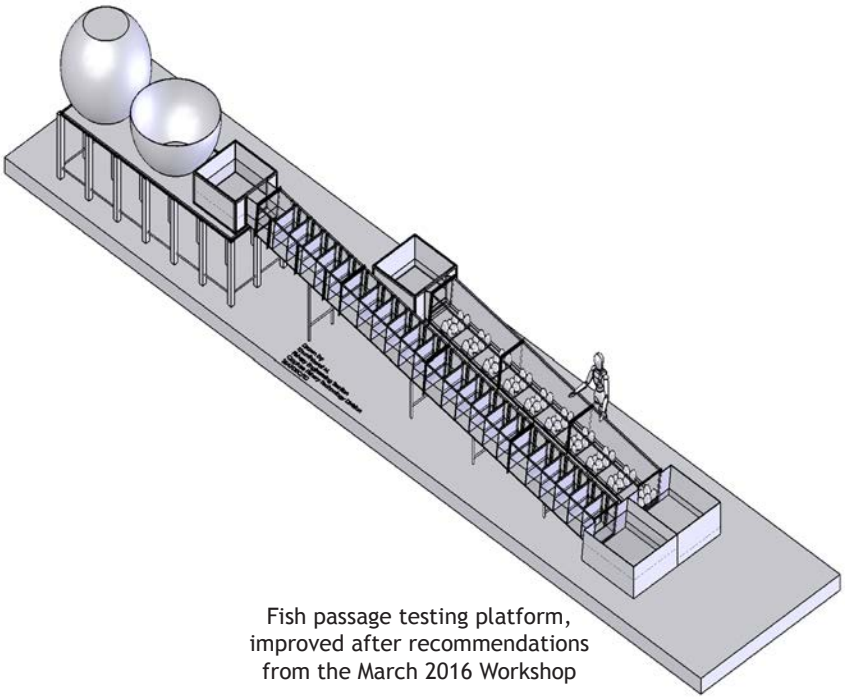
The SEAFDEC-ACIAR Project

To follow-up on the recommendations from the 2013 FAO-SEAFDEC Workshop, SEAFDEC in 2015 proposed to conduct a 16-month project on "the Application of Fish Passage Design Principles to Enhance Sustainability of Inland Fishery Resources in the Southeast Asian Region," with funding support from the Australian Centre for International Agricultural Research (ACIAR) to design and construct an experimental fish-way facility near Bangkok, Thailand. Launched in May 2015, the project takes into consideration the typical situation in the Lower Mekong Basin where inland capture fisheries is increasingly threatened by construction of development infrastructures across the Mekong River system. These include fish migration barriers that are intended to cater to the increasing demand for agricultural irrigation, hydro-power generation, and domestic water supply for the increasing populations. Construction of such infrastructures has been creating changes in the migration routes of freshwater fish species, which are critical for their life cycle, and altering not only their reproduction but also on the overall biodiversity of the aquatic resources, and as a consequence, resulting in unsustainable inland capture fisheries. Nevertheless, the impacts of creating such migration barriers could be mitigated through the construction of fish-way facilities or fish passage. Fish-ways have been constructed in many regions in the world, but it is important that designs of fish-ways for the Southeast Asian region should be developed to suit the characteristics of local and indigenous fish species.

Through the experience from projects supported by ACIAR in relation to fish-way designs in the Southeast Asian region, two general approaches had been considered, *i.e. in-situ* field studies and laboratory-based studies. *In-situ* studies are currently being undertaken in Lao PDR, *i.e.* development of fish passage technology to increase fisheries production from floodplains in Lao PDR. Although these studies are excellent ways to investigate the characteristics of migrating fish, such studies are subject to water level and species diversity fluctuations. The experimental sites are also difficult to showcase to visiting dignitaries, scientists and developers especially when field locations become difficult to access. With such limitations, laboratory-based experiments could be great alternative as these would allow information to be collected in strictly controlled manner, and are generally more accessible. The project undertaken by SEAFDEC therefore seeks to design a laboratory fish-way such that different important parameters could be adjusted during the development stage of the model, and determine the most appropriate design for various conditions. Subsequent to the development of the fish-way model, experiments could also be conducted on-station using selected indigenous fish species.

To start off the project, SEAFDEC through its Training Department (TD) embarked on the construction of a preliminary fish passage model at its premises in Samut Prakan, Thailand, taking into consideration the criteria agreed upon during the 2013 Workshop. Subsequently, a research study is being carried out on station where various parameters are controlled and experimented. The results would provide the basic information on the considerations for designing fish passage that could be applied for different localities of the Southeast Asian region. While the design of the model has been undergoing modifications to assure its practicability, SEAFDEC organized the Experts Workshop on Fish-way Design Principles to Enhance the Sustainability of Inland Fishery in the Southeast Asian Region on 6-10 March 2016 in Thailand and Lao PDR (SEAFDEC, 2016a).

The March 2016 Experts Workshop was meant to compile information on the biology and ecology of fish species in relation to fish migration and fish-way designs, particularly on the criteria for fish-way design that could enhance the



Fish passage testing platform, improved after recommendations from the March 2016 Workshop

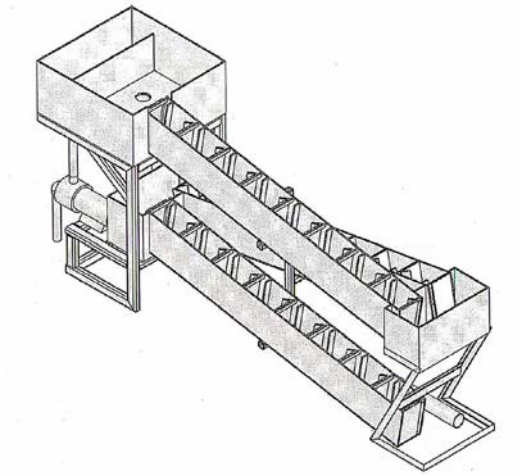
sustainability of inland fishery resources in the Southeast Asian region. After the presentations of the experts and discussions on the issues and constraints, the Workshop came up with recommendations on the appropriate components for a fish-way design as well as on how to improve the preliminary fish-way model developed by SEAFDEC (**Box 2**). The preliminary model designed by SEAFDEC based on the results of March 2013 Workshop is aimed at observing the possibility of various indigenous fish species to pass through the channels, targeting fingerlings of cyprinids that require longitudinal migration. Suggestions on improvements of the preliminary model were therefore welcome in order that the improved model could be used for experiments on various fish species. Moreover, in order to enhance the understanding of the public on the concepts and uses of fish-ways, a smaller prototype model was constructed by SEAFDEC/TD to demonstrate the principles of fish passage, and this has been displayed during several exhibitions.

Conclusion and Way Forward

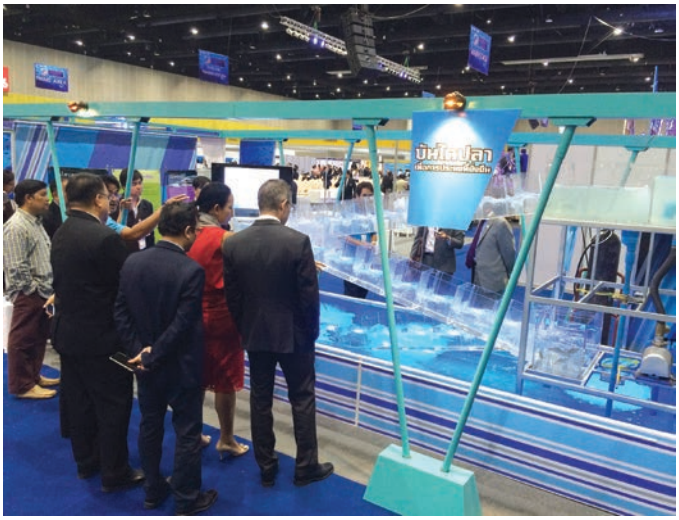
Information Collection and Exchange

The March 2016 Experts Workshop also recommended that activities should be pursued to collect additional biological information on various fish species, including:

- fish swimming performance in different turbulences and water velocities (*high priority*)
- fish behavior in the rivers, approaching the weirs and below the weirs (*e.g.* using acoustic telemetry, radio telemetry, camera), but consideration should be made on the fact that fish in the Southeast Asian region are small-size, large in number and with high species diversity



Prototype of fish-way model for demonstration purposes



Box 2. Recommendations raised during the March 2016 Experts Workshop

Components and Criteria for Fish-way Design

- Designing and construction of fish-ways need to consider both biological aspects of aquatic species (*e.g.* fish species, size, etc.), as well as hydrological aspects of the fish-way (*e.g.* water discharge volume of the river, water head, etc.). Although standard criteria for fish-ways (*e.g.* pool dimension, entrance size) is already available, but this should be tailored to fit the specificity of different localities of Southeast Asia making use of available indigenous knowledge.
- Steps for prioritization of sites for fish-ways could include: (i) Use of satellite data to mark water barriers, observe physical characteristics, position/size of catchment and aquatic habitat; (ii) Conduct of field survey to the site to see the actual barriers, conditions of habitat/species, fishing activities, local/indigenous knowledge; (iii) Evaluation/assessment to determine the potential benefits from fish-ways (based on socio-economic and biological dimensions), give score/rank and prioritize the site; and (4) Allocation of funds to develop a preliminary design, and formulate proposals for donor support. Criteria for prioritizing sites for fish-way could be found at *http://aciar.gov.au/project/fis/2009/041*. Priority should be given not only to fish-ways for upstream migration, but also downstream migration, as fish can migrate into downstream part of the river, and can also migrate upstream later on.
- Attraction of fish to the entrance is important to facilitate migration:
  - Based on the experts' experiences, the need for ~10% of total discharge through fish-way (including auxiliary flow) to attract fish should be considered, and the structure of fish-way should accommodate such condition.
  - Requirements of discharge to attract fish is only during fish migration period, *e.g.* early period of rainy season and not all-year-round (water flow during fish migration peak is not as much as it should be during water flow peak).
  - Entrance position and design are also very important to facilitate/attract fish to find the entrance (should be placed near the bank where fish usually swim).
- Designing fish-ways should also take into consideration migratory requirements of species under international concerns *e.g.* eels (*Anguilla* spp.), which is crucial for SEAFDEC/IFRDMD in designing a fish-way to facilitate eel migration to. In addition, migration of other important species, such as the giant freshwater prawn should also be considered.

Improvement of the Preliminary Fish-way Model of SEAFDEC/TD

- The initial design of on-station fish-way model of SEAFDEC/TD should be improved by increasing the depth as much as possible. It was noted that the existing model still have ~ 30 cm freeboard, and thus water depth could be increased by adding more water pumps.
- SEAFDEC/TD should consider varying the shape of slot opening (*e.g.* using straight slot, wide at the bottom and/or top, blocked at the middle). However, different opening shapes should be designed based on various factors, *e.g.* fish species/size/behavior, amount of water discharge. The shape has to be carefully chosen for specific site/situation.
- Based on research by Mallen-Cooper *et al.*, (2008): i) baffle deflector (small baffle) should be increased to 1.6 times of slot width; ii) large baffle return should be increased to 2.0 times of slot width; iii) sill in the base of the slot should be used and should be equal or greater than the height of the head loss; and iv) pool proportions should be closer to 3:2 (length: width).
- Experiments should be conducted making use of the on-station fish-way model, using different species and size of fish, different water flow rate and fish-way slope, etc. Data should be recorded on the:
  - water depth, pool depth, head loss between each pool, etc.
  - fish species/groups, fish size that could pass through the fish-way (with assistance from the Department of Fisheries (DOF) of Thailand in identifying priority species/groups to be experimented)
  - migration during different times of the day (day/night time)
  - flow measurement details, including spatial and temporal, and equipment used for measurement
- Experts as well as staff of DOF Thailand, Cambodia and Lao PDR should be invited to make use of the experimental model at SEAFDEC/TD to conduct relevant studies.
- In the future, TD should transfer the fish-way model laboratory data to Southeast Asian countries for them to undertake field experiments before publishing the design components and criteria.

- influence of lunar cycle which should also be considered in the data collection

Harmonized methodology for data collection should be developed and used for collection of data/ information on migratory fishes by various agencies/institutions, *e.g.* along Mekong River to the upstream river in China, as this could facilitate sharing/exchanging of information in the future. Existing methodologies developed by the Mekong River Commission (MRC) should also be considered. Regular exchange of relevant information should therefore be sustained, and such information could include not only the success cases, but also the failures.

Data should also be collected on performance indicators of fish-ways, including:

- whether fish population upstream could be maintained,
- proportion of fish that can pass through the fish-ways (entrance attraction), and
- whether fish migrate from bottom to top of the fish-way itself.

Other recommendations include the establishment of e-group by SEAFDEC, comprising experts attending in the Experts Workshop, to facilitate communication and sharing/exchange of information (*high priority*). Creation of working group was considered necessary in seeking approval for the engineering designs of fish-ways. Such working group could comprise engineers, scientists, biologists, etc., to review the construction plans and minimize the chance of making mistakes.

Enhancing Cooperation between the Project and the Royal Irrigation Department of Thailand

Cooperation with the Royal Irrigation Department (RID) of Thailand should be enhanced in the future to ensure that appropriate fish-way designs would be taken into consideration in designing new development projects especially in Thailand. Since it is necessary to have clear standards/ criteria for designing fish-ways (both for upstream and downstream migration), support from RID could also facilitate communication with decision makers, especially in making them understand better the specific criteria/requirements for fish-ways and raising their awareness on the benefits of fish-ways to biodiversity and contribution to nutritional requirements of peoples, and ensure that such aspects would form part in the plans of every development projects.

Moreover, water-gate operators/managers should also be involved in designing fish-ways to be able to enhance their knowledge on the basic principles of fish-ways (*e.g.* water demand for fish-ways, discharge time, etc.), considering that the effectiveness of fish migration also relies on water-gate operations. In addition to the criteria to be considered in construction of new fish-ways, modification of the existing fish-way structure or its operation to facilitate fish migration should also be considered. Finally, for the future actions, the Experts Workshop recommended that: (1) fish-way experiment at SEAFDEC/TD should be continued; (2) funding should be sought for the conduct of field experiments and validation studies (particularly on turbulence and baffle design); and (3) assessment should be made on new design of fish-way comparing its performance with existing design(s).

The Workshop also suggested that as the conduct of experiments using the fish-way model developed by SEAFDEC/TD may take some time, it is necessary to come up with biological information on various fish species/species groups. Therefore, SEAFDEC, DOF and RID should consider developing a proposal for funding support from donors, *e.g.* ACIAR or USAID, for the conduct of field experiments using the fish-way model. Nonetheless, such field experiments could only proceed after obtaining the required biological information on various fish species and their habitats.

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Understanding the Current Status of Anguillid Eel Fisheries in Southeast Asia

Dina Muthmainnah, Satoshi Honda, Ni Komang Suryati, and *Budi IskandarPrisantoso*

Anguillid eels are economically-important species because of their good nutritional value and are utilized for the peculiar food culture in East Asian countries. However, due to its high rate of utilization, eel stocks have dramatically decreased worldwide. Research surveys were conducted to understand the current features of the Anguillid eel resources and their fisheries in the Southeast Asian region. Considering that these catadromous eels are produced mainly in three ASEAN Member States, the survey was carried out by direct observation of fishing activities in 2015 and 2016 in the inland waters of three countries, namely: Indonesia (Bengkulu Province, Palabuhan Ratu Regency and Cilacap Regency), Philippines (Aparri River, Cagayan Province), and Myanmar (Yangon and Mandalay). Results of the survey indicated that in each location, there is one kind of gear used for eel collection, such as Bubu, and pole and line without hook in Bengkulu and Cilacap; scoop net in Palabuhan Ratu; fyke net in Aparri River; and eel bamboo trap in Yangon and Mandalay. In addition, it is only in Palabuhan Ratu where the people catch glass eels, while in the other places, people tend to catch the yellow eel. Moreover, eel farms producing unagi kabayaki (processed/semi-processed eels) are only found in Indonesia where production is shipped to eel markets overseas. Regulations on trading of eels are in place in these three countries, *e.g.* exportation of eels smaller than 150 grams is prohibited in Indonesia, smaller than 15 cm in length in the Philippines, and closed season for capturing eels in Myanmar. However, information on the status of eel fisheries in the Southeast Asian region would be quite difficult to compile unless the system of collecting eel data and statistics is improved.

Anguillid eels (*Anguilla* spp: Anguillidae) are commercially popular as important food because of their good nutritional value with protein and fat contents, and its utilization in peculiar food culture of East Asian countries. Eels are also well known for their unique catadromous life history, breeding far from offshore after migrating thousands of kilometers from their growth habitats in freshwater and estuaries to their spawning areas in oceanic waters (**Fig. 1**). Catadromous eels start their lives in the ocean and migrate to the shore as larvae (leptocephali) that metamorphose into juveniles called "glass eels" and go up rivers with pigmentation (called "elvers") then spend several years in freshwater environment as "yellow eel."

Mature and ready to spawn, the Anguillid eels (called "silver eel") swim downstream and head to the spawning ground in the ocean, and after spawning they die. Unlike that of the other freshwater fishes, the morphology of Anguillid eels (yellow eel) displays a long cylindrical shape and continuous dorsal, caudal and anal fins, and they have pectoral fins but no pelvic fins. Anguillid eels are distributed throughout tropical and temperate waters, except for the Eastern Pacific and South Atlantic (Silfvergrip, 2009 in Crook & Nakamura, 2013). So far, most of the investigations on eels had been focused on the temperate species, in the northern hemisphere, such as *Anguilla japonica*, *A. anguilla* and *A. rostrata*. Based on results of recent studies on eels, there are at least 19 Anguillid eel species inhabiting the world's inland waters. These include: *A. ancentralis*, *A. anguilla*, *A. australis australis*, *A. asustralis schmidtii*, *A. borneensis*, *A. celebesensis*, *A. bicolor bicolor*, *A. bicolor pacifica*, *A. dieffenbachia*, *A. interioris*, *A. japonica*, *A. tominiensis*, *A. marmorata*, *A. megastoma*, *A. nebulosa nebulosa*, *A. nebulosa labiata*, *A. obscura*, *A. reinhardtii*, and *A. rostrata* (Aoyama, 2009). Ten of these species are known to inhabit the Indonesian waters and other waters in Southeast Asia. Recently, one species has been discovered as a new species in the Philippines, *i.e. Anguilla luzonensis* (Watanabe *et al*., 2009).

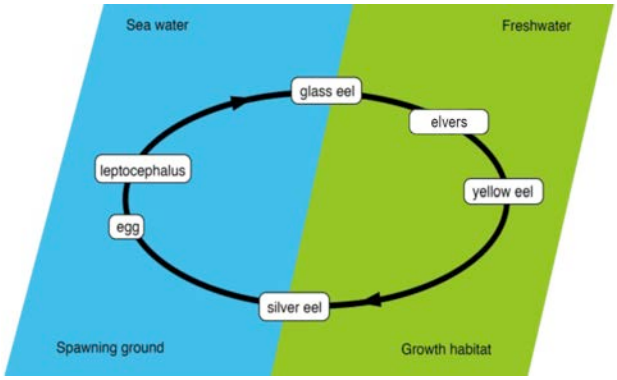


Fig 1. Typical life history of catadromous Anguillid eels (Adapted from Arai, 2015a)

Issues and Concerns

Reports have indicated that the international market for cultured eels in 2000 exceeded 200,000 metric tons (MT) and reached the peak at 275,014 MT in 2009 (FAO, 2015). In Japan, the Japanese eel (*Anguilla japonica*) has long been esteemed as an important food fish, and as much as 130,000 MT of this eel is consumed per year. Nevertheless, most of this production is based on the exploitation of wild adults and rearing of wild-caught juvenile glass eels. However, capture activity of the glass eels since the mid-1990s has increased rapidly (Jacoby *et al*., 2014), and recently, juvenile abundance has declined dramatically by 99% for the European eel and by 80% for the Japanese eel (Dekker, 2003).

While the current population of temperate eels has dramatically decreased due to overfishing, habitat loss and migration barriers, as well as increased natural predation, parasitism, ocean climate variation, and pollution (Arai, 2014), the tropical Anguillid eels become more important in the global market. There is however, limited knowledge on the distribution of the tropical Anguillid eel species in the southern or tropical zones. As the population of several species of Anguillid eels worldwide had been declining, there has been a call for the development of effective conservation and management measures of eel species to ensure their sustainability, noting also that several eels had been listed as species of international concern, *e.g.* the European eel (*Anguilla anguilla*) under the Appendix II of CITES and as critically endangered on the IUCN Red List; the American eel (*A. rostrata*) and Japanese eel (*A. japonica*) as endangered in IUCN Red List; while several tropical Anguillid eels have also been included in the IUCN Red List as near threatened or vulnerable species. Concerns have also been expressed recently on the need to ensure the sustainable utilization of tropical Anguillid eels to avoid possible listing of the species in the CITES Appendices or imposition of other instruments that may impact on the utilization and trade of the species in the future (CITES, 2015). When the European eel, *A. anguilla* had been listed in CITES Appendix II since 2009 virtually prohibiting their export and import, tropical Anguillid eels such as the Indian mottled eel (*A. bengalensis*), Indonesian shortfin eel (*A. bicolor*), and marbled eel (*A. marmorata*) became economically-important Anguillid eel species in the Southeast Asian region. With such a situation, it has become necessary to ensure that these resources should be conserved and managed properly in order that they would not be critically endangered and end up listed in the CITES Appendices as a consequence. Conservation and management of these eel species have become necessary for the sustainability of the tropical Anguillid eel species to compensate for the shortage of supply of the temperate Anguillid eels.

Nonetheless, the catch statistics of the species which are the most important basic data for assessing the current status and trend of the eel resources remain very inadequate. Therefore, in order to evaluate the relative abundance of eel resources, the need to develop the catch statistics on eels had been raised in many fora, especially for the tropical Anguillid eels in Southeast Asia. Since data on catch statistics of Anguillid eels in the region are insufficient, an inventory system needs to be established as soon as possible for the conservation, management and sustainable utilization of the tropical Anguillid eel resources and also for future development of the eel industry in the region. SEAFDEC has initiated measures to address the issues on data collection on eels. Through the SEAFDEC Inland Fishery Resources Development and Management Department (IFRDMD), the First Workshop on Enhancement of Sustainability of Catadromous Eel Resources in Southeast Asia was organized on 27-29 April 2016 in Palembang, Indonesia. Attended by various stakeholders from Southeast Asia, the Workshop served as an avenue for exchanging information on the status of eel fisheries/ eel farming in the Southeast Asian countries. The Workshop also discussed the important and controversial issues regarding the eel industry in Southeast Asia and came up with recommendations and the way forward, as shown in **Box 1**.

Research Study Sites

To form part and parcel of compiling information on eel fisheries, SEAFDEC/IFRDMD spearheaded the conduct of a study survey in the major eel producing countries of Southeast Asia. Although a number of studies had been previously conducted by many researchers to collect data on eels, this recent research survey was aimed at obtaining better understanding on the current features of the catadromous eel resources and also their fisheries in the inland waters of Indonesia, Philippines, and Myanmar. The research was carried out in 2015 and 2016 through direct observation of the eel fishing activities in the inland waters of Indonesia (Bengkulu (1), Palabuhan Ratu (2) and Cilacap (3)), the Philippines (Aparri River, Cagayan (4)), and Myanmar (Yangon(5) and Mandalay (6)). The research study sites are shown in **Fig. 2**.

Fig 2. Map of study sites: 1.Bengkulu, 2.Palabuhan Ratu, and 3. Cilacap (in Indonesia); 4.Aparri River, Cagayan (in Philippines); 5.Yangon and 6. Mandalay (in Myanmar)

Bengkulu Province is located in the west coast of Sumatra facing the Indian Ocean, while Palabuhan Ratu is located in Sukabumi Regency, West Java Province. Cilacap is one of the regencies in Central Java Province. Palabuhan Ratu and Cilacap also face the Indian Ocean and are in the southwest coast of Java Island. Cimandiri River in Palabuhan Ratu is a famous fishing ground for glass eels that usually gather at the River's mouth every year. Cilacap Regency is a fishing ground of yellow eels through its rivers and swamps that have varying areas.

The Aparri River in Cagayan Province of Northern Luzon in the Philippines is inhabited by various eel species and is already known as an important eel habitat. Yangon and Mandalay are in Myanmar, where Yangon (formerly Rangoon) is the largest city in Myanmar (formerly Burma). Based on local reports, fishers send their harvest of Anguillid eels to a collector, while in Mandalay also in Myanmar collectors transfer the Anguillid eels to some farms for rearing before these are sent to the markets.

Under the research study, the necessary data were collected by interviewing the fishers, fish collectors, officers of local governments, as well as Fish Quarantine Stations to obtain the official statistics on catch and shipment of eels and understand the commodity chain of the eel seeds. The statistical data were collected assuming that the concerned local government officers had been collecting catch data on eel from eel collectors using the same method. However, the respondents could not confirm the detailed methods they used for data collection.

Results and Discussion

Fishing Gears

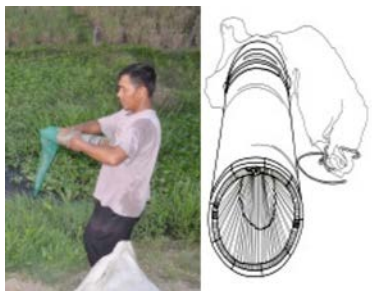
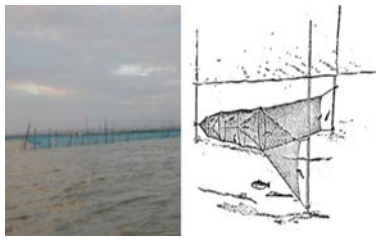
Results from the research survey indicated that there is one type of fishing gear used for eel fisheries in each location site as shown in **Table 1**.

Eel Capture Activities: Indonesia

Bengkulu Province

In Bengkulu, fishers catch the yellow eels at the middle basin of the river but nobody scoops the glass eels at the river mouth. As described in **Table 1**, "bubu" trap is used by fishers to catch the yellow eels. The Local Government of Bengkulu Province reported that in 2014, the highest number of yellow eels was collected in August as recorded in the Province's yearly statistics of yellow eel catch (**Fig. 3**). The peak of eel capture in August could be related to the shifting from dry season to

Table 1. Fishing gears used in eel fisheries in each survey site

Site	Location	Fishing gear	Description
1.	Bengkulu		Bubu is made of split bamboo sticks forming a tube. The tube has a wide mouth fixed by a bamboo ring and a body that tapers down to the closed end. The trap is operated in shallow waters and river branch where the eels are usually swept by water current into the trap.
2.	Palabuhan Ratu		Scoop net is a kind of hand net for sweeping the bottom of waters. It is made of bamboo frames and mounted with fine mesh netting panel. Its width is about 1.5 m.
3.	Cilacap		Bubu in Cilacap is similar with the bubu in Bengkulu but the Cilacap bubu is made of plastic pipe instead of bamboo.
4.	Philippines		Fyke net is a fishing net that hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats.
5.	Myanmar		Eel trap is a vertically positioned bottle-shaped trap with entrance on the sides near the base. Small bait basket is hung inside the trap. It is operated in floodplains and rice fields during the rainy season.

rainy season and in March which is the end of rainy season. This implies that eel capture increases during the overlapping period of the dry and rainy seasons.

Transport of eel from Bengkulu occurs the whole year and peaks in August, which is about 53% of the total eel transported. Fish collectors send the yellow eels by air to Java Island for nursing and rearing to marketable size prior to processing these into *unagi kabayaki* and exported to other countries. Local reports also mentioned that aside from Bengkulu Province in the west coast of Sumatra, eels are also found in Enggano Island, sub-district of North Bengkulu Regency.

Palabuhan Ratu

The mouth of Cimandiri River in Palabuhan Ratu is one of the fishing grounds frequented by local people to collect glass eels (*Anguilla bicolor* and *A. mamorata*) as the glass eels approach the coastal areas through the ocean currents which transport the young eels (transparent body) back to the coast for foraging, growing and gradually becoming mature while ascending upstream. The fishers collect glass eels using a hand-held scoop net described in **Table 1**. **Fig. 4** shows that glass eel catch increases in the fourth quarter then reaches its peak at year-end. The Local Government of Sukabumi Regency collects the monthly catch statistics of glass eels.

Glass eel collection is carried out between 18.00 until 06.00 the next morning. A pressurized kerosene lamp is used to provide lighting while functioning also as luring light to attract the glass eels. The depth of the capture area is only less than 30 cm. However, during the lean season, fishers could only capture 10-20 g (60-80 individuals) of glass eels every night. These are then transferred to another buyer, for rearing to reach an average weight of 200 g before transporting them to eel farmers for rearing to marketable size.

Cilacap Regency

Serayu River of Cilacap Regency is one of the most important and largest yellow eel fishing grounds in Indonesia. Most of the yellow eels cultured in eel farms in Indonesia come from this River. Fishers catch the yellow eels using bubu (**Table 1**). The Local Government of Cilacap Regency collects the yearly statistics of yellow eel catch (**Fig. 5**). The peak season to catch the yellow eels is from December to January of the following year. Eel fishers collect the yellow eels then transport them by land to eel farms, where the eels are cultured until product size and finally shipped to the market.

Eel Capture Activities: Philippines

The peak season for glass eels in Aparri River, Cagayan Province is from October to March. Fyke net is mainly used to collect glass eels in the estuary, set from 17.00 to 06.00 the following day throughout the year. Fyke net consists of cylindrical or cone-shaped netting bags mounted on rings

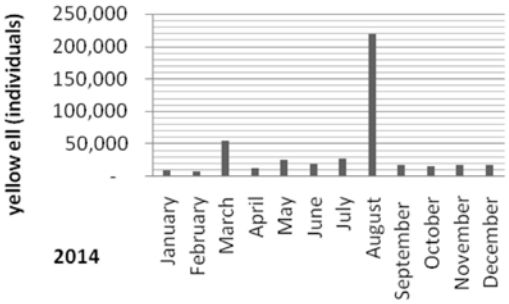


Fig. 3. Monthly catch of yellow eel in Bengkulu Province in 2014 (Local Government of Bengkulu Province, 2015)

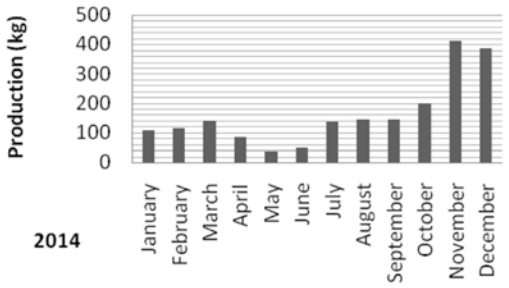


Fig. 4. Monthly catch statistics of glass eels at each stage in Sukabumi Regency (Sukabumi Local Government, 2014)

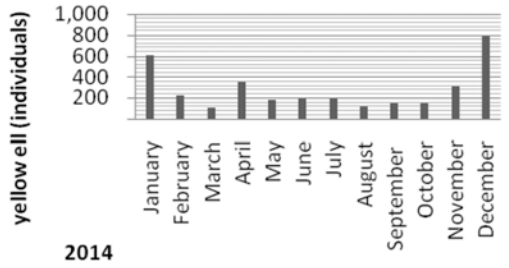


Fig. 5. Monthly catch statistics data of yellow eel in Cilacap Regency in 2014 (Local Government of Cilacap Regency, 2015)

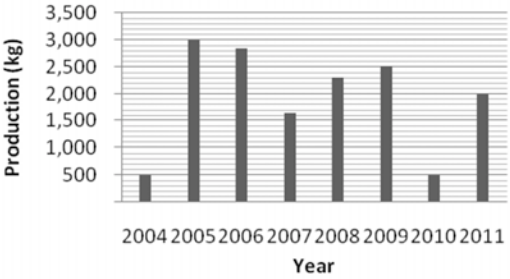


Fig. 6. Annual production (kg) of elvers in Aparri, Cagayan Province during 2004 to 2011 (Source: LGU Aparri through the Municipal Agriculture Office)

or other rigid structures. The wings or leads guide the fish towards the entrance of the bags. Length of the wing is usually 30 to 50 m and the bag is about 20 m. Fyke net is fixed on the bottom by anchors, ballast or stakes. Records have shown that the price for one kg of glass eels from fishers is PHP 2,000.00 (US $44.82). Two to three fishers set 2-3 fyke nets every day and the eel catch comprises less than 50 individuals sorted from a total catch of 1.0 kg of fish. The catch data on elvers production during 2004 to 2011 are shown in **Fig. 6**. It was noted during the research survey that fishers stopped catching

glass eels from Aparri River in 2014 because the price had gone down. Before this period, the price of glass eels reached PHP 30,000/kg. Fishers have however indicated willingness to catch glass eels again if there are orders, in which case the price should be more than PHP 5,000/kg.

Eel Capture Activities: Myanmar

In Myanmar, *Anguilla bicolor* commands the best price compared with the other Anguillid eels. The peak season for eel capture is from August to November, and eel breeding season coincides with the rainy season. Usually, small-sized eels are collected in April. The national production during this period is about 15 metric tons/day. Eel collectors or fishers use bamboo traps (**Table 1**) to collect eels using crabs or earthworms as bait, and rear the catch for about one week. **Fig. 7** shows the annual export data of eels during 2011 to 2016. Almost (98%) of the country's eel production are for export, with only around two percent intended for the domestic market and this activity is reported to have been stable for the past 20 years. Reports also indicated that price of eels depends on the season, during the rainy season (May to August), the price is US$ 3.50/kg and increases to US$6.50/kg during the lean season.

Results from the research survey indicated that one collector from Myanmar receives around 15 metric tons of eels each year, which he could sell live or frozen. There are actually two types of trade routes for eels in Myanmar. In the normal trade, the collected eels are sold to Japan and Korea, and in the border trade, eels are sent to Mandalay and later to China. In both cases, health certificates which are required are issued by the country's Quarantine Office. Some eels are also transported to other domestic markets within Myanmar.

Trend of Eel Fisheries

According to certain eel farmers in Indonesia, the mouth of Cimandiri River is one of the largest glass eel fishing grounds while Cilacap Regency is one of the largest yellow eel fishing grounds in Indonesia. In Palabuhan Ratu, there are more than 1,500 part-time fishers scooping glass eels during the peak season but concentrating only in collecting glass eels.

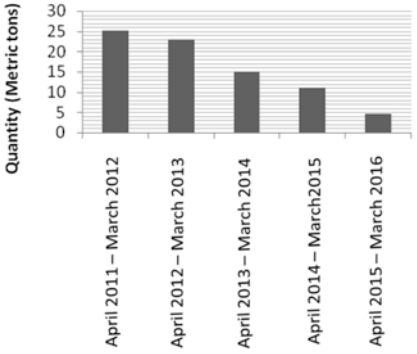


Fig. 7. Annual data of yellow eel export of Myanmar during 2011-2016 (Government of Myanmar, 2016)

Although it has been reported that eel fishery in Bengkulu Province targets the yellow eels as they could command good prices, some small eel farmers also reported that rearing glass eels into elvers needs high-level eel culture technology. Nowadays, there has been a constant demand for yellow eels as seeds for eel farming. However, since there is no eel farm in Bengkulu, eel seed stocks are transported from Bengkulu to eel farms in Java Island.

Similarly in Cilacap Regency, yellow eels are targeted for temporary rearing before these are sent to eel farms by land. Large-scale eel farms, many of which are funded by foreign investors, have been established mainly in Java Island since late 2000s and have been culturing the tropical eels (Fahmi, 2014). Meanwhile, the Philippines is exporting live Anguillid eels mostly to China as well as to other countries such as Taiwan and Hong Kong (Ame, 2016). To restore the natural population of eels, communities near the Aparri River in the Philippines, stock the upstream river with 200,000 glass eels every year. Likewise, Myanmar also exports eels to China through the border trade since about a decade ago. Eel trading is very common in Myanmar but big amounts of eels are meant for the export market only. Live eels are collected from collection centers at the township and district levels by fishers and sent by collectors to Yangon and Mandalay.

Concerns on Resource Enhancement

Since eel populations in the temperate zone have been diminishing due to the rising demand of glass eels, capture activity of glass eels also tends to increase significantly. In order to avoid the over-exploitation of glass eel resources, the Indonesian Government issued a regulation prohibiting the export of eels weighing less than 150 g per individual from the country's territory. In 2009, the decree was revised to include a provision that prohibits the export of eel seed stocks unless these are used for research purposes. In 2012, the decree was again revised making such provision more conservative, *i.e.* prohibiting the export of eel seed stocks for any reason.

In the Philippines, a regulation on trading of eels is also in place. The issuance of Fisheries Administrative Order No. 107 on 23 February 1973 resulted in the total stop of marketing elvers from the country. The said Order specified that exportation of elvers not smaller than 15 cm in length is totally banned. In Myanmar, closed season for eel fishery has been promoted to facilitate eel recruitment and in order that silver eels could go back to the ocean and glass eels could get into the rivers. During the First Workshop on Enhancement of Sustainability of Catadromous Eel Resources in Southeast Asia in April 2016 in Palembang, Indonesia, it was reported that the Government of Myanmar considers closed season as more appropriate than closed area. For the region and considering the migratory nature of eels, measures such as closed season or closed area would depend on what is most appropriate in each country.

Arai (2015b) mentioned that to enhance eel stocks and promote commercial production for human consumption, studies related to the establishment of commercial glass eel production should be carried out. He also mentioned that the Japanese eel population size has already been considered to be outside of safe biological limits, and its current fishery is no longer sustainable. Since the Japanese eels are not protected under local or international laws, these eels are currently seriously threatened with extinction. Meanwhile, stock assessments of the Japanese eels have not yet been seriously considered. Currently, the development of eel conservation and management policy measures has become fundamental in Southeast Asia for the sustainability of eel resources that have high economic and strategic value. Therefore, the Southeast Asian region should establish management policies that would balance the utilization and sustainability of the region's eel resources. As a result of Indonesia's ban on export of eel seeds, farming activities rose in Indonesia since 2009, and many Indonesian fish farmers have already started culturing eels using simple technologies. At the same time, foreign companies have also started to invest in Indonesia's eel culture industry where advanced eel culture technologies have been introduced.

Box 1. Recommendations and Way Forward developed during the First Workshop on Enhancement of Sustainability of Catadromous Eel Resources in Southeast Asia, 27-29 April 2016, Palembang, Indonesia

Issues	Recommendations and Way Forward
1. Improving data collection and statistics on Anguillid eels	• Considering that information on status and trends of eel resources are necessary for management to ensure sustainability of the species, and since data collection on status and trends of eels which inhabit the deep ocean is not possible, production trends of eel juveniles caught for aquaculture purposes should be monitored as these could provide some pictures on the trend of eel population in natural habitats. • To facilitate data collection by the countries, a standardized template should be developed by harmonizing the existing templates currently used by the countries, and data compiled on eels should be categorized as: 1) glass eels = transparent/non-pigmented; 2) elvers (kuroko) = pigmented, up to 50 grams; and 3) yellow/silver eels = above 50 grams • Catch data should be collected by weight, which could be used for calculating the number of juveniles caught, fishing hours, fishing gears, etc. • Data on production of eels from aquaculture should also be collected. • For marketable size eels, difficulties have been encountered by many countries in reporting eel catch statistics because Anguillid eels are recorded under the group of "eels" together with the other eels or "others" together with other unidentified fish, thus, efforts should be made to improve the statistics on eels in the future.
2. Increasing the survival rate during culture of glass eels to elvers	• The most critical stage in eel aquaculture in the region is from glass eels to elvers, which takes 3-4 months and survival rate has been recorded to be very low, but records in Japan showed that survival of cultured *A. bicolor* from glass eels to elvers was as high as 90% and in Indonesia up to 55% (in a company supervised by Japan), and up to 90% in laboratory-scale. Therefore, existing eel aquaculture technologies should be improved and extended to concerned stakeholders to enhance survival rate in culture farms, and optimize the utilization of glass eels which could eventually lead to increased eel production in the region. • In glass eels, particularly for *A. bicolor*, 5-7 cm in length are the most appropriate size for aquaculture to attain high survival and growth, and since it had been difficult to regulate the catching size of glass eels, other measures should be developed, *e.g.* identification of appropriate geographical areas for catching, appropriate collecting season, etc. while R&D in culture of eels should be continued, *e.g.* optimum water quality (physical and chemical), feeding/nutrition (*e.g.* appropriate protein and lipid content requirement), disease management, etc.
3. Compilation of existing information/ research results from Southeast Asian countries	• Considering that several studies relevant to Anguillid eels have been undertaken and published by many researchers in several Southeast Asian countries, including those published in national languages, such information should be collected and compiled to facilitate further research studies and undertake activities towards the conservation and management of the eel species.
4. Mitigating problems on unregulated trade of eels	• Regulations on trading of eels should be established taking into consideration those that are already available in several countries, *e.g.* exportation of eels smaller than 150 grams is prohibited in Indonesia and smaller than 15 cm in length in Philippines. • Considering that Anguillid eels command high price while demand had been increasing, large quantities of glass eels are being traded without proper regulation and recording in some cases. Therefore, measures should be developed and imposed to prevent illegal trade and laundering of glass eels, and such measures should focus on those that could be undertaken by exporting countries.
5. Development of restocking and resource enhancement measures	• Considering the migratory nature of Anguillid eels, from the deep ocean to freshwater rivers, of which the migratory route along the river could be long with obstacles/conditions that hinder their migration, *e.g.* fishing activities, cross-river obstacles, and habitat degradation, therefore, habitat restocking of eel species should be considered as an option.

Conclusion and Recommendations

At this point in time and based on the results of the research survey, information on catch data and statistics on eel fisheries in Southeast Asia is still very limited. It is therefore necessary that the system of collecting data and information on eel fisheries in the region, especially in major eel producing countries, should be improved. Specifically, collection of eel data and statistics should be done at species level for the purpose of conducting stock assessment of certain species of eels. However, such approach would require capacity building on the part of enumerators or data collectors, especially on eel species identification. With these aspects in place, management measures could be developed for the sustainability of the tropical eel resources. The experience of Indonesia, Philippines and Myanmar as the most potential countries in the region for intensified promotion of eel conservation and management could be used as reference for the other Southeast Asian countries in the conservation and management of their respective eel resources.

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Introduced Aquatic Species for Inland Aquaculture: Boon or Bane?

Maria Lourdes A. Cuvin-Aralar

Boosting fisheries and aquaculture production is the primary driver for the introduction of aquatic species to inland water bodies. Various records show that a total of 155 fish species, 24 mollusks, 13 crustaceans, 6 reptiles, 1 amphibian, and 6 seaweed species are introduced aquatic species (IAS) in Southeast Asia. The Philippines ranks the highest in terms of number of introductions with 115 different species, followed by Singapore with 95. The bulk of these introductions are freshwater fishes, dominated by representatives from the family Cichlidae (33 species) and Cyprinidae (40 species). Nonetheless, IAS continues to provide tremendous gains in terms of increased production and consequent economic gains for Southeast Asian countries, contributing from 9 to almost 99% of freshwater aquaculture production in the region based on average 2010-2014 data. Despite these, there are well known adverse impacts of species introductions such as their effects on biodiversity, and possible introduction also of new pathogens and diseases. In addition, some of these IAS become well adapted to their new environment to the extent of being classified as invasive. Measures to address these adverse impacts of species introductions in inland waters should be undertaken through careful crafting and implementation of regulations on species introductions; conduct of science-based risk assessment prior to introduction; shift in focus towards culture of commercially important native species; and balancing ecological risk and economic gains through valuation of ecosystem goods and services of inland water bodies.

Aquaculture is seen to address the growing demand for fish which can no longer be addressed solely by capture fisheries. Both mariculture and inland aquaculture had continuously increased in the past decades, with the world inland aquaculture production continuously outpacing mariculture production since the late 1980s. Statistical data in 2012 showed that mariculture production contributed 44.2 million metric tons (MT) to the total aquaculture production while 66.6 million MT came from inland aquaculture. Of this, 92% are fish, 6% crustaceans and the rest comprised mollusks and other species. Inland aquaculture is relatively easy to achieve compared to mariculture and hence, has developed rapidly particularly in developing regions with high poverty incidence like Asia, Africa and Latin America (FAO, 2014).

The Role of Introduced Aquatic Species

As a consequence of speeding up the development of aquaculture to improve fisheries production, introduction of already domesticated species in areas beyond their natural distribution became inevitable. As a result, the number of introductions worldwide has more than doubled recently compared to 30 years ago (Gozlan, 2008), which according to Welcomme and Vidtayanom (2003) could be because of the need to: (1) provide new species that have high productivity or higher market value than the local species, *e.g.* introduction of tilapias in various inland water bodies worldwide; (2) fill a vacant niche, *e.g.* introduction of milkfish, *Chanos chanos* in the largest inland water body in the Philippines, Laguna de Bay, and since milkfish is a phytoplankton feeder and Laguna de Bay is a eutrophic lake with high phytoplankton production, milkfish, a high value commodity can utilize the phytoplankton in the Lake that appear to be underutilized by the native species (Delmendo and Gedney, 1976), although milkfish is a euryhaline marine species native to the marine waters of the Philippines; (3) control pests that are vectors of diseases, *e.g.* the mosquito fish, *Gambusia affinis* has been introduced in many parts of the world to control mosquitoes (Pyke, 2008); control water quality, *e.g.* grass carp has been introduced in water bodies with aquatic weed infestation problems (Pipalova, 2006); and develop aquaculture and fisheries, which is the main driver of aquatic species introduction worldwide (Welcomme, 1988; Naylor *et al*., 2001). The FAO Database of Introduced Aquatic Species (*http://www.fao.org/fishery/dias/en*) cited that the reasons for introduction are predominantly for aquaculture (39%), fisheries (17%), ornamental and accidental (8%), bio-control (6%), and interestingly, 22% are for "other" and "unknown" reasons. This bears out the earlier observations that aquaculture is the driver of a great bulk of introductions of alien species (Welcomme, 1988; Naylor *et al*., 2001). Of these introductions, 76% are "unreported" while 11% are initiated by Governments, 6% by the industry and 4% by individuals, and the rest by other entities. The use of introduced species which had been domesticated, both in their areas of natural distribution and beyond, has become a common practice to fast track the growth of aquaculture in many parts of the world, including Asia. Furthermore, the ease of culture and development of techniques for the propagation and farming of a number of species has made it popular for introduction to wide number of habitats and large number of countries. Indeed, the introduction of non-native species in aquaculture is less a result of natural colonization than their association with lucrative ecosystem services. In fact, the growth of the aquaculture industry has been coupled with the introduction of non-native species.

Asia has experienced multiple introduction and translocation of fish species mainly for aquaculture and to a limited extent

Table 1. Aquatic species introductions in Southeast Asia (data based on FAO DIAS)

Country	Fishes	Mollusks	Crustaceans	Reptiles	Amphibians	Seaweeds	TOTAL
Brunei Darussalam	3	n.d.*	1	n.d.	n.d.	n.d.	**4**
Cambodia	19	2	n.d.	n.d.	n.d.	n.d.	**21**
Indonesia	45	4	1	1	n.d.	1	**52**
Lao PDR	15	n.d.	n.d.	n.d.	n.d.	n.d.	**15**
Malaysia	44	n.d.	1	n.d.	n.d.	n.d.	**45**
Myanmar	20	1	1	n.d.	n.d.	n.d.	**22**
Philippines	76	20	10	3	1	5	**115**
Singapore	86	1	3	4	n.d.	n.d.	**95**
Thailand	39	3	3	3	1	n.d.	**49**
Viet Nam	20	n.d.	n.d.	n.d.	n.d.	n.d.	**20**

**n.d.- no data*

for stock enhancement (Silva *et al*., 2006). In Southeast Asia a total of 155 fishes, 24 mollusks, 13 crustaceans, 6 reptiles, 1 amphibian, and 6 seaweed species have reportedly been introduced in many ASEAN Member States (AMSs). The Philippines ranks highest in terms of total number of aquatic species introductions with a reported total of 115 different species, next is Singapore at 95 different species, followed distantly by Indonesia and Thailand (**Table 1**). Introduced fish species in the AMSs come from 40 families from 14 orders, with 61 species from the Order Perciformes, dominated by 33 species from Family Cichlidae. This is followed by 40 species from Order Cypriniformes with 37 representatives from the Family Cyprinidae. Of the 150 fish species introduced in the region, 70% are freshwater species while the rest are mostly euryhaline species that can also inhabit freshwater environments (**Table 2**). Admittedly the FAO Dataset for Introduced Aquatic Species (DIAS) is limited compared to what the different countries provided as data from the survey. The data in **Table 2** is supplemented by information obtained from literatures.

Table 2. Introduced species in ASEAN countries, data based on FAO DIAS (*http://www.fao.org/fishery/dias/en*) unless otherwise stated and classification is based on Fishbase (*www.fishbase.org*)

Order, Family, Species	Common name	BR	KH	ID	LA	MY	MM	PH	SG	TH	VN	Habitat*
Anguilliformes, Anguillidae												
Anguilla anguilla	European eel			1								MW;FW;BW
Anguilla japonica	Japanese eel		1			1[f]				1		MW;FW;BW
Atheriniformes, Melanotaeniidae												
Melanotaenia nigrans	black-banded rainbowfish							1				FW
Beloniformes, Adrianichthyidae												
Oryzias latipes	Japanese ricefish					1			1			FW;BW
Characiformes, Characidae												
Gymnocorymbus ternetzi	black tetra									1		FW
Hemigrammus spp.	rummy nose tetra								1			FW
Hyphessobrycon spp.	candy cane tetra								1			FW
Moenkhausia oligolepis	glass tetra								1			FW
Paracheirodon innesi	neon tetra								1			FW
Thayeria obliquus	Penguinfish								1			FW
Characiformes, Serrasalmidae												
Colossoma macropomum	cachama			1				1	1	1[a]		FW
Colossoma sp.	Red pomfret					1[b]						FW
Piaractus brachypomus	Pirapitinga		1	1			1	1				FW
Pygocentrus nattereri	Red-bellied piranha							1				FW
Cypriniformes, Cobitidae												
Chromobotia macracanthus	clown loach									1		FW

Table 2. Introduced species in ASEAN countries, data based on FAO DIAS (*http://www.fao.org/fishery/dias/en*) unless otherwise stated and classification is based on Fishbase (*www.fishbase.org*) (Cont'd)

Order, Family, Species	Common name	BR	KH	ID	LA	MY	MM	PH	SG	TH	VN	Habitat*
Misgurnus anguillicaudatus	pond loach				1[a]			1				FW
Cypriniformes, Cyprinidae												
Abbottina rivularis	Chinese gudgeon				1[a]					1		FW
Acheilognathus sinensis	Chinese bitterling				1[a]							FW
Amblypharyngodon chulabhornae									1			FW
Aristichthys nobilis (*Hypopthalmichthys nobilis*)	Bighead carp	1	1	1	1	1	1	1	1	1	1[f]	FW
Aspidoparia morar	Morari			1							1[f]	FW
Barbodes spp.	Barb								1			FW
Barbonymus gonionotus	Silver barb			1		1	1	1	1			FW
Carassius auratus auratus	goldfish			1		1		1	1	1	1[f]	FW
Carassius carassius	cruscian carp							1		1		FW
Catla catla	catla		1			1		1		1	1[f]	FW
Cirrhinus chinensis	mirror carp			1		1			1	1	1[f]	FW
Cirrhinus cirrhosus	mrigal		1[f]		1[f]	1[f]						FW
Cirrhinus molitorella	mud carp			1		1[b]			1	1		FW
Cirrhinus mrigala	mrigal carp		1	1		1		1		1		FW
Ctenopharyngodon idella	grass carp		1	1		1	1	1	1		1[f]	FW
Cyprinus carpio	Common carp	1	1	1	1	1	1	1	1	1	1[f]	FW
Devario malabaricus	Malabar danio						1		1			FW
Esomus metallicus									1			FW
Hemibarbus labeo	Barbel steed				1[f]							
Hemibarbus maculatus	Spotted steed				1[a]							FW
Hypophthalmichthys molitrix	silver carp		1	1		1	1	1	1	1	1[f]	FW
Labeo rohita	Roho labeo		1[f]			1		1				FW
Leptobarbus hoevenii	Hoven's carp							1	1			FW
Megalobrama amblycephala	Wuchang bream							1				FW
Mylopharyngodon piceus	black carp					1[b]		1		1		FW
Osteochilus hasseltii	bonylip barb			1				1				FW
Pseudorasbora parva	Stone moroko				1[a]							FW
Puntius binotatus (*Barbodes binotatus*)	spotted barb			1					1			FW
Puntius conchonius	rosy barb								1			FW
Puntius gonionotus (*Barbonymus gonionotus*)	silver barb			1		1[f]	1	1				FW
Puntius orphoides (*Systomus rubripinnis*)	Javaen barb			1			1					FW
Puntius partipentazona (*Puntigrus paripentazona*)									1			FW
Puntius semifasciolatus (*Barbodes semifasciolatus*)	Chinese barb				1[a]				1			FW

Table 2. Introduced species in ASEAN countries, data based on FAO DIAS (*http://www.fao.org/fishery/dias/en*) unless otherwise stated and classification is based on Fishbase (*www.fishbase.org*) (Cont'd)

Order, Family, Species	Common name	BR	KH	ID	LA	MY	MM	PH	SG	TH	VN	Habitat*
Puntius spp.	Barbs								1			FW
Puntius tetrazona (*Puntigrustetrazona*)	Sumatra barb								1			
Rasbora borapetensis	Blackline rasbora								1			FW
Rasbora spp.									1			FW
Rasborinus lineatus (*Metzia lineata*)					1[a]							FW
Rasborinus macrolepis (*Metzia mesembrinum*)									1			FW
Tinca tinca	tench			1								FW
Cyprinodontiformes, Aplocheilidae												
Aplocheiluspanchax	blue panchax			1		1						FW
Cyprinodontiformes, Fundulidae												
Fundulus heteroclitus	mummichog							1				
Cyprinodontiformes, Poecillidae												
Gambusia affinis	mosquitofish		1	1	1[f]	1	1	1			1[f]	FW
Poecilia latipinna	sailfin molly			1				1	1	1	1[f]	FW
Poecilia reticulata	guppy			1				1	1			MW;FW;BW
Poecilia sphenops	molly			1		1[b]			1			FW;BW
Poecilia velifera	sailfin molly					1[b]			1	1		FW;BW
Xiphophorus hellerii	swordtail			1				1	1			FW;BW
Xiphophorus maculatus	swordtail			1				1	1			FW
Xiphophorus variatus	swordtail								1			FW
Cyprinodontiformes, Rivulidae												
Austrolebias nigripinnis	Blackfin-pearlfish							1				FW
Lepisosteiformes, Lepisosteidae												
Lepisosteus spatula						1[b]						FW
Mugiliformes, Mugilidae												
Mugil cephalus	flathead grey mullet									1		FW
Osmeriformes, Osmeridae												
Osmerus mordax	rainbow smelt							1			1	MW;FW;BW
Osteoglossiformes, Arapaimidae												
Arapaima gigas	Arapaima					1[b]		1[g]	1	1		FW
Osteoglossiformes, Notopteridae												
Chitala chitala	clown knifefish						1					FW
Chitala ornata	clown featherback							1	1			FW
Osteoglossidae, Osteoglossiformes												
Osteoglossum bicirrhosum	Arawana							1				FW
Scleropages formosus	Asian bonytongue								1			FW
Perciformes, Ambassidae												
Parambassis siamensis	glass fish								1			FW
Perciformes, Anabantidae												
Anabas testudineus	climbing perch			1				1		1		FW
Perciformes, Blenniidae												
Omobranchus elongatus	cloister blenny							1				MW

Table 2. Introduced species in ASEAN countries, data based on FAO DIAS (*http://www.fao.org/fishery/dias/en*) unless otherwise stated and classification is based on Fishbase (*www.fishbase.org*) (Cont'd)

Order, Family, Species	Common name	BR	KH	ID	LA	MY	MM	PH	SG	TH	VN	Habitat*
Perciformes, Centrarchidae												
Lepomis cyanellus	green sunfish							1				FW
Lepomis macrochirus	bluegill							1				FW
Micropterus dolomieu	smallmouth bass									1		FW
Micropterus salmoides	largemouth black bass					1		1				FW
Pomoxis nigromaculatus	black crappie							1				FW
Perciformes, Channidae												
Channamaculata	blotched snakehead										1	FW
Channa micropeltes	Indonesian snakehead								1			FW
Channa striata	striped snakehead			1				1				FW
Perciformes, Charangidae												
Trachinotus falcatus	snubnose pompano								1			MW
Perciformes, Cichlidae												
Aequiden slatifrons	Platinum acara			1								FW
Amphilophus citrinellus	midas cichlid								1			FW
Amphilophus labiatus	red devil								1			FW
Astronotus ocellatus	Oscar								1			FW
Cichla monoculus						1[b]			1			FW
Cichla ocellaris	peacock cichlid					1[b]			1			FW
Cichlasoma festae	guayas cichlid								1			FW
Cichlaso maoctofasciatum	Jack dempsey									1		FW
Cichlasoma spp.									1			FW
Cichlasoma trimaculatum	three spot cichlid								1			FW
Cichlasoma urophthalmus	mayan cichlid							1[d]	1			FW
Etroplus suratensis	Pearlspot			1		1		1	1			BW; tolerate FW and MW
Geophagus brasiliensis	pearl cichlid							1				FW;BW
Geophagus surinamensis	red striped eartheater								1			FW
Hemichromis bimaculatus	Jewelfish							1				FW;BW
Oreochromi saureus	blue tilapia						1	1	1	1		FW;BW
Oreochromis mossambicus	Mozambique tilapia		1	1		1	1	1	1	1	1[f]	FW;BW
Oreochromis niloticus	Nile tilapia	1	1	1	1	1	1	1	1[a]	1	1[f]	FW;BW
Oreochromis niloticus x Oreochromis mossambicus	hybrid tilapia (Molobicus?)		1	1				1		1		FW;BW
Oreochromis spilurus spilurus	Sabaki tilapia							1				FW;BW
Oreochromis spp.				1				1				FW;BW
Oreochromis urolepis hornorum	Wami tilapia					1[b]		1				FW;BW
Parachromis managuensis	Jaguar guapote							1[e]	1			FW
Pelvicachromis pulcher	rainbow krib								1			FW
Pterophyllum spp.	freshwater angelfish								1			FW

Table 2. Introduced species in ASEAN countries, data based on FAO DIAS (*http://www.fao.org/fishery/dias/en*) unless otherwise stated and classification is based on Fishbase (*www.fishbase.org*) (Cont'd)

Order, Family, Species	Common name	BR	KH	ID	LA	MY	MM	PH	SG	TH	VN	Habitat*
Sarotherodon galilaeusgalilaeus	Mango tilapia							1				FW;BW
Sarotherodon melanotheron	blackchin tilapia		1[f]					1[d,e]				MW;FW;BW
Symphysodon spp.	Blue discus								1			FW
Thorichthys meeki	firemouth cichlid								1			FW
Tilapia buttikoferi									1			FW
Tilapia rendalli (*Coptodon rendalli*)	redbreast tilapia							1		1		FW;BW
Tilapia zillii (*Coptodon zillii*)	redbelly tilapia					1[b]		1	1	1		FW;BW
Vieja synspila (*Paraneetroplus synspilus*)	redhead cichlid								1			FW
Perciformes, Eleotridae												
Oxyeleotris marmorata	marble goby								1			FW;BW
Perciformes, Gobiidae												
Rhinogobius giurinus						1[b]			1			FW
Rhinogobius sp.					1[a]							FW
Perciformes, Helostomatidae												
Helostoma temminckii	kissing gourami			1		1[b]		1	1			FW
Perciformes, Lutjanidae												
Lutjanus argentimaculatus	mangrove snapper								1			MW;FW;BW
Perciformes, Osphoronemidae												
Betta imbellis	crescent betta					1[f]			1			FW
Betta splendens	siamese fighting fish					1[b]	1		1			FW
Colisa lalia (*Trichogaster lalius*)	dwarf gourami								1			FW
Osphronemus gorami	giant gouramy		1	1			1	1	1	1		FW
Trichogaster leerii	pearl gourami							1				FW;BW
Trichogaster microlepis	moonlight gourami								1			FW
Trichogaster pectoralis	snakeskin gourami			1		1[f]	1	1	1			FW
Trichogaster trichopterus	three spot gourami or blue gourami							1				FW
Perciformes, Percidae												
Gymnocephalus cernuus	ruffe							1				FW;BW
Perciformes, Pomacentridae												
Neopomacentrus violascens	violet demoiselle							1				MW
Perciformes, Sciaenidae												
Sciaenops ocellatus	red drum							1	1			MW;FW;BW
Perciformes, Terapontidae												
Bidyanus bidyanus	silver perch							1[g]				FW
Scortum barco	Jade perch					1[b]						FW
Salmoniformes, Salmonidae												
Oncorhynchus mykiss	rainbow trout			1		1		1		1		MW;FW;BW
Oncorhynchus rhodurus	Japanese amago							1		1		MW;FW;BW
Salmo salar	Atlantic salmon			1				1				MW;FW;BW

Table 2. Introduced species in ASEAN countries, data based on FAO DIAS (*http://www.fao.org/fishery/dias/en*) unless otherwise stated and classification is based on Fishbase (*www.fishbase.org*) (Cont'd)

Order, Family, Species	Common name	BR	KH	ID	LA	MY	MM	PH	SG	TH	VN	Habitat*
Salmo trutta fario	Sea trout			1				1				MW;FW;BW
Siluriformes, Callichthyidae												
Corydoras spp.	armored catfish								1			FW
Siluriformes, Clariidae												
Clarias batrachus	Philippine catfish			1				1		1		FW
Clarias gariepinus	North African catfish		1	1	1[f]	1	1	1	1	1	1[f]	FW
Clarias gariepinus x C. macrocephalus						1						FW
Clarias macrocephalus	bighead catfish		1	1		1	1[f]				1	FW
Siluriformes, Ictaluridae												
Ameiuruscatus	white catfish							1				FW
Ictalusus nebulosus	American catfish										1[a]	FW
Ictalurus punctatus	channel catfish			1				1		1		FW
Siluriformes, Locariidae												
Hypostomus plecostomus	suckermouth catfish					1			1	1	1[f]	FW; BW
Hypostomus spp.				1						1		FW; BW
Liposarcus pardalis (*Pterygoplichthys pardalis*)	Amazon sailfin catfish							1	1		1[c]	FW
Pterygoplichthys disjunctivus	Vermiculated sailfin catfish					1[b]		1[e]				FW
Pterygoplichthys spp.	armored catfish									1		FW
Siluriformes, Pangasiidae												
Pangasius hypophthalmus	striped catfish						1[f]	1				FW
Pangasius pangasius	Pangas catfish		1	1					1	1	1[f]	FW
Synbranchiformes, Syngbranchidae												
Monopterus albus	Asian swamp eel							1[e]	1[f]			FW

* ***BW***- *brackishwater;* ***FW***-*freshwater:* ***MW***-*marine waters*
BR-*Brunei Darussalam;* ***KH***-*Cambodia;* ***ID***-*Indonesia;* ***LA***-*Lao PDR;* ***MY***-*Malaysia;* ***MM***-*Myanmar;* ***PH***-*Philippines;* ***SG***-*Singapore;* ***TH***-*Thailand;* ***VN***-*Viet Nam*
Sources: *a - Welcomme and Vidthayanom (2003); b - Rahim* et al. *(2013); ; c - Levin* et al. *(2008); d - Ordoñez* et al. *(2015); e – Guerrero (2014); f - Fishbase; g - personal observation by the author*

Beneficial Impacts of IAS to Fisheries and Aquaculture

Positive impact of fisheries and aquaculture in the livelihood of fishers and fish farmers has been amply demonstrated. Six of the top ranked 22 species in freshwater aquaculture in the world have more than 20% of their production coming from areas outside of their natural range of distribution. In 2000-2004, about 16% of global fish production from aquaculture is from alien freshwater species (Silva *et al*., 2009). From 2010 to 2014, introduced aquatic species (IAS) significantly contributed to the freshwater fish production in the AMSs. **Table 3** shows the average contribution of IAS to total aquaculture production as well as solely to freshwater aquaculture production. In the Southeast Asian region, aquaculture of IAS contributes about 23% to its total aquaculture production and more than 47% to the total freshwater aquaculture production. In Cambodia, about 67% of total aquaculture production comes from freshwater IAS. In freshwater aquaculture, the Philippine production ranks first in terms of contribution from IAS with close to 99%. Data for the Philippines includes milkfish production in inland waters since milkfish, although native to marine waters is considered an introduced species in inland water bodies. Keeping track of introductions by country is quite a challenge for the Mekong River Basin since jurisdiction is shared by several member states. In general, IAS in freshwater aquaculture contribute about 50% to total freshwater fisheries production of five AMSs, *i.e.* Cambodia, Malaysia, Philippines, Singapore, and Thailand. As in previously stated, both the Philippines and Singapore had the highest number of IAS. Vietnam and Brunei Darussalam had much lower contribution at just 28% and 19%, respectively. Viet Nam's production of its native pangas catfish in freshwater contributes on the average 50% to total freshwater aquaculture production.

Table 3. Contribution of introduced species to freshwater aquaculture production of AMSs in relation to total production and freshwater fisheries production (values are averages for the period 2010-2014 computed from FAO FishStatJ (*http://www.fao.org/fishery/statistics/ software/fishstatj/en*))

Country	Total aquaculture productiona (MT)	Total freshwater aquaculture productionb (MT)	Total freshwater aquaculture production of IAS (MT)	Contribution to total aquaculture production of IAS (%)	Contribution to freshwater aquaculture production of IAS (%)
Brunei Darussalam	570.38	17.64	3.41	0.6	19.3
Cambodia	83,211.00	80,063.00	56,246.00	67.6	70.3
Indonesia	3,303,182.60	2,120,915.58	681,008.92	20.6	32.1
Lao PDR	99,191.00	99,191.00	28,160.00	28.4	28.4
Malaysia	301,764.77	136,576.63	71,768.00	23.8	52.5
Myanmar	888,804.35	826,648.19	77,702.26	8.7	9.4
Philippines	908,546.60	308,673.00	305,143.20	33.6	98.9
Singapore	4,258.94	516.45	417.54	9.8	80.8
Thailand	1,138,390.09	425,984.29	220,323.80	19.4	51.7
Viet Nam	3,040,907.80	2,295,301.80	642,333.00	21.1	28.0
TOTAL	**9,768,827.52**	**6,292,035.80**	**2,083,106.13**	**23.4***	**47.1***

a *- Excluding seaweeds;* ***b*** *- excluding production of euryhaline IAS in marine and brackish waters; *average for the region*

The common carp, *Cyprinus carpio* is one of the first species introduced to all AMSs although aquaculture production records had shown that this commodity has not contributed significantly to the region. Among the early record of common carp introduction to the Philippines was in 1915 with the release of this species from Hong Kong in Lake Lanao in Mindanao (Villaluz, 1966; Escudero, 1994). However, this species did not thrive well and are now considered nearly decimated in this Lake. Another cyprinid which has grown in importance to freshwater aquaculture in a number of AMSs is the bighead carp, *Aristichthysnobilis* spp. In the Philippines, this species was introduced from Taiwan in 1968 (Guerrero, 2014) and is now among the top commodities cultured in Laguna de Bay, the country's largest inland water body. Other ASEAN countries that reflect this species in the FAO aquaculture production data are Brunei Darussalam, Cambodia, Lao PDR, Malaysia, Myanmar, and Singapore.

The tilapias are tropical to subtropical species native to Africa and the Middle East. Due to its relative ease to domesticate and culture, a number of species of tilapia has been introduced in various parts of the world. Of the various species of tilapias that have been introduced in the AMSs, Nile tilapia, *Oreochromis niloticus* is the species common to all. Since the 1980s nearly all worldwide introduction of tilapia is for aquaculture (Canonico *et al*., 2005). Unlike the common carp which is one of the species with earliest records of introduction, production of tilapia continues to contribute significantly not only to freshwater but also brackishwater culture as well (**Fig. 1**). Millions of dollars have been invested, in improving breeds of tilapia for better production traits, particularly for the Nile tilapia, *Oreochromis niloticus*. Among the most well-known ones are the Genetically Improved Farmed Tilapia or GIFT (Ponzoni *et al*. 2011), and the Genetically Male Tilapia or GMT (Mair *et al*., 1995), among others. Tilapia production in the AMSs contributed 43% to world's total tilapia production based on average for the period 2010-2014. The contribution of tilapia aquaculture in the different AMSs, averaged from FAO reported values from 2010 to 2014, is shown in **Tables 4** and **Table 5**. Tilapias contribute as much as 25% both to total aquaculture and freshwater aquaculture production in Lao PDR given that this country has only inland resources. In terms of contribution to total aquaculture production in the AMSs, tilapia only contributes 6.7% in volume and just 2.1% in value. However, in terms of total freshwater aquaculture

Fig. 1. Harvest of Nile tilapia from fish cage in Lake Bato, Camarines Sur, Philippines

Table 4. Contribution of tilapia production to total aquaculture production of AMSs from FAO FishStatJ data (values are averages from 2010-2014 of tilapia production in marine, brackish and freshwater)

Country	Total tilapia volume (MT)	Total tilapia value ('1000 US$)	Contribution to total volume of aquaculture (%)	Contribution to total value of aquaculture (%)
Brunei Darussalam	3.88	18.21	0.7	0.1
Cambodia	2,360.00	3,540.00	2.8	0.5
Indonesia	721,011.53	1,261,717.40	7.0	2.9
Lao PDR	24,816.00	37,032.78	25.0	5.0
Malaysia	43,454.75	95,933.31	7.8	2.3
Myanmar	43,677.78	41,700.60	4.9	0.6
Philippines	43,677.78	414,112.89	1.8	4.0
Singapore	48.41	174.21	1.1	0.2
Thailand	184,863.00	280,141.47	16.2	1.8
Viet Nam	190,110.20	268,353.12	6.2	0.8
TOTAL	**1,254,023.33**	**2,402,724.00**	**6.7***	**2.1***

Note: *comparison to total production only uses data for aquatic animals and excludes seaweeds; *average for the region*

Table 5. Freshwater (FW) tilapia production in AMSs and its contribution to FW aquaculture both in volume and value (values are means from annual production from 2010 to 2014) from FAO FishStatJ data

Country	Total volume of FW aquaculture (MT)	Total value of FW aquaculture ('1000US$)	Total volume of tilapia production in FW (MT)	Total value tilapia production in FW ('1000US$)	Volume contribution of tilapia in FW aquaculture (%)	Value contribution of tilapia in FW aquaculture (%)
Brunei Darussalam	17.64	91.58	3.11	18.11	17.6	19.8
Cambodia	80,063.00	138,068.50	2,360.00	3,540.00	2.9	2.6
Indonesia	2,119,063.81	3,781,539.88	677,548.06	1,191,765.64	32.0	31.5
Lao PDR	99,191.00	148,023.68	24,816.00	37,032.78	25.0	25.0
Malaysia	136,576.63	270,585.13	42,221.26	92,649.34	30.9	34.2
Myanmar	826,648.19	1,158,200.74	42,710.40	40,667.96	5.2	3.5
Philippines	308,673.00	478,620.16	245,557.60	389,652.53	79.6	81.4
Singapore	516.45	2,637.48	48.41	174.21	9.4	6.6
Thailand	425,984.29	759,379.26	184,863.00	280,141.47	43.4	36.9
Viet Nam	2,295,301.80	4,308,533.60	190,110.20	268,353.12	8.3	6.2
TOTAL	**6,292,035.80**	**11,045,680.00**	**1,410,238.03**	**2,303,995.17**	**22.4***	**20.8***

**average for the region*

production, tilapias contribute significantly to the region's aquaculture production at 22.4% in volume and 20.8% in value. The importance of tilapia in each country varies with the Philippines having the highest contribution of tilapias at almost 80% in volume (almost 246 thousand MT) and more than 81% in value (at almost US$ 390 million).

For the AMSs, it is without a doubt that IAS has greatly contributed to production and the economy of the region. As mentioned previously, inland freshwater aquaculture is relatively more accessible to poorer communities than mariculture as it entails less initial start-up costs. Indeed, one can start with a small cage in an inland water body, and expand the operations as more capital becomes available. Another benefit of introduction is for the enhancement of natural water bodies. Even native fish species are not immune from being introduced to other bodies of water where they are not part of the native population. The translocation of native species from one drainage system to another in the same country is a widely accepted method for enhancement of many natural waters around the world (Innal & Erk'akan, 2006). In the Philippines, the endangered tiny goby *Misthichthys luzonensis*, indigenous to Lake Buhi in Camarines Sur, Philippines, has been translocated to another adjacent water body, *i.e.* Lake Manapao which serves as sanctuary (Soliman, 1994). Translocation may be a way of enhancing fisheries productivity, an example of which is the intentional introduction of milkfish *Chanos chanos* in Laguna de Bay, Philippines for the fish pen culture industry. Milkfish is a marine species but with euryhaline characteristics that enable it to be cultured in a variety of aquatic environments, from marine cages to brackishwater ponds to freshwater fish pens (Bagarinao, 1999). The commodity is continuously being produced in a wide range of culture environments, including other lakes in the country because this is a preferred food fish for Filipinos.

Adverse impacts of IAS

Impact on Biodiversity

Introduction and/or translocation of aquatic organisms primarily affect biodiversity in localities of introduction. IUCN (1999) cited that introduction of exotic species is the second leading cause for the loss of biodiversity, after habitat destruction. There are examples of invasive species altering the evolutionary pathway of native species by competitive exclusion, niche displacement, hybridization, introgression, predation, and ultimately extinction (Mooney and Cleland, 2001). Moreover, introduced invasive species are considered the second leading cause of species extinction and endangerment worldwide, after habitat destruction (Williams *et al*., 1989).

Introduced species have far reaching adverse impacts, as in the case of the golden apple snail *Pomacea canaliculata* whose introduction was as alternative protein source for Filipinos. Its introduction to the country has been blamed for the loss of the edible native snail *Pila luzonica* (Pagulayan, 1997). The loss of most of the endemic cyprinids of in Lake Lanao, the third largest lake in the country, has been attributed to the introduction of the white goby *Glossogobius giurus* and the eleotrid *Hypseleotris agilis* (Juliano *et al*., 1989). Furthermore, the introduction of the walking catfish *Clarias batracus* has resulted in the loss of the native bighead catfish *Clarias macrocephalus* in many inland water bodies in the country. Thus, the Philippine-based SEAFDEC Aquaculture Department (AQD) had been implementing R&D activities to breed *C. macrocephalus* (Tan-Fermin *et al*., 2008) in the hope of restocking depleted inland water bodies but difficulties in obtaining wild broodstock for the induced spawning activities has hampered AQD's efforts.

Comparison of the fish biodiversity in an aquaculture and non-aquaculture site in Laguna de Bay of the Philippines, which widely used for fish production, showed that fish biodiversity was significantly lower in the aquaculture site compared to the non-aquaculture site. There was a significantly higher predominance of introduced species for culture (Nile tilapia, bighead carp, and Tra catfish) compared to native species in the aquaculture site. The non-aquaculture site had significantly higher relative dominance of native species. Indices of biodiversity, such as Shannon-Wiener Index, Simpson index and Evenness, all indicate significantly higher fish biodiversity in non-aquaculture sites (Cuvin-Aralar, 2014; 2016). In the same lake, historical fish production records show that prior to aquaculture activities (with introduced species such as milkfish and tilapia) in the 1960s, 70% of fish catch in the lake comprised mainly of native species such as silver therapon (*Leiopotherapon plumbeus*), white goby (*Glossogobius giurus*), Manila sea catfish (*Arius* sp.), and native catfish (*Clarias macrocephalus*).

These same species contributed only 52% a few years after the introduction of aquaculture by 1970s (Delmendo, 1987). This native species were further diminished to just 6.4% of the catch in a localized area used for aquaculture of introduced species (Cuvin-Aralar, 2014; 2016).

Extirpation of native species from introduced species, especially those that are considered invasive, could be mainly due to competition, predation, habitat degradation, and alien pathogens and parasites (Gurevitch and Padilla, 2004; Gozlan, 2010).

Introduction of new pathogens and diseases

Translocation of animals is always associated with significant risks of transmission of pathogenic organisms (Leighton, 2002). Apparently, the healthy Pacific white shrimp, *Litopeneus vannamei* introduced to Asian countries from unreliable sources has resulted in the spread of the Taura syndrome virus (TSV). Taiwan and later Thailand experienced this TSV outbreak in 2003 which affected not only *L. vannamei* population but also that of the local black tiger shrimp *Penaeus monodon* (Phalitakul *et al*., 2006).

Genetic impact of introduced aquatic species

Species introductions also have genetic impacts. This concern is often neglected because it is more difficult to assess than the other more overt impacts of introductions. Hybridization and introgression are among the impacts, where hybridization occurs if individuals of two genetically distinct individuals interbreed, regardless of taxonomic class (Harrison, 1993). Introgression occurs from backcross of hybrids with either or both parents. Although hybridization is said to result in hybrid vigor for hybrids of genetically closely related population, the reverse may be true for hybrids of genetically distant populations. In this case hybridization may result in reduced fitness (Nguyen and Na-nakorn, 2004). In Thailand, the native catfish *Clarias macrocephalus* is the preferred species but due to its slow-growth, it was hybridized with the North African catfish *Clarias gariepinus*. Escaped hybrid catfish from crosses between female *C. macrocephalus* and male *C. gariepinus* were shown to interbreed with wild population of *C. macrocephalus*. Wild *C. macrocephalus* had been found to have hybrid genotypes. The use of introgressed *C. macrocephalus* as broodstock in producing hybrids with *C. gariepinus* by fish farmers threaten the loss of hybrid vigor for growth and disease resistance (Senanan *et al*., 2004). In the natural environment, hybridization does occur but greater risks are posed when native population hybridizes with introduced species due to potential loss of adaptive characteristics, *e.g.* timing of migration and ability to locate natal streams may be lost in the host (native species). Another possibility is the hybrid becomes more successful than the original native species wherein the later will become lost through competition (Welcomme and Vidthayanon, 2003).

IAS as Invasive species

Although many introduced species have negligible effects on native biodiversity, there are a few that will become invasive and have adverse ecological effects (Britton *et al*., 2011). Among the characteristics of an introduced species becoming invasive is a rapid adaptation to new environment. Genetic studies show that it takes 20 generations or less for a new species to adapt to novel environments indicative of the role of evolutionary processes in invasiveness of a species (Prentis *et al*., 2008). The invasive species then achieve "pest" status if this species has no appreciable socioeconomic value (Britton *et al*., 2011). Escapees from the ornamental fish trade like the South American sucker mouth catfish, also known as janitor fish *Pterygoplichthys pardalis* and *P. disjunctivus*, have become invasive in many areas in Luzon including Marikina River and Laguna de Bay (Chavez *et al*., 2006; Jumawan *et al*., 2011) and Agusan Marsh in Mindanao (Hubilla *et al*., 2008). The fish (**Fig. 2**) with its hard armor-like covering inflicted damage to the banks of the Marikina River due to is burrowing habit and damaged the aquaculture fish cages in Laguna de Bay. Considerable expense has been incurred from a "bounty system" type of approach to eradicate janitor fish wherein fishers were paid to catch the janitor fish at PhP5.00/kg, after which the caught fish are destroyed (Joshi, 2006). The fish is considered invasive since it is not considered a food fish, in addition to the aforementioned damage it has been causing. **Fig. 2** shows the janitor fish catch in a fish trap in Laguna de Bay, Philippines. This fish constituted an average relative dominance of 10.4 % and a peak of 64.0% in the Lake, based on catch data from fish traps set in the Lake from 2013 to 2015 (Cuvin-Aralar, 2016).

Fig. 2. South American sucker mouth catfish or janitor fish caught in fish traps in Laguna de Bay, Philippines

The clown featherback *Chitala ornata*, also known as knifefish in the Philippines has also become invasive in Laguna de Bay (**Fig. 3**). The fish was introduced in the country for the ornamental fish trade, although in its native range in mainland Asia, it is considered a food fish. Its introduction in the Philippines was thought to be accidental from lakeshore ponds damaged by typhoons. Fish pen and fish cage owners have

Fig. 3. Juveniles of clown featherback caught in fish traps in Laguna de Bay, Philippines

complained of severe predation of their cultured milkfish and tilapia by the clown featherback when the fish inadvertently enter their cages, resulting in poor harvest. Open water fishers also complain that their catch is being dominated by the clown featherback, in place of the more valuable commodities. Indeed, the claim has been backed by recent findings that this fish had a mean relative dominance of 4.5% and a peak of 68.0% from 2013 to 2015, from fish trap catch data (Cuvin-Aralar, 2016).

As mentioned in the foregoing, among the top freshwater species being farmed in the region is an introduced species, the Nile tilapia *Oreochromis niloticus*. Although many countries have accepted this species as an important aquaculture commodity, there are those that consider the introduction of this species as a nuisance and considered an invasive species (Linde-Arias *et al*., 2008; Angienda *et al*., 2011). Another cichlid, the black chin tilapia *Sarotherodon melanotheron* and the Mayan cichlid *Cichlasoma urophthalmus* introduced in freshwaters in the Philippines has now spread to brackish and marine waters of the country (Ordoñez *et al*., 2015). These two species had successfully adapted way beyond their area of original introduction.

Way Forward

Regulation and Enforcement

The SEAFDEC Regional Guidelines for Responsible Aquaculture in Southeast Asia (Platon *et al*., 2005) includes Article 9.3 on the use of aquatic genetic resources for aquaculture and culture-based fisheries. Under this article, are provisions on introduction of aquatic organisms, *i.e.* "States should recognize the potentially serious impact of introduced species on the local aquatic biodiversity"; and "States should consider a total ban on the introduction of species shown by appropriate risk assessment to be detrimental to local ecosystems." The Guidelines had been formulated and consolidated in consultation with the AMSs and its adoption should be enforced by the countries. Prior to the publication

of the aforementioned Regional Guidelines, some AMSs have already in place limited provisions on introduction of aquatic species.

In the Philippines for instance, the Bureau of Fisheries and Aquatic Resources (BFAR) had issued Fisheries Administrative Order 189 series of 1993 prohibiting the importation of live shrimp and prawn of all stages. However, this ban was lifted to favor the culture of the Pacific white shrimp *Penaeus vannamei* through Fisheries Administrative Order 225, 225-1 series of 2007, and Fisheries Administrative Order 225-2, 225-3 series of 2008. This was meant to address the demand for the entry of this shrimp into the country to save the ailing tiger shrimp (*Penaeus monodon*) that has been devastated by various diseases. Although no other Fisheries Administrative Orders had been issued by BFAR prohibiting the introduction of other species for aquaculture in either the food or ornamental fish industry, it had issued numerous Fisheries Administrative Orders through the years mainly prohibiting or regulating the export of various fisheries commodities as well as establishing fish sanctuaries in various parts of the country. Such regulations should be revived and strictly imposed, and made imperative as aquaculture continues to expand.

Other non-ASEAN countries have in place approaches that strictly regulate exotic introductions, for example, New Zealand has the Hazardous Substances and New Organisms Act (1996) which other countries could follow, as the Act is a comprehensive legislation with clear oversight, especially in terms of exotic introductions, where importers of non-native species must apply to an independent regulatory authority accountable to the country's Environment Ministry and Parliament for public approval (Naylor, 2001). It is a case of guilty until proven otherwise. Thus, all species are considered potentially invasive and therefore entry is prohibited unless proven otherwise.

Risk Assessment

It would be difficult to enforce guidelines and regulations on entry of alien species if there is no clear assessment of risks. Assessment of the potential risk of an alien species should be among the first line of defense against unwarranted effects of introduced species. The Convention on Biological Diversity Biosafety Protocol (also known as the Cartagena Protocol) states that risk assessment should be carried out in a scientifically sound manner, taking into account recognized risk assessment techniques (CBD, 2000: *https://www.cbd.int/doc/legal/cartagena-protocol-en.pdf*). Risk assessment for invasive species is for the purpose of implementing two classes of risk management decisions, *i.e.* introduction of potentially invasive non-native species, their vectors, or conveyances prior to establishment; and decisions regarding the allocation of scarce resources for the control of established invasive species, including rapid response to emerging threats (Andersen *et al*., 2004). In the first case, result of risk assessment would lead to decisions whether to authorize or permit introduction under specified conditions. The second case would involve efforts to address problems and issues after introduction of the invasive species. Appropriate risk management ensures that strategies implemented are commensurate with the level of risk posed by non-native species in the environment (Britton *et al*., 2010). There are some risk management tool available to assess the potential invasiveness of non-native freshwater fishes, such as the FISK (Fish Invasiveness Scoring Kit) which is useful in aiding decision- and policy-makers in assessing and classifying freshwater fishes based on their potential invasiveness (Copp *et al*., 2009).

Focus on Culture of Native Species

Aquaculture in the Southeast Asian region as well as the rest of the world has been largely dependent on introduced species. Reducing the dependence on alien species for aquaculture, and focusing on the domestication of commercially important native species, is the most appropriate means of facilitating the expansion of the industry without the accompanying risks of species introductions (Ross *et al*., 2008). However, this move will have to be supported by the Governments, considering that shifting focus to inland native species with high consumer preference but remain largely unstudied, *e.g.* in terms of biology and culture potential, will require huge investments in time, personnel, and funds. This should follow a research and development track taken by popularly cultured commodities such as tilapias. The Mekong River Commission (MRC) implemented the Aquaculture of Indigenous Mekong Fish Species Project (AIMS) and has undertaken research in Lao PDR on six indigenous fish species, and the results showed the potential for producing fish fingerlings on farms (Hortle *et al*., 2013).

Balance between Ecological Risk and Economic Gains

There is growing populatity in the wholistic approach to the valuation of ecosystem goods and services (Bateman *et al*., 2011) as opposed to valuing an ecosystem, in this case inland waters, based only on its aquaculture and fisheries output. When monetary value is placed on the total ecosystem services provided by inland waters, the realization can be achieved that it provides much more than fishery resources but other goods and services as well, *e.g.* water supply, recreational value, and the incentive for more sustainable development (inclusive of aquaculture and fisheries *vis-à-vis* introduced species). In the aquaculture sector, a model was created for the accounting price of the habitat services provided by a mangrove ecosystem to a shrimp population (Mäler *et al*., 2008). Similar valuation could also be done for inland water bodies. Admittedly, the concept of wealth accounting and valuation of ecosystem services still has much room for improvement and development. Nonetheless,

attempts to calculate the value of environmental services can provide insights into the tradeoffs between market activity and environmental quality that are implicit in the process of economic growth (Howarth and Farber, 2002).

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Increasing Fish Production from Inland Water Bodies through Stock Enhancement: Experience of Thailand

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Old-age proverbs in Thailand: "ในน้ำมีปลาในนามีข้าว" which means "in the waters are fish and in the field is rice" and "กินข้าวกินปลา" which means "eat fish eat rice" imply that fish and rice are very crucial for the daily nutrition of its people. These proverbs also reflect the abundance of resources in the country that are utilized to produce substantial quantities of fish and supply the demand for food fish of its people especially those living in the rural areas as well as for export. In the past, the people of Thailand had been utilizing the country's natural inland waters for fisheries such as rivers, canals, swamps, lakes, and other small water bodies and producing large quantities of freshwater fishes. However, after these fishery habitats had been altered for the sake of progress and development, the fishery resources had been reported to be at the verge of depletion. Meanwhile, uncontrolled fishing activities have also led to overfishing that exacerbates the already depleted fishery resources. In an effort to address the concern on dwindling fishery resources, the Department of Fisheries (DOF) of Thailand embarked on stock enhancement programs which had been adopted throughout the country to revive the status of the country's inland fishery resources. The approach used by DOF is aimed at enhancing the fisheries production from inland water bodies through fisheries law enforcement, habitat rehabilitation, and stocking programs. The experience of DOF and the lessons learned from such efforts are revealed in this article as reported by the authors during the Symposium on Strategy for Fisheries Resources Enhancement in the Southeast Asian Region organized by SEAFDEC in Thailand in July 2015.

Inland Capture Fisheries in Thailand

The development of inland capture fisheries in Thailand has played very significant role in the country's national economies, by ensuring people's food security and stable nutrition, creating livelihoods for rural communities, enhancing local knowledge in sustainable capture fisheries, and increasing the incomes of small-scale fishers. Thailand has been endowed with abundant inland water resources that its people could utilize not only for their daily life activities but also for them to exploit the fishery resources. Pongsri *et al*. (2015) reported that Thailand has 25 river basins which cover a total area of about 511,300 km^2; 12,851,980 ha of flood plains; 645,350 ha of dams and reservoirs; and 965,730 ha of other water bodies that could be tapped to improve the country's total fisheries production from inland capture fisheries. Ingthamjitr and Boonsong (2016) also reported that large areas of swamps and lakes are found in 36 sites throughout the country, and that small water bodies are abundant in more than 14,000 locations in the country.

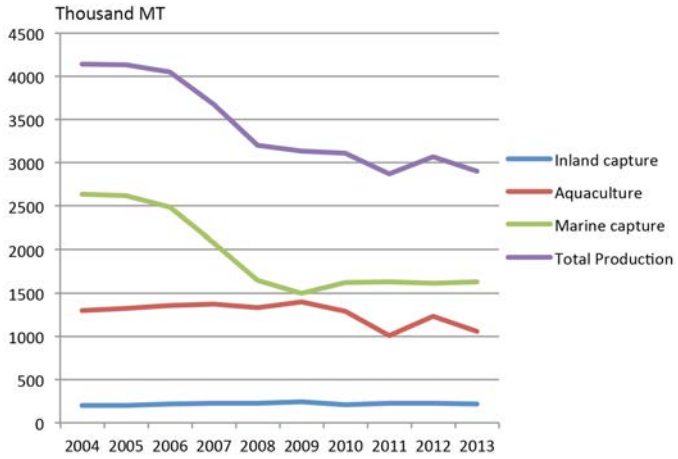

Fig. 1. Trend of fisheries production of Thailand during the ten-year period from 2004 to 2013

Sources: *SEAFDEC (2010); SEAFDEC (2015)*

Although advanced fish culture technologies led to increased production from aquaculture, inland capture fisheries although growing slowly, has always sustained its role in providing cheap protein for the rural poor in remote areas. However, it has become alarming that the total fisheries production of Thailand has been decreasing during the past ten years or so (**Fig. 1**). Specifically, the country's production from marine capture fisheries had decreased sharply although aquaculture production has been increasing substantially (**Table 1**). Nevertheless, there is much potential for increased production from inland capture fisheries which has experienced minimal increases during the past ten years, considering the country's

Table 1. Total fisheries production of Thailand (in thousand metric tons (MT)), 2004-2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Inland capture	199.6	198.8	214.0	225.6	228.6	245.5	209.8	228.5	222.5	213.7
Aquaculture	1,301.5	1,318.4	1,353.0	1,370.4	1,330.8	1,396.0	1,286.1	1,007.9	1,233.8	1,056.8
Marine capture	2,636.0	2,615.6	2,484.8	2,079.4	1,644.8	1,496.2	1,617.4	1,633.7	1,612.1	1,630.1
Total Production	**4,137.1**	**4,132.8**	**4,051.8**	**3,675.4**	**3,204.2**	**3,137.7**	**3,113.3**	**2,870.1**	**3,068.4**	**2,900.6**

Sources: *SEAFDEC (2010); SEAFDEC (2015)*

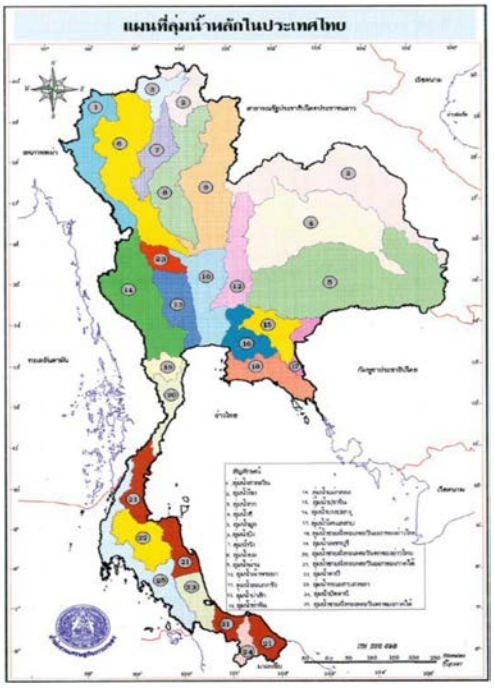

Fig. 2. Map of Thailand showing the locations where stock enhancement activities are being carried out by DOF

vast inland water resources, which could be tapped for sustainable exploitation.

Efforts have therefore been exerted by the Government of Thailand to increase production from inland water bodies through the implementation of stock enhancement programs spearheaded by the Department of Fisheries (DOF) of Thailand, and implemented throughout the country as shown in **Fig. 2**. The stock enhancement programs focus on three strategies, namely: law enforcement, habitat rehabilitation, and stocking or restocking.

Issues and Concerns

While the country's abundant fishery resources had in the past, adequately supplied the demand for food fish of Thailand's rural populace, infrastructure developments seem to have impacted on the sustainability of inland fish habitats and resources. It is alarming that with such developments, Thailand's fish supply might not be able to provide the nutrition that its people need especially those in remote rural areas, considering that the country's population had increased from 25 million to 65 million during the last decade. Increasing the production from inland capture is however confronted with many challenges including habitat alteration, overfishing, genetic alteration, interpretation of the national fisheries law, and climate change. Unsustainable production from inland capture fisheries would adversely impact the rural poor who rely on the natural aquatic resources for their livelihoods. Therefore, the potentials of inland fishery resources for development should not be overlooked as these could supply the food fish required by the growing population.

Nonetheless, the factors that influence the sustainable production from inland fisheries should be considered in planning and policy formulations, in order to sustain and/or enhance the production, *e.g.* appropriate management for the complex interaction of physical, chemical and biological conditions and fishing practices.

These three approaches generally adopted for sustainable fisheries management should therefore be considered, namely: compliance with fisheries regulations such as gear and size restrictions, seasonal closures, limitation on entry, paying of tax levies and property rights; habitat rehabilitation to increase and/or recover available habitats and/or access to key habitats for at least some life stages of a target species which could be accomplished by improving connectivity in rivers, *e.g.* construction of fish passage, reconstruction of fish habitats, installation of artificial habitats/reefs; and stock enhancement.

Pawaphutanon (1988) reported that stock enhancement is one of the most successful techniques for fisheries management, where stock enhancement could also include not only the aspect of manipulating fish stocks by adding some materials of desired species but also stocking or restocking water bodies to improve their productivity and conserve biodiversity. In the Southeast Asian region, stock enhancement of aquatic species for restocking is generally associated with traditional and religious ceremonies such as merit-making on birthdays, new-year celebrations and many other special occasions. Nevertheless, aquatic animal restocking could be promoted more widely and intensively if fish hatcheries are able to produce considerable volumes of seed stocks of various aquatic species. Furthermore, stock enhancement would only be effective only if the related challenges and concerns are addressed and properly managed.

Stock Enhancement Program of Thailand

In carrying out the activities under the country's stock enhancement program, DOF has been collaborating with various stakeholders including the Tambon (Local) Administrative Organizations (TAOs), provincial fisheries stations and offices, the Electricity Generating Authority of Thailand (EGAT), private sector involved in inland fisheries development and other government agencies that have also been doing independent stock enhancement programs. Together with the stock enhancement program, DOF has also been promoting various projects to demonstrate the sustainable utilization and management of the fishery resources in inland water bodies, *e.g.* Village Fisheries Project, School Fisheries Project, *Bamrung Phan Pla Pracha-arsa* Project (Participatory Voluntary Fish Stock Enhancement Project), Small Water Bodies Rehabilitation for Fisheries Project, Large Water Bodies Fisheries Development Project, Seed Production for Stocking Project. In order to support the massive requirements for seeds, breeding activities in several

Table 2. Number of seed stocks released for stocking several inland water bodies of Thailand (2006-2014*)

Year	Freshwater Fishes	Giant Freshwater Prawn	Frog	Turtle	Total
2006	1,227,566,543	309,042,080	1,500	85	**1,536,610,208**
2007	1,152,855,640	295,722,850	115,740	291	**1,448,694,521**
2008	1,117,229,393	340,943,455	100,000	308	**1,458,273,156**
2009	1,111,075,907	356,846,990	129,500	245	**1,468,052,642**
2010	1,019,923,981	336,838,200	261,000	179	**1,357,023,360**
2011	1,030,291,348	325,604,747	7,414,647	113	**1,363,310,855**
2012	1,004,187,891	327,280,910	5,211,050	233	**1,336,690,084**
2013	994,347,245	330,764,000	8,681,450	392	**1,333,793,087**
2014*	713,126,794	260,634,150	6,147,000	409	**979,908,353**
Total	**9,370,604,742**	**2,883,677,382**	**28,061,887**	**2,255**	**12,282,356,266**

**number is for 10-month stocking operations only*

fisheries stations all over the country have been intensified. In fact, throughout the years, the annual stocking program of DOF recorded that billions of seeds had been released for stocking in inland water bodies. As shown in **Table 2**, more than 1,333 million seeds of 59 aquatic species had been released in 2013, which include 53 freshwater fish species, six species of frogs, turtles, and giant freshwater prawn.

The progress of the stock enhancement programs had been closely followed up by DOF while the impacts of the programs have been assessed since 1985. Results have indicated overall positive impacts on the sustainable development of the country's inland fisheries. This is considering that the stock enhancement programs being promoted by DOF cover not only restocking inland water bodies but also habitat rehabilitation and law enforcement. Stock enhancement can be carried out using a number of approaches depending on conditions of particular water bodies. Based on the experienced of Thailand, law enforcement on illegal fishing has been successfully promoted in the Yom River Basin, while stocking large number of the giant freshwater prawn has been successful at Pak Mun Dam and community-based fisheries management has been effective at Ubol Ratana Reservoir. These stock enhancement achievements, however, had been greatly influenced by the active participation of local communities that comprise the core aspect in fisheries management.

Lessons Learnt from the Stock Enhancement Program of Thailand

Combating illegal fishing in Yom River Basin

Yom River (**Fig. 3**) originates from the mountain range in the north of Thailand and flows through agricultural and communities' plain areas in the lower northern part of the country. Yom River is a main tributary of Nan River that flows into the Chao Phraya River and is the only main river which has no dam impoundments. Since flood always occurs at the

Fig. 3. Yom River in Thailand

lower part of the Basin during monsoonal season, flood plain is created covering an area of 500,000-600,000 rai (80,000-96,000 ha) which serves as significant spawning and nursing grounds for various aquatic species. However, it has been observed that illegal fishing gears had been operating in the Basin, *e.g.* large stationary bag net, small stationary bag net, push net, and giant lift net, and such operations had been increasing during the past years.

These destructive fishing gear operations result not only in decreasing fish abundance but also creating unfair exploitation of the fishery resources that increased the conflicts among the resource users. Through its project implemented in 2008-2011, DOF managed to reduce the number of destructive fishing gears in the Lower Yom River Basin. Stock enhancement was initiated on the first year of the project with the involvement of government agencies and enhanced participation of local administration agencies, communities and fishers. The project was mainly aimed at reducing fishing effort while research was conducted to assess the stocks of the fishery resources and catch production of different types of fishing gears operating in the Basin (**Fig. 4**), *i.e.* 123 units of large and small stationary bag nets, 40 units of giant push nets, 30 units of giant lift nets, 22 units of small bag nets, 25 units of bamboo fence installations, and 8 electro-fishing equipment.

Fig. 4. Samples of illegal structures in Yom River: giant lift net (above) and bush-park (below)

Prior to the assessment, the project focused on reduction of fishing effort based on an agreement with fishers to reduce the use of large stationary bag nets by 25% during 3-12 December 2008. The results in 2009 showed that the fisheries production increased by 84,000 kg which is equivalent to 12.20 million fish fingerlings that were saved from the 25% reduction of fishing effort of the large stationary bag nets (**Table 3**). The value of the increased production could be about 2.55 million Baht at conservative level while the maximum value could reach up to 12 million Baht. From 2009 to 2011, the project tried to reduce the number of illegal fishing gear operations by training fishers on participatory fisheries management, developing collaborative fisheries management plan with the participation of government agencies and fisheries communities, strict enforcement of regulations and tougher punishment, buying-back of large stationary bag nets, providing support in construction of fingerlings and cage culture facilities to those volunteering to stop the use of large stationary bag nets, and developing the fish habitats for fish broodstock conservation purposes.

Stocking of giant freshwater prawn in Pak Mun Dam

Located in Ubon Ratchathani Province, Pak Mun Dam was constructed in 1994 to impound the Lower Mun River stretch. The dam is located about 4-5 km away from the confluence of the Mun and Mekong Rivers. An apparent decrease in fish abundance was observed due to the obstruction of fish migration of aquatic species from the Mekong River to the Mun River (**Fig. 5**).

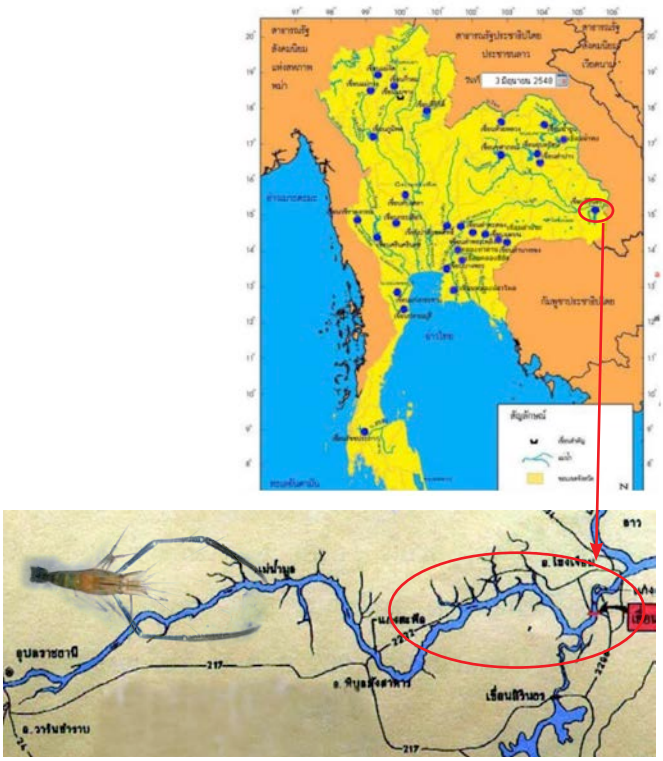

Fig. 5. Pak Mun Dam restocked with giant freshwater prawn and other economically important fish species

Fish ladder was installed at Pak Mun Dam as an attempt to facilitate fish migration but the design appeared inefficient. For years, local fishers who had been encountering the negative impacts from the dam-impoundment through the communities' Poor Association, asked the Government that their concerns on the decreasing fishery resources should be addressed. As a solution, the Government announced a compromised solution in 2003 by regulating the dam operations, *i.e.* closing for 8 months to generate electricity and opening for 4 months

Table 3. Preliminary results of the stock enhancement program in Yom River

Project Operation Period	Results				
2008-2009	• 25% reduction in fishing effort of giant stationary bag nets • 12.2 million fingerlings survived and increased in natural stocks				
2009-2010	**Stationary Bag Net**	**Small Bag Net**	**Purse Net**	**Giant Lift Nets**	**Electro-fishing**
Existing number in 2008	123	22	40	30	8
Target reduction (%)	73%	50%	50%	25%	95%
Target reduction (number)	32	11	20	22	8
2011 (total number left)	0	0	35	27	0

Table 4. Stocking of giant freshwater prawn in Pak Mun Dam, Ubon Ratchathani Province, Thailand

Year	Number stocked (million/year)	Cost (USD)	Catch/Landing (kg)	Value of Catch (USD)	Recapture (%)	Return of Investment
1995-1998	5	19,110	11,675	113,827	**1.0%**	**5.96**
2003-2006	40	182,000	90,108	1,062,000	**2.4%**	**5.84**

during fish migration period to allow the migratory fish to enter Mun River from the Mekong River. The Government also assigned EGAT in collaboration with DOF to enhance the fisheries production at the lower Mun River stretch by stocking 50 million fingerlings or juveniles of aquatic species annually for 5 years from 2003 until 2007. In response, DOF stocked 40 million giant freshwater prawns and another 10 million of economically important freshwater fishes annually during that particular period. Post stock assessment revealed an apparent increase in production, especially the production of giant freshwater prawn with recapture rate of about 2.4% (**Table 4**). Moreover, prawn production accounted for more than 90 metric tons during the 8-month culture period, valued at 35 million Baht with return of investment of about 584%.

Community-based fisheries management in Ubol Ratana Reservoir

Located in Khon Kaen Province of Thailand, Ubol Ratana Reservoir is a multi-purpose dam constructed in 1966 and was the first hydro-electric power project developed in the north-eastern part of Thailand (**Fig. 6**). The annual fish production in Ubol Ratana Reservoir had showed a declining trend over the past 40 years. Specifically, the annual catch production decreased after 12 years of operation of the impoundment. The CPUE (kg/boat/day) in the wet season is less than that of the dry season. Two measures were employed for fisheries management to mitigate the situation, *i.e.* closed season (16 May -15 September) and mesh size limitation (not less than 2.5 cm). However, trend of the catch continued to decline year by year, so that in 2009, the catch was only about 21.4 kg/ha/yr and with very high fishing effort. More than 5,000 fishing households in 101 villages are located around the Reservoir.

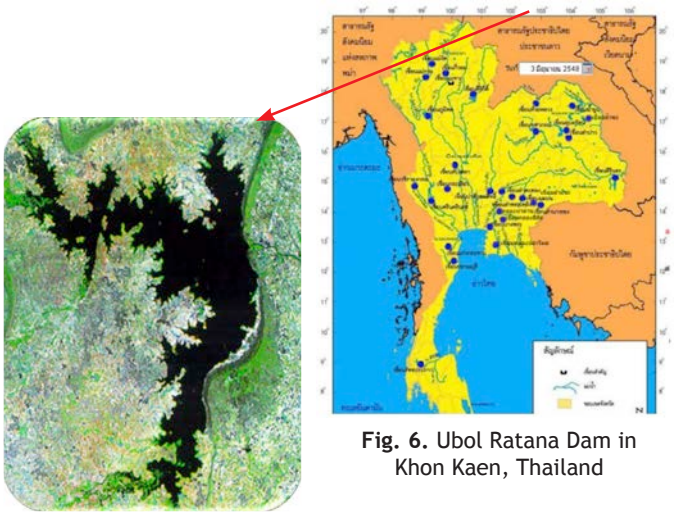

Fig. 6. Ubol Ratana Dam in Khon Kaen, Thailand

In an effort to mitigate the issue, DOF introduced Community-Based Fisheries Management in the Ubol Ratana Reservoir since 2009 to improve the fish habitats with the involvement of local communities and government agencies.

The project was intended to encourage relevant stakeholders to participate in the fisheries management of the Reservoir, especially the Tambon Administrative Organizations (TAOs), resource users and government agencies, by co-managing the Reservoir's fishery resources. The 3-year project (2009-2011) commenced by organizing a stakeholders' meeting for the development of the project management plan with fisheries resources enhancement as the ultimate goal.

During 2010–2011, DOF established 30 Fish Conservation Zones (1 habitat/village) in the Reservoir to increase the fish sanctuary area for broodstock enhancement. Together with fish habitats construction, restocking was introduced to enhance the fish production. Since then, fish production had markedly increased in 2010 and 2011 as results of the new fisheries management strategies introduced (**Fig. 7**).

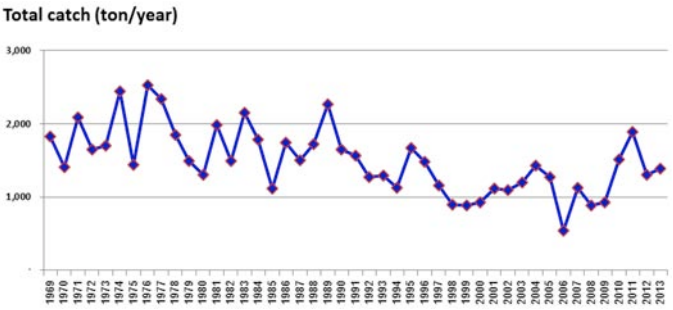

Fig. 7. Trend of fish production in Ubol Ratana Dam, Khon Kaen, Thailand

Conclusion

In summary, it could be gleaned from the stock enhancement programs of Thailand that changes in production from inland capture fisheries because of various reasons could have adverse impacts on the livelihoods and food supply of the rural communities especially the rural poor. Stock enhancement is therefore necessary to maintain the productivity of inland water bodies, in order that the rural poor would have something to rely on. However, the strategies to enhance fish stocks would depend largely on the conditions of particular inland water bodies, hence the need to conduct environmental

studies the results of which would serve as scientific evidence for stock enhancement activities. Moreover, participatory approach through co-management should be promoted as it is the key element in successful stock enhancement programs.

Recommendations and Way Forward

Wild capture fisheries could tremendously impact on the livelihoods of peoples especially the rural poor in remote areas near river basins. Basin-wide fisheries management has been promoted worldwide and among the strategies promoted under such management is fisheries stock enhancement, which is always taken as a top priority. Basin-wide fisheries management include water management as well as management of the other concerned sectors and stock enhancement, and is also sometimes known as integrated water resources management (IWRM). For effective IWRM, data and information together with knowledge on hydrology, aquatic ecology and fish biology associated with each type of water, are crucial in undertaking appropriate planning and implementing such plans. In this regard, human resource and institutional capacity building is necessary, particularly enhancing the capability of stakeholders in planning and implementing basin-wide fisheries management. Fisheries law and regulations to control illegal fishing is necessary but law enforcement alone does not function completely due to limitation of budget and number of officials required. Therefore, fisheries co-management with participation of local communities in fishery resources management is the best option, as it has shown its effectiveness and efficiency in many pilot areas. In addition, compliance with laws and regulations and effective enforcement are essential factors for successful fish stock enhancement.

As noticed worldwide, fish habitats and species diversity of aquatic animals, the essential basic elements for fisheries production, have been deteriorated by a number of influential factors including basin development projects and natural phenomenon like climate change. Holistic approach of basin development through IWRM is a promising strategy in order to maintain and/or increase fisheries production from inland water related activities and optimize their potentials. Stocking and/or restocking aquatic species will continue its crucial role in stock enhancement but focus on the stocking or restocking of indigenous aquatic species is highly recommended

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Enhancing the Fishery Resources in Philippine Lakes:
The Philippine National Inland Fisheries Enhancement Program

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This article is based on the paper presented by Dr. Adelaida L. Palma during the Symposium on Strategy for Fisheries Resources Enhancement in the Southeast Asian Region organized by the Southeast Asian Fisheries Development Center on 27-30 July 2015 in Pattaya, Thailand. In her paper, Dr. Palma discussed the efforts of the Philippines through its Bureau of Fisheries and Aquatic Resources (BFAR) – Inland Fisheries Technology Center (IFTC) in enhancing fish production from 36 lakes and reservoirs in the sixteen regions of the country. Specifically, BFAR-IFTC conducts research and develops rehabilitation measures for indigenous freshwater fish species, *e.g. Leiopotherapon plumbeus*, *Anabas testudineus*, *Clarias macrocephalus*, *Ophicephalus striatus*. As part of the promotion of its initiatives, BFAR-IFTC established a network of private hatcheries to sustain the fish fingerling requirements. A prototype model of such initiatives is the physical restoration and reconstruction of the fisheries in 7-ha Dagatan Lake.

The Philippines embraces more than 80 lakes with a total area of more than 200,000 ha (Palma, 2016), 10 of which could be considered major lakes in view of their surface areas and economic importance (**Box 1**, **Fig. 1**). In addition, there are about 106,330 ha of swamplands, 19,000 ha of reservoir and dams, and 31,000 rivers with total area of approximately 10,892,300 ha (Pongsri *et al*., 2015). These resources host some 340 freshwater fishes (Fishbase, 2015), 16% of which

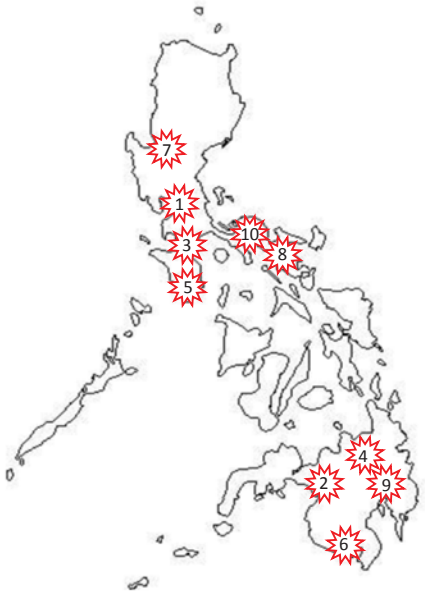

Fig. 1. Map of the Philippines showing the 10 major lakes of the country

Box 1. Ten major lakes in the Philippines

1	**Laguna de Bay**: Total area: 93,000 ha; depth: 2.8 m; located in Luzon Island of the Philippines. Third largest freshwater lake in Southeast Asia; and hosts 34 species of zooplanktons and 33 fish species, 14 of which are indigenous and 19 are exotic or introduced.
2	**Lake Lanao**: Located in Lanao del Sur in Mindanao Island; surface area: 34,000 ha; maximum depth: 112 m: one of the 15 ancient lakes in the world; home to 18 endemic species of cyprinid fish and 42 endemic freshwater crab species.
3	**Lake Taal**: Located in the Province of Batangas; surface area: 23,420 ha; maximum depth: 198 m; at center lies a volcano island with its crater lake considered as the world's **"largest lake on an island in a lake on an island;"** host to the world's famous freshwater sardine (*Sardinella tawilis*) locally known as *tawilis*.
4	**Lake Mainit**: Located in northeast Mindanao and bounded by Surigao del Norte and Agusan del Norte Provinces; surface area: 17,340 ha; maximum depth: 223 m; haven to 12 species of fish, 2 of which are endemic, *i.e. bolinao* (*Neostethus thessa*) and *baguan* (*Hypseleotris agilis*).
5	**Lake Naujan**: Located in the Island of Mindoro; surface area: 8,125 ha; lowest depth: 50 m; habitat of the endangered freshwater crocodile (Crocodylus mindorensis) and several commercially important species of fish, *i.e. Mugil dussmiere* (local name: banak), *Chanos chanos* (milkfish or bangus), *Caranx sexfasciatus* (talakitok), a species of shrimp (*Atya* sp.) and bivalve *Corbiculla* sp. (*tulya*).
6	**Buluan Lake**: Bordered by Maguidanao and Sultan Kudarat Provinces; surface area: 6,134 ha; elevation: 4.3 m; home to the country's nine commercially important fish species, *i.e.* climbing gourami (*Anabas testudineus*), snakehead murrel (*Channa striata*), milkfish (*Chanos chanos*), walking catfish (*Clarias batrachus*), common carp (*Cyprinus carpio carpio*), sundari bele (*Glossogobius giuris*), Mozambique tilapia (*Oreochromis mossambicus*), spotted barb or common barb (*Puntius binotatus*), snakeskin gourami (*Trichopodus pectoralis*).
7	**Pantabangan Lake**: Earth-filled embankment on Pampanga River, located in Nueva Ecija Province; surface area: 5,293 ha; elevation: 232 m; provides water mainly for irrigation and hydro-electric power generation.
8	**Lake Bato**: Located in Camarines Sur Province; surface area: 2,810 ha; depth: 8 m.
9	**Pulangi Lake**: Artificial lake created by a Hydroelectric project on the Pulangi River in Bukidnon Province; Area: 1,985 ha.
10	**Lake Buhi**: Located in Camarines Sur Province; surface area: 1,707 ha; average depth: 8 m; one of the few habitats of the world's smallest commercially-harvested fish *Mistichthys luzonensis* (local name: *sinarapan*)

Table 1. Total fisheries production of the Philippines (in thousand metric tons (MT)), 2004-2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total Production	**3,926.2**	**4,161.9**	**4,412.2**	**4,711.0**	**4,964.7**	**5,084.7**	**5,155.7**	**4,973.6**	**4,865.7**	**4,695.4**
Marine capture	2,067.1	2,122.2	2,514.8	2,327.8	2,377.5	2,418.8	2,424.5	2,171.8	2,145.2	2,127.4
Aquaculture	1,717.0	1,895.9	2,092.3	2,214.8	2,407.7	2,477.4	2,545.8	2,608.1	2,524.7	2,373.4
Inland capture	142.1	143.8	165.1	168.4	179.5	188.5	185.4	193.7	195.8	194.6

Sources: *SEAFDEC (2010); SEAFDEC (2015)*

are endemic, 56% indigenous and 28% exotic. In spite of such vast resources, the country's fish production from inland capture fisheries in 2013 comprised only about 4% of its total fisheries production (SEAFDEC, 2015). An analysis of the inland fisheries production trend of the Philippines (**Fig. 2**) during the past ten years (2004-2013) shows that production stagnated to an average of about 190,000 metric tons (MT) per year (**Table 1**).

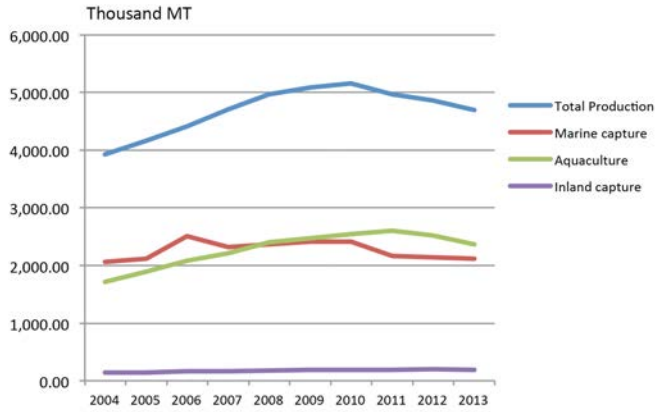

Fig. 2. Total inland fisheries production of the Philippines compared with the country's total fisheries production (2004-2013)

Sources: *SEAFDEC (2010); SEAFDEC (2015)*

BFAR National Inland Fisheries Enhancement Program

Based on the abovementioned information, production from the country's inland water resources could be lower than 50 kg/ha/year. Considering that these resources could provide the nutritional requirement through food fish for the poor rural people, the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) embarked on an ambitious program of rehabilitating and/or restoring the physical conditions of lakes and reservoirs, specifically focusing on minor lakes as their development had been mostly overlooked or to some extent abandoned for low economic returns. Known as the National Inland Fisheries Enhancement Program (NIFEP), this initiative is mainly aimed at restoring the conditions of lakes to optimize their economic benefits; enhancing the fisheries towards sustainability to alleviate poverty in rural areas; and repopulating indigenous species in support of biodiversity conservation and food sufficiency.

A 5-year program, NIFEP applies scientific approach to fish stocking utilizing the vacant-niche and the food-base approach to maximize production from these resources. This food-base approach explores the natural productivity of lakes and reservoirs, where the available natural food is analyzed qualitatively and quantitatively, and its production capacity is converted into fish production, where the natural food present is matched with the species of fish to be stocked. NIFEP comprises five main components, namely: (1) Social Preparation and Capacity Building — organization of the management teams comprising a national coordinator, regional focal persons and technical support staff; and strengthening of the fisherfolk beneficiaries; (2) Resource Profiling — validation of project sites, upgrading of Regional Water Quality Laboratories, and water quality and productivity profiling; (3) Habitat Restoration — clearing of aquatic weeds and buffer zone rehabilitation; (4) Rationalized Fisheries Enhancement (using the food-base approach to open water stocking) — establishment of habitat structures as specific management areas in coordination with local government units, and introduction of culture-based open water fisheries; (5) Monitoring and Evaluation — making use of fish production/catch survey.

Ongoing Inland Fishery Resources Enhancement Activities of NIFEP

As of 2015, the fishery resources in 16 lakes, reservoirs and dams, and six river sanctuaries have been rehabilitated for additional fish production from inland capture fisheries. These are located in Cordillera Administrative Region (CAR) - 2, Region II - 1, CARAGA Region - 2, Region IV-A or CALABARZON Region - 11, and 6 river sanctuaries also in CALABARZON Region (**Table 2**). The major activities carried out in these areas include water quality monitoring, promotion of sustainable culture management, restocking and stock enhancement, repopulation of indigenous fish species, habitat restoration, control of invasive and introduced species, and establishment and/or maintenance of fish refuge, among others. NIFEP is targeting to expand its activities to other lakes, reservoirs, dams and rivers in the near future (**Fig. 3**).

Table 2. Current activities of NIFEP (As of 2015)

Region	Lakes and Dams	Activities
Cordillera Administrative Region (CAR): Abra, Benguet, Ifugao, Kalinga, Mountain Province, and Apayao	Ambuklao Dam and Binga Dam, Benguet Province	• Water quality monitoring • Culture Management • Open water stocking • Repopulation of indigenous fishes
Region II (Batanes, Cagayan, Isabela, Nueva Vizcaya, and Quirino)	Magat Dam, Isabela Province	• Water quality monitoring • Establishment of Magat Inter-agency Task Force • Development of Aquapark to promote culture management • Open water stocking • Repopulation of indigenous fishes
CARAGA Region (Agusan del Norte, Agusan del Sur, Surigao del Norte and Surigao del Sur)	Lake Mainit, Surigao Province	• Management of Goby Fisheries • Capacity Building
	Lake Mahucdam, Surigao	• Water quality profiling • Proposed establishment of brush park • Open water stocking
Region IV-A or CALABARZON (Cavite, Laguna, Batangas, Rizal, and Quezon)	Bal-on Reservoir, Quezon Province	• Habitat restoration
	6 River sanctuaries, Rizal Province	• Maintenance of fish refuge • Open water stocking
	Laguna de Bay, Rizal	• Maintenance of Municipal fish sanctuaries • Control of invasive species
	7 lakes of San Pablo City and Tadlak Lake in Laguna	• Capacity Building • Open water stocking
	Dagatan Lake, Quezon Province	• Habitat restoration • Buffer zone rehabilitation • Water quality monitoring • Maintenance of fish refuge • Fisheries repopulation

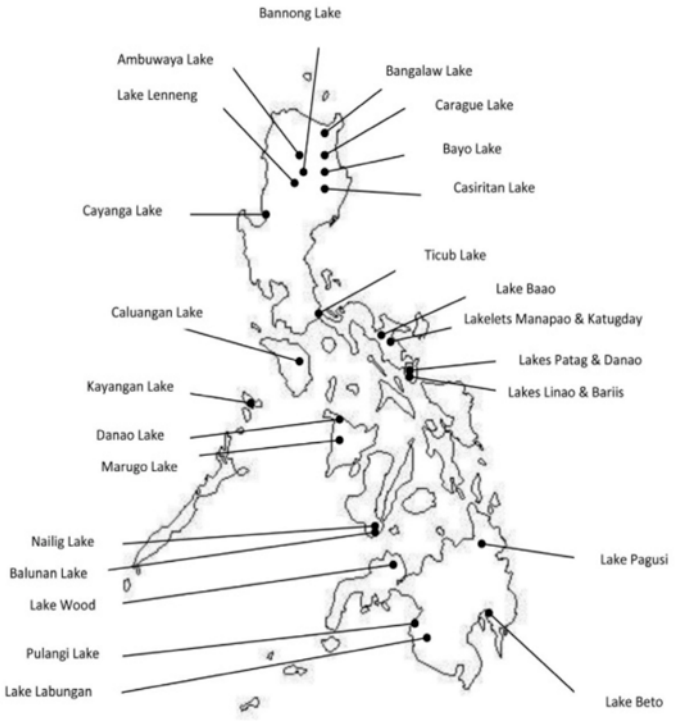

Fig. 3. Map of the Philippines showing the additional sites targeted by NIFEP for resource enhancement (Palma, 2016)

Constraints and Challenges Encountered by NIFEP

During the implementation of inland fishery resource enhancement activities in more than 15 lakes, dams, reservoirs, and river sanctuaries, NIFEP was confronted with various issues and concerns. These include: conflicting legal and juridical mandates between BFAR and the local government units (LGUs) which need to be harmonized; inadequate management skills among fisherfolk that necessitated intensified capacity building; insufficient supply of fingerlings for restocking which calls for the intensification of hatchery activities and networking of existing hatcheries;

Fig. 4. Fisheries in Dagatan Lake, Quezon Province, Philippines (Palma, 2016)

Box 2. Strategies being adopted by the NIFEP of BFAR-IFTC

- Establishment of a national center for indigenous fishes
- Establishment of gene bank for commercially important indigenous fishes.
- Development of breeding protocols for low trophic species
- Repopulation, management and conservation of indigenous fishes
- Development of a network of satellite regional government hatcheries and private hatcheries to supply the fingerling requirements

source of indigenous aquatic species which requires the conduct of surveys; and inaccessibility of the activity sites.

Nevertheless, NIFEP was able to take off and is now working on more than 15 sites with more sites targeted for its future activities. Furthermore, in order to address the aforementioned constraints, NIFEP has adopted several strategies and interventions as shown in **Box 2**.

Using the scheme that had been developed for the implementation of NIFEP, rehabilitation of the fishery resources in Dagatan Lake could be considered successful. Dagatan Lake used to be a thriving water body with rich resources. Specifically, the Lake was once home to economically important freshwater fishes, *i.e.* swamp eel, snakeskin gourami, common carp, tilapia, snakehead, and the native Asian catfish (**Fig. 4**). However, through the years, growth of abundant vegetation was left uncontrolled that choked the fish and other aquatic organisms in the Lake. With economic benefits almost nil, the Lake was eventually abandoned.

Restoring Dagatan Lake and its Fisheries - A success story

Dagatan Lake is a 7-ha freshwater lake located at 13°44' N and 121°18' E in San Antonio, Quezon Province, Luzon Island, Philippines. In spite of its small size, the Lake plays a significant role in biodiversity being one of the last remaining frontiers for some indigenous freshwater fishes, most especially the native Asian catfish *Clarias macrocephalus*. Thus, the need to rehabilitate the Lake which for sometime was abandoned when it was covered with thick aquatic vegetation (**Fig. 5**) that posed serious problems on the conservation of the native catfish species and prevented any economic activity.

Fig. 5. Dagatan Lake before rehabilitation took place (Palma, 2016)

The physical restoration of Dagatan Lake and the reconstruction of its fisheries were the serious challenges encountered by the NIFEP, and called for the harmonization of the legal and juridical mandates between BFAR as the national agency mandated under the Philippine Fisheries Code for the management and conservation of the fishery resources; the Local Government Unit of Quezon Province which has jurisdiction over the management of Dagatan Lake under the Philippine Local Government Code; and the fisherfolk beneficiaries. The series of consultations among the concerned stakeholders resulted in collaborative efforts which facilitated in pooling of funds and resources, mobilization of the local communities, and application of technical tools to revive Dagatan Lake to its natural physical state.

The objective of such effort was to reconstruct the fisheries in Dagatan Lake through a system of managed open water stocking of indigenous fishes, improvement of the coastal buffer zone by the planting of freshwater mangroves, and organization of the Municipal Fisheries and Aquatic Resource Management Council for capacity building. As a result of the restoration and community management of Dagatan Lake, its fisheries had been revived, while its water resource services had also been expanded to provide irrigation and the development of eco-tourism activities.

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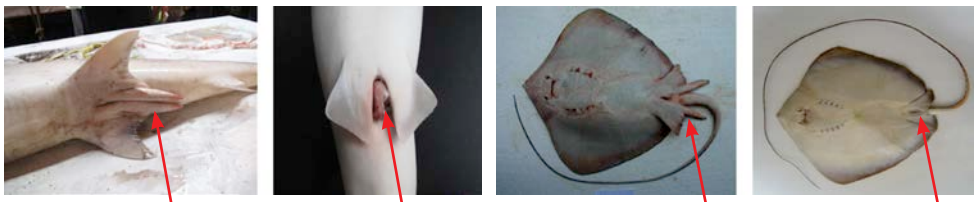
Application of Standard Operating Procedures for Collecting Data on Sharks and Rays in Southeast Asian Countries

Worawit Wanchana, Ahmad bin Ali and *Sukchai Arnupapboon*

The increasing pressure from international community to list several commercially-captured shark and ray species in the CITES Appendices has caused grave concern for many Southeast Asian countries. In their efforts of developing their respective management plans for sharks and rays, the ASEAN Member States (AMSs) sought the assistance of SEAFDEC in species identification of elasmobranches as this is a fundamental step in efficient data collection and in the development of effective management measures for these species which are considered economically important in the Southeast Asian region. In response, SEAFDEC implemented a one-year SEAFDEC Regional Project on Sharks and Rays Data Collection which was financially supported by the Government of Japan (through the SEAFDEC Secretariat and MFRDMD) and the European Union (EU) through the CITES Secretariat. The one-year Project activities implemented from 2015 to 2016, were aimed at strengthening the expertise and capacity of the AMSs in species identification and compilation of biological data on sharks and rays for better management, conservation, and enforcement of the necessary management measures, and were carried out in pilot countries of the ASEAN, namely: Cambodia, Indonesia, Malaysia, Myanmar, Thailand, and Viet Nam.

The Southeast Asian waters have been reported to embrace the richest elasmobranch diversity in the world. However, the status of these resources and their utilization remain vague due to inadequate data on catch landings at species level. In addition, marketing, trade and utilization data are also very limited due to the inability of the countries to collect and compile the necessary data. Such limitations led to the difficulties encountered by many ASEAN Member States (AMSs) in carrying out stock assessment, fishers dependencies of sharks and rays as well as, and developing management measures for these economically-important species (Wanchana *et al*., 2016). Nevertheless, in an effort to help out the AMSs address their concerns and comply with international requirements to avoid the possible listing of these species in the CITES Appendices, SEAFDEC launched a one-year project on sharks and rays data collection in Southeast Asia. Supported by the Japanese Trust Fund and the European Union, the SEAFDEC Regional Project on Sharks and Rays Data Collection was initially implemented in seven AMSs as pilot countries, namely: Cambodia, Indonesia, Malaysia, Myanmar, Thailand, Viet Nam, and the Philippines. However, the latter country was not able to complete the one-year data collection process of the Project as planned. During the implementation of the Project, the Standard

Box 1. Main Features of the Standard Operating Procedures (SOPs) on Sharks Data Collection in Southeast Asia

Approach	Procedure
Sampling at Landing Sites	• **Identification of landing sites** - Select the major landing sites/jetties of sharks and rays, which must be accessible to enumerators, must have good working condition/space area to record length-weight of sharks and rays specimens, and there must be good support, cooperation and communication with local fishers, traders and boat owners • **Compilation of information at selected landing sites** - Determine how many sites/jetties are suitable for data collection - Identify and record the main fishing gears used for catching fish landed at the jetties, *e.g.* gillnet, longline, trawl - Identify and record the main fishing gears used for catching sharks and rays landed at the jetties, *e.g.* gillnet, longline, trawl - Identify other fishing gears used for catching sharks and rays, *e.g.* bottom gillnet, traps, miscellaneous (harpoon, spear, etc) - Record data on fishing operations, *i.e.* how many days per trip of each fishing operation, length of trawling time - Record the time when all catches are landed • **Sampling techniques** - Sample size: target is 1-3 fishing boats per day (fishery profile of study sites is necessary for choosing the sample boats) - Sampling days: five days per month (although countries are encouraged to collect landing data more than 5 days/month if possible using national budget) - Sampling should be done for at least 12 fishing boats/month - In some cases, sampling the same boat every day or week is acceptable - Landing data must be collected from multi-gear (trawl, longline, gillnet) and if there are too many gears used, focus only on main gears that catch sharks and rays - Select boats that land catches separately from other boats at a jetty - If fishing boat is suspected to be IUU fishing boats or unlicensed of without registration, take note of the boat owner's name - Do not select landing sites where boat owner mixes catch of sharks and rays from other boats • **Sampling of sharks and rays for recording of landing data** - Separate sharks and rays by groups, *i.e.* sharks, rays - Separate sharks and rays by species - Separate sharks and rays by sex (male, female)
Equipment and Techniques for Measuring Sharks and Rays	• **Measuring sharks** - Measure total length (TL) of all shark species (except for *Alopias* spp or other sharks/rays species without caudal fin) where the pre-caudal length (PCL) is measured) as shown in **Fig. 1** and **Fig. 2**, respectively, using measuring tape of ruler which must be put straight from shark head to tail in horizontal position (it is easy to measure if enumerators use a big caliper) - Do not put measuring tape on the dorsal nor ventral surface of shark because both areas are not flat • **Measuring rays** - Measure disc length (DL) of all rays and skates (except those from order Pristiformes, Rhinobatiformes and Torpediniformes where the total length (TL) is measured) as shown in **Fig. 3** and **Fig. 4**, respectively, using measuring tape or ruler which must be put straight (it is easy to measure if enumerators use a big caliper) - Do not put measuring tape on the dorsal surface because this area is not flat - Measure DL of rays, eagle rays (Family Myliobatidae), Mobula and Manta Rays (Family Mobulidae) either from dorsal side or ventral side (**Fig. 5**, **Fig. 6**) • **Recording sex of sharks and rays** - Identify the sex of sharks and rays by looking for claspers (male) or cloaca (female)  *Male claspers* *Female cloaca* *Male claspers* *Female cloaca*
Photography Techniques for Unidentified Specimens	• **Difficulties in identifying some species** Some species may be difficult to identify because enumerators are not well-trained: specimens are uncommon; specimens are probably new species; specimens are new record in country or region; specimens are newly-born or too old; specimens are not listed in the field guide prepared by SEAFDEC; specimens are in bad condition or already rotten; some body parts of specimens may be lost or broken.

Box 1. Main Features of the Standard Operating Procedures (SOPs) on Sharks Data Collection in Southeast Asia (Cont'd)	
Approach	Procedure
Photography Techniques for Unidentified Specimens (Cont'd)	• **Unidentified specimens** For unidentified specimens, enumerators must take photographs and send these to national experts or regional expert for correct identification. • **Use "Line" or "Whatsapp" applications or email** For proper identification and verification of species using "Line" or "Whatsapp" applications or email and coordinate with national experts or the regional expert, using the following addresses: **National Experts** *Mr. Tassapon Krajangdara* (**Thailand**) Tel: +6676391138 (office), +66840542315 (private); Fax: +6676391139; Email: *tas19702011@hotmail.com* *Ms. Lim Pek Khiok* (**Malaysia**) Tel: +6082349533 (office), +60138068272 (private); Fax: 6082349686; Email: *pekhiok@hotmail.com* *Mr. Dharmadi* (**Indonesia**) Tel: +622164700929 (office), +6281389200731 (private); Fax: +62164700927; Email: *darma_ancol@yahoo.com* *Mr. Fahmi* (**Indonesia**) Tel: +622164713850 (office), +6281387889155; Fax: +622164711948; Email: *fahmi_lipi@yahoo.com* **Regional Expert** *Dr. Ahmad bin Ali* Tel: +6096171543/6096175940 (office), +6096173150 (private); Fax: +6096175136; Email: *aaseafdec@seafdec.org.my*
Photography Techniques	• **Photography techniques for recording sharks** - Take photo of whole body of shark, identify the species or write the code number of species - Use white or dark background (polystyrene) depending on color of specimens - Take close up photo of the shark's eye - Take close up photo of gill slits - Take close up photo of 1st dorsal fin - Take close up photo of 2nd dorsal fin (making sure that color of dorsal fin tip is clear) - Put white background so that the white color of tip could be clearly seen - Take close up photo of caudal fin - Take close up photo of 2nd dorsal fin and anal fin (to compare size of 2nd dorsal fin and anal fin) - Take close up photo of the free rear tip of second dorsal fin and anal fin - Take close up photo of whole body (top view) - Take photo of top view (whole body) and head - Take close up photo of inter-dorsal space - Take close up photo of inter-dorsal to check whether inter-dorsal ridge is present or not - Take close up photo showing shape of pre-caudal pit - Take close up photo of underside of head - Take close up photo of cloaca or claspers (to check whether shark is male or female) • **Photography techniques for recording rays and skates** - Take photo of whole body of rays/skates, identify the species or write the code number of species - Use white or dark background (polystyrene) depending on color of specimens - Take close up photo of the head - Take close up photo of the head side - Take close up photo of the center of disc - Take close up photo of the base of tail and end of tail - Take photo of ventral side (whole body) - Take close up photo of mouth • **Difficulties in identifying species of sharks, rays and skates** - When head is not in good position and fin(s) not complete - Photograph is taken only from ventral side - Photograph is taken with someone holding the specimen
Data Key-in and Management	• **Data Management** - Enumerator to key-in all data from field form in Microsoft Excel and email to National Coordinator at the end of each sampling month or within the first week of new sampling month - National Coordinator to verify all data and any miss-recording will be referred back to enumerator - Data are then keyed and arranged according to standard for "Pivot Table" analysis or for shark database managed by SEAFDEC • **Expected Output** - One national report published by each participating country on landing data of sharks and rays at species level and CPUE with corresponding percentages, prices at jetty and marketing information - One regional report published by SEAFDEC Secretariat on landing data of sharks and rays at species level and CPUE with corresponding percentages, prices at jetty and marketing information

Operating Procedures (SOPs) on Sharks Data Collection in Southeast Asia was developed and was used to harmonize data collection, compilation, analysis, and reporting (Ali *et al*., 2016).

Standard Operating Procedures on Sharks Data Collection in Southeast Asia

The Standard Operating Procedures (SOPs) on Sharks Data Collection in Southeast Asia was developed to serve as guide and reference for enumerators from the pilot countries during their sampling activities for data collection on sharks and rays. Specifically, the SOPs is also intended to guide the enumerators in recording the landing information at species level and corresponding local prices which could be used for developing management measures for sharks and rays. In order to achieve such objectives, the SOPs comprises five main approaches (Ali *et al*., 2016) as shown in **Box 1**.

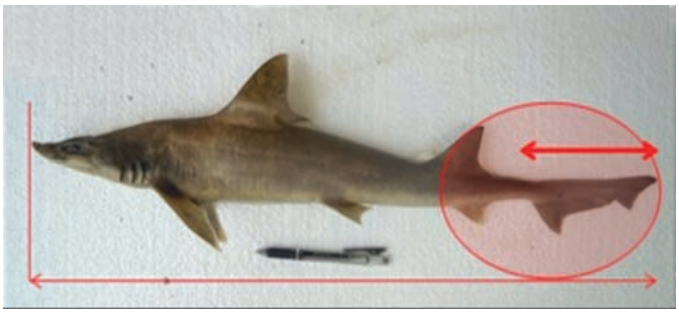


Fig. 1. Proper way of measuring the total length (TL) of sharks

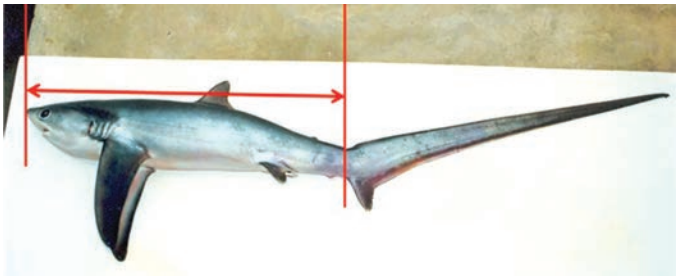


Fig. 2. Proper way of measuring the pre-caudal length (PCL) of *Alopias* spp. and other sharks without tail or with damaged tail

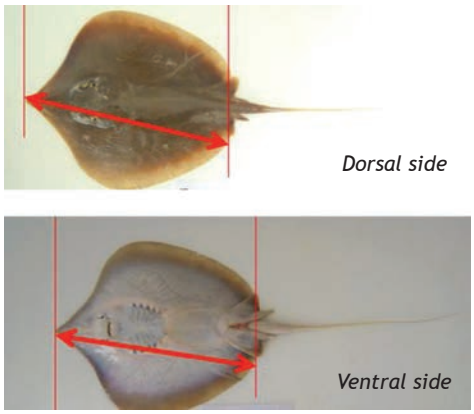
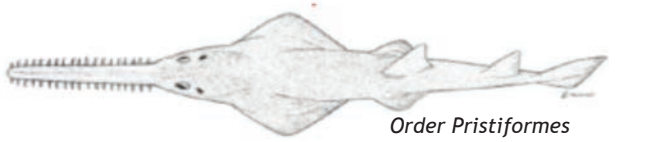


Fig. 3. Proper way of measuring the disc length (DL) of rays (measure either from dorsal or ventral side)



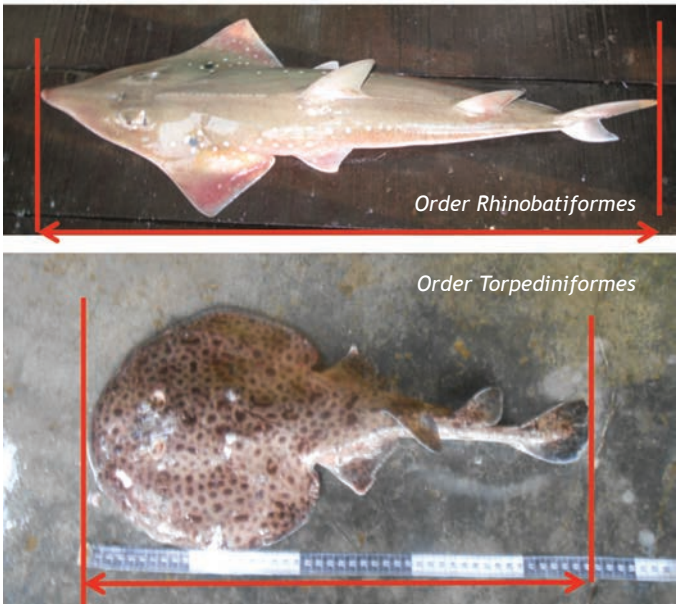


Fig. 4. Proper way of measuring the total length (TL) of rays from Order Pristiformes, Rhinobatiformes and Torpediniformes

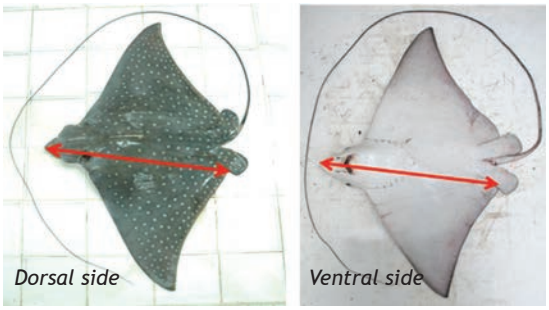


Fig. 5. Proper way of measuring the disc length (DL) of eagle rays from Family Myliobatidae (measure either from dorsal or ventral side)

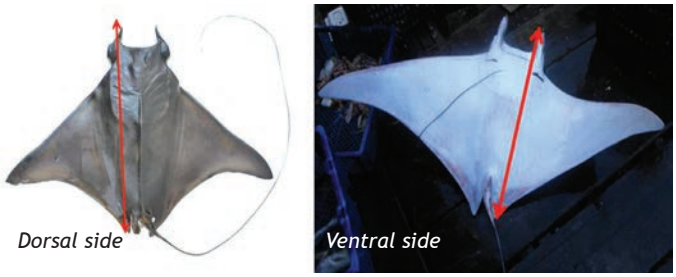


Fig. 6. Proper way of measuring the disc length (DL) of mobula and manta rays from Family Mobulidae (measure either from dorsal or ventral side)

Conclusion and Recommendations

While the one-year SEAFDEC Regional Project on Sharks and Rays Data Collection has come to an end, a Project-End Meeting was convened in August 2016 to provide a forum

for the Project's participating countries to report and discuss the results of their one-year data collection from selected landing sites in their respective countries. It was also the most appropriate time to validate the data collected which would be compiled for the regional report on the Project which would be disseminated to the Southeast Asian countries.

During the data validation and verification however, the general consensus was for the countries to harmonize the data collected based on the SOPs to ensure that these could be used for the computation of CPUEs required for stock assessment of sharks and rays in the respective countries (SEAFDEC, 2016). Nevertheless, the SOPs developed through this one-year Project could also be used as reference and/or guide for the development of similar SOPs for other economically-important aquatic species, especially freshwater species. As noted in various reports, difficulties have been encountered by the AMSs in fisheries data collection as many countries have insufficient expertise in aquatic species identification, *e.g.* in the case of catadromous eels. Therefore, fisheries data collection in inland fisheries could be improved with the development and use of relevant SOPs.

Way Forward

The Project Report would be published, including the Standard Operating Procedures (SOPs) on Sharks Data Collection in Southeast Asia, which would be disseminated to the countries in Southeast Asia. Nonetheless, during the August 2016 Project-End Meeting, the AMSs strongly indicated the need to organize a regional training-workshop on stock assessment and data collection of total fishing effort of common fish species. Moreover, the AMSs also asked SEAFDEC to publish a manual or guidebook for species identification of sharks and rays which could national enumerators could use to enhance their capacities in this aspect. For other aquatic species that are commercially important in the region, similar effort could be exerted, especially for freshwater aquatic species. Meanwhile, the AMSs have also asked SEAFDEC to continue supporting human resource development on sharks and rays species identification even after the completion of the SEAFDEC Project, as well as continue enhancing the region's capacity in data collection and analysis for stock assessment. The AMSs on their part, agreed to continue improving their data collection on sharks and rays based on the SOPs which would include compilation of total fishing effort for CPUE analysis and stock assessment. Lessons could therefore be learned by the AMSs from this Project's experience for similar initiatives to be undertaken for other economically-important aquatic species especially those in inland fisheries.

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CALENDAR OF EVENTS

Date	Venue	Title	Organizer(s)
2016			
4-14 July	Samut Prakan, Thailand	Regional Training Workshop on Larval Fish Identification and Fish Early-life History Science (Advanced course: Key to Species)	SEAFDEC-Sweden Project
11-15 July	Rome, Italy	32nd Session of FAO Committee on Fisheries	FAO
18-22 July	Singapore	Regional Training Course on Identification of Biotoxin-producing HAB Species in the ASEAN Region	MFRD
27 July	Jakarta, Indonesia	Ministerial Meeting on "Traceability of Fish and Fisheries Product"	Indonesia
3 August	Bangkok, Thailand	High-level Consultation on Regional Cooperation in Sustainable Fisheries Development Towards the ASEAN Economic Community	Secretariat
4-6 August	Bangkok, Thailand	ASEAN Fisheries Conference and ASEAN Seafood Exposition	Thai DOF & NACA
7-9 August	Kanchanaburi Province, Thailand.	Too Big To Ignore (TBTI) Symposium on Small-Scale Fisheries in Asia-Pacific Region and Beyond 2016	TBTI
8-10 August	Palembang, Indonesia	1st Workshop to Review Activities and Methodologies for Promotion on Inland Fishery	IFRDMD
9-11 August	Kuala Lumpur, Malaysia	Core Expert Meeting for Comparative Study on Purse Seine Fishery in the Southeast Asian Region	MFRDMD
August-October	TMS-Philippines	Distance Learning Course on Principles of Aquaculture Nutrition (ANOL)	AQD
5-10 September	Cambodia	Training on Essential Ecosystem Approach to Fisheries Management (E-EAFM) for Cambodia	SEAFDEC-Sweden project
12-16 September	BFS-Philippines	Training Course on Freshwater Prawn Hatchery & Grow-out Operations	AQD
12-23 September	TMS-Philippines	Training Course on Seaweed Farming	AQD
12 Sep 16-26 Feb 17	TMS-Philippines	Distance Learning Course on Principles of Health Management in Aquaculture (AHOL)	AQD
20-22 September	Preah Sihanouk, Cambodia	On-site Training on Energy Saving and Safety at Sea for Small Fishing Vessels in Cambodia	TD
22-23 September	Bangkok, Thailand	Experts Group Meeting on Stock Status and Geographical Distribution of AIB-Species in the Gulf of Thailand	SEAFDEC-Sweden Project
24 Sep-5 Oct	South Africa	17th Conference of the Parties of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	CITES
11 October	Siem Reap, Cambodia	Regional Consultation Stakeholder Workshop on Proposal for a Basin-wide Fisheries Management and Development Strategy	MRC
12-13 October	Siem Reap, Cambodia	22nd Meeting of Technical Advisory Body (TAB) on Proposal for a Basin-wide Fisheries Management and Development Strategy	MRC
18-20 October	Bangkok, Thailand	3rd Meeting of the Andaman Sea Sub-region	SEAFDEC-Sweden Project
24 - 26 October	Rome, Italy	FAO Workshop on "Exploring the Human Rights Based Approach in the Context of Implementation and Monitoring of the SSF Guidelines"	FAO
26 October	Samut Prakan, Thailand	Umitaka-maru On-board Seminar among Fisheries Universities and Institutions	TUMSAT
7-10 November	Bangkok, Thailand	Workshop on Regional Cooperation for Implementation of Port State Measures to Improve Fisheries Management and Reduce IUU Fishing in Southeast Asia	SEAFDEC Sweden Project
14-17 November	Lao PDR	Conference on Fish Passage in the Lower Mekong Basin	LARReC
21-23 November	Hokkaido, Japan	10th Meeting and Conference of Asian Fisheries Acoustic Society (AFAS) 2016	AFAS
22 Nov-1 Dec	BFS-Philippines	Training Course on Community-based Freshwater Aquaculture for Remote Rural Areas of Southeast Asia	AQD
28-30 November	Rome, Italy	Expert Workshop on Gender-equitable Small-scale Fisheries in the Context of the Implementation of the SSF Guidelines	FAO
28-30 November	Yogyakarta, Indonesia	39th SEAFDEC Program Committee Meeting (PCM)	Secretariat & IFRDMD
1-2 December	Yogyakarta, Indonesia	19th Meeting of the Fisheries Consultative Group of the ASEAN-SEAFDEC Strategic Partnership (FCG/ASSP)	SEAFDEC & ASEAN

Southeast Asian Fisheries Development Center (SEAFDEC)

What is SEAFDEC?

SEAFDEC is an autonomous intergovernmental body established as a regional treaty organization in 1967 to promote sustainable fisheries development in Southeast Asia.

Mandate

To develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies, research and information dissemination activities

Objectives

- To promote rational and sustainable use of fisheries resources in the region
- To enhance the capability of fisheries sector to address emerging international issues and for greater access to international trade
- To alleviate poverty among the fisheries communities in Southeast Asia
- To enhance the contribution of fisheries to food security and livelihood in the region

SEAFDEC Program Thrusts

- Developing and promoting responsible fisheries for poverty alleviation
- Enhancing capacity and competitiveness to facilitate international and intra-regional trade
- Improving management concepts and approaches for sustainable fisheries
- Providing policy and advisory services for planning and executing management of fisheries
- Addressing international fisheries-related issues from a regional perspective


Secretariat


TD


MFRD


AQD


MFRDMD


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The second prize drawing winner, *Thavisouk Hadthakone*, from the national drawing contest in Lao PDR

National Drawing Contests were organized in all ASEAN-SEAFDEC Member Countries as part of the preparatory process for the ASEAN-SEAFDEC Conferene on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment" held by ASEAN and SEAFDEC in June 2011 in Bangkok, Thailand, in order to create awareness on the importance of fisheries for food security and well-being of people in the region.