FISH for the PEOPLE

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

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Equating enhanced sustainability in fisheries with secured trade: Southeast Asia on the hub

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Editorial

Based on the official SEAFDEC statistical reports in 2016, the fisheries production of the Southeast Asian region had exhibited a continuously increasing trend especially during the past ten years. From more than 25 million metric tons in 2007, the region's production almost doubled in 2016 to more than 45 million metric tons, having an annual average increase of about 6.3% in terms of volume over the past 10 years. Such an achievement could be attributed to the persistent efforts of the Southeast Asian countries in improving their fisheries production by making sure that their operations are sustainable and in compliance with good and responsible practices. Such a scenario could also be an offshoot of the programs and projects, implemented by SEAFDEC in the region with the support from donors and collaborating partners, aimed at ensuring the sustainability of the region's fisheries not only in terms of the availability of fish and fishery products but also accessibility, quality, and safety.

At the outset, SEAFDEC was mandated to "*develop the fisheries potential of the region by rational utilization of the resources for providing food security to the people through transfer of new technologies, research and information dissemination activities*." Upon achieving its original objective per se, and looking beyond the 50 years of its existence in the region, SEAFDEC is now adopting a revitalized vision of pursuing the "*sustainable management and development of fisheries and aquaculture to contribute to food security, poverty alleviation and livelihood of people in the Southeast Asian region*."

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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 Southeast Asian region.

Going towards such direction, and considering that production from marine capture fisheries had been sluggish during the past few years, SEAFDEC gives more focus in boosting the production from aquaculture and making sure that advancements are aimed for sustainability. With such development safely in place, SEAFDEC has also turned its attention to the sustainable development of inland capture fisheries in Southeast Asia for increased production from the vast inland water resources that abounds the region, as well as for improved data collection and reporting in order that this sub-sector could be properly valuated and its management improved also towards sustainability.

Now that fisheries development in the region is becoming stable and sustainable, and where fish and fishery products are readily available for peoples in the Southeast Asian region, the time is ripe for the countries to also flood the world market with their safe and quality produce. This would fill the respective countries' coffers leading to improved economies as well as enhanced lives and livelihoods of their peoples. Many countries have already tried the waters in the international fish trading arena, and as of 2016, Viet Nam and Thailand have succeeded, landing in the third and fourth places, respectively, of the top ten fish exporting countries of the world. While the other countries are trying to attain sustainability in their fisheries, these countries are also on their way up the ladder towards topping the list of fish exporters of the world. With sustained support from the intensified programs and projects of SEAFDEC, there is no reason why these other countries could not succeed. Once achieved, this feat will eventually balance the equation of enhanced fisheries sustainability with secured market stability.

Call for Articles

FISH for the PEOPLE is a policy-oriented special publication of SEAFDEC. Now on its 17th year, the Publication is intended to promote the activities of SEAFDEC and other relevant fisheries concerns in the Member Countries. We are inviting contributors from the SEAFDEC Departments, Member Countries, and partner organizations to submit articles that could be included in the forthcoming issues of the special publication. The articles could cover fisheries management, marine fisheries, aquaculture, fisheries postharvest technology, fish trade, gender equity in fisheries, among others. Written in popular language and in layman's terms for easy reading by our stakeholders, the articles are not intended to provide detailed technical and typical scientific information as it is not a forum for research findings. Please submit your articles to the Editorial Team of Fish for the People through the SEAFDEC Secretariat at *fish@seafdec.org*. The article should be written in Microsoft Word with a maximum of 10 (ten) pages using Times New Roman font 11 including tables, graphs, maps, and photographs.

Safeguarding the Niche for Southeast Asian Fish and Fishery Products in the World Market

IBM Suastika Jaya, Thumawadee Jaiyen, Nant Kay Thwe Moe, Thuch Panha, Vanny Sengkapkeo, Bernadette B. Soliven, Virgilia T. Sulit, and *Shiela Villamor Chumchuen*

As of 2016, the Southeast Asian countries have already secured a niche in the global market for their fish and fishery products, contributing about 13.8% to the world's total export of fish and fishery products in terms of value. In a summary provided by FAO (2016), Viet Nam and Thailand ranked as the world's third and fourth highest exporters, respectively, with Viet Nam contributing about 5.1% to the world's total export value and Thailand accounting for about 4.1%. The efforts made by the Southeast Asian countries to improve their respective fisheries management policies and regulations towards sustainability have greatly contributed to this success. Such initiatives also enabled the countries to comply with the requirements of importing countries. SEAFDEC will therefore continue to assist the Southeast Asian countries in these endeavors in order that the growth of the region's export of fish and fishery products would remain positive in the future. Considering that large volumes of the fishery production from several Southeast Asia countries are now targeted for the international as well intra-regional markets, several international fisheries-related issues are also being addressed by SEAFDEC and the Southeast Asian countries to minimize the possible impacts of such concerns on the competitiveness of the region's fish and fishery products in the international markets. Compliance with the international requirements for safety and quality of fish and fishery products *vis-à-vis* the sustainability of fisheries operations would safeguard the niche of the region's fish and fishery products which had already been secured since the mid of 2000s.

During the five-year period from 2012 to 2016, the worldwide trend of production from capture fisheries and aquaculture appeared to be increasing at a steady pace in terms of volume at an average rate of about 3% annually (SEAFDEC, 2018). In 2016, the Southeast Asian countries accounted for about 45.3% of the world's total fisheries production (**Table 1**).

Table 1. World's total production from capture fisheries and aquaculture (in million metric tons or mt)

Regions	2012	2013	2014	2015	2016
Africa	10.1	10.1	10.5	10.8	11.4
America	21.9	22.4	20.7	21.3	20.0
Asia*	91.6	98.4	101.7	104.2	106.9
Southeast Asia	**39.5**	**40.1**	**42.1**	**44.0**	**45.3**
Europe	16.1	16.5	16.9	17.3	16.9
Oceania	1.5	1.4	1.5	1.6	1.7
TOTAL	**180.7**	**188.9**	**193.4**	**199.2**	**202.2**

**Data do not include those of Southeast Asia*
Source (except for Southeast Asia): FAO FishStat Plus-Universal Software for Fishery Statistical Time Series
Source (for Southeast Asia): SEAFDEC (2018)

Fisheries production of the Southeast Asian region

For the Southeast Asian region, fisheries production during 2012-2016 exhibited a continuously increasing trend in volume as well as in value, with Indonesia reported to have obtained the highest fisheries production contributing about 51.1% to the region's total fisheries production in 2016 in terms of volume (SEAFDEC, 2018). This was followed by Viet Nam accounting for 15.0%, Myanmar at 12.3%, the Philippines at 9.6%, and the other Southeast Asian countries contributing the remaining 12.0% (**Table 2**).

As shown in **Table 2**, the trend of the total production from capture fisheries has been slowly increasing during the past five years but production from aquaculture has been increasing at a much faster rate. Among the Southeast Asian countries, Indonesia remains the highest producer not only from capture fisheries but also from aquaculture. Although Myanmar is the second largest producer from capture fisheries, mainly from its inland waters, the country ranked only fourth in terms of aquaculture production, while Viet Nam is the second largest producer from aquaculture. The Philippines ranked the third highest producer from capture fisheries as well as from aquaculture, followed by Thailand.

Utilization of fish and fishery products of the Southeast Asian region

In the Southeast Asian region, fisheries form an integral part of the people's livelihoods providing significant contribution to food security and economic stability (SEAFDEC, 2017). With the world's increasing population, fisheries will be confronted with the challenges in ensuring that nutritious food is available to all people not only from Southeast Asia but also all over the world. Specifically for Southeast Asia, the population is expected to rise exponentially, from 641.7 million in 2017 to 723.2 million in 2030 and by 2050 about 790.0 million (**Table 3**). Meanwhile, the region's fisheries production which has been increasing was recorded at 45.3 million mt as of 2016 (**Table 2**), and with an average annual fish consumption of 39.3 kg/capita/year (as of 2013), this means that peoples from the region consumed 25,218.81 thousand mt of fish. This could be translated to mean that about 56% of the region's total fish production is being consumed by its people, with the remaining 44% bound for non-food production or processed into various fishery products for export or traded in the export market live or frozen. The latter provides the much needed

Table 2. Total production of Southeast Asia from capture fisheries (CAP)* and aquaculture (AQUA), in '000 mt

Countries	2012		2013		2014		2015		2016	
	CAP	AQUA	CAP	AQUA	CAP	AQUA	CAP	AQUA	CAP	AQUA
Brunei Darussalam	4.52	0.56	2.89	0.61	3.19	0.76	3.38	0.97	13.29	0.83
Cambodia	638.00	90.00	638.00	90.00	625.76	120.55	588.89	143.00	636.53	172.02
Indonesia	5,794.53	12,969.36	6,098.34	13,147.29	6,413.65	14,167.12	6,520.33	15,634.09	6,497.85	16,675.02
Lao PDR	34.10	101.90	40.14	124.09	60.23	90.36	62.64	95.96	70.92	95.96
Malaysia	1,477.28	283.56	1,488.54	260.78	1,463.74	524.56	1,481.97	506.47	1,580.30	407.69
Myanmar	3,579.25	838.43	3,786.84	929.00	4,083.27	957.04	4,317.32	999.63	4,577.41	1,020.59
Philippines	2,341.04	2,524.64	2,321.98	2,373.39	2,343.81	2,337.61	2,297.71	2,348.16	2,149.85	2,200.91
Singapore	2.67	3.58	1.65	5.56	1.43	5.27	1.26	6.90	1.24	6.11
Thailand	1,719.62	1,272.00	1,824.83	997.26	1,670.04	897.76	1,501.22	928.64	1,463.30	962.60
Viet Nam	2,705.40	3,110.70	2,803.80	3,215.90	2,919.20	3,413.30	3,036.40	3,513.30	3,163.30	3,640.60
TOTAL	**18,296.41**	**21,194.73**	**19,007.01**	**21,143.89**	**19,584.32**	**22,514.33**	**19,811.12**	**24,177.12**	**20,153.99**	**25,182.33**
	39,491.14		**40,150.90**		**42,098.65**		**43,988.24**		**45,336.32**	

**includes marine capture and inland capture fisheries*
Source: SEAFDEC (2018)

Table 3. Population, fish production, per capita fish consumption, and GDP of the Southeast Asian countries

Countries	Population (million)			Fish production in 2016[c] (thousand metric tons)	2013[d] ave. per capita fish consumption (kg/person/year)	GDP in 2016[a] (billion US$)
	2017[a]	2030[b]	2050[b]			
Brunei Darussalam	0.4	0.5	0.6	14.12	47.0	11.4
Cambodia	15.4	18.9	22.5	808.55	41.4	20.04
Indonesia	261.9	295.5	322.2	23,172.87	31.8	932.45
Lao PDR	6.7	8.5	10.2	166.88	19.8	15.92
Malaysia	32.0	36.1	40.7	1,987.99	54.0	297.83
Myanmar	53.4	60.2	63.6	5,598.00	60.7	63.25
Philippines	104.9	123.6	148.3	4,350.76	30.2	304.89
Singapore	5.6	6.4	6.7	7.35	46.9	309.75
Thailand	67.7	68.3	62.4	2,425.90	26.1	411.84
Viet Nam	93.7	105.2	112.8	6,803.90	34.8	301.33
Southeast Asia	**641.7**	**732.2**	**790.0**	**45,336.32**	**39.3[e]**	**266.87**
World	**7,300.0[d]**	**8,084.0**	**9,587.0**	**202,200.00**	**19.7**	**77.61**

Source: SEAFDEC (2017)
[a] *Statista – The Statistics Portal, accessed 1 March 2019*
[b] *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables*
[c] *SEAFDEC (2018)*
[d] *FAO Yearbook 2014*
[e] *Average, based on per capita consumption in 2013*

dollars that would fill the countries' coffers, which could be used to improve the socio-economic well-being of the peoples in the region.

Regional initiatives towards the sustainability of fisheries

To ensure that the development of fisheries and aquaculture in the Southeast Asian region is directed towards sustainability of the fishery resources, SEAFDEC has been promoting the implementation by the ASEAN Member States (AMSs), of the various tools and measures that had been developed and aimed for the sustainable utilization of the region's fishery resources (SEAFDEC, 2017). Guided by the FAO Code of Conduct for Responsible Fisheries, SEAFDEC developed regional guidelines for responsible fisheries, aquaculture, and post-harvest technology. Meanwhile, in the development of their respective fisheries, the AMSs also continued to adhere to such regional guidelines which had been strengthened through the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region, the first of which was adopted in 2001, and the subsequent revitalized Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 adopted in 2011 (SEAFDEC, 2017). These instruments had been used as basis for the formulation of the Strategic

Plan of Action on ASEAN Cooperation in Fisheries (2016-2020), which the AMSs use as guide for their activities that aim for the sustainable development of their respective fisheries. Specifically, SEAFDEC for its part is also being tasked to "promote and facilitate concerted actions among its Member Countries to ensure the sustainability of fisheries and aquaculture in Southeast Asia." Guided by the Resolution on the Future of SEAFDEC which was adopted by the SEAFDEC Council of Directors in November 2017, SEAFDEC has continued to implement programs and activities that are in line with the aforementioned regional fisheries frameworks and instruments to support the efforts of the AMSs that aim for the sustainability of their respective fisheries sector.

Sustainable fisheries development being promoted in the Southeast Asian region

With the collaboration of the SEAFDEC Member Countries, regional instruments, measures and tools had been developed and promoted in the Southeast Asian region. These were established through the implementation of programs and activities that have been financially supported by the Government of Japan through its Japanese Trust Fund (JTF) for SEAFDEC and also by the Government of Sweden through the SEAFDEC-Sweden Project.

- ***Development of measures and tools to combat illegal, unreported and unregulated fishing***

Illegal, unreported, and unregulated (IUU) fishing is one of the greatest threats to the marine ecosystems due to its potent ability to undermine not only the national and regional efforts to sustainably manage fisheries but also all endeavors to conserve the marine biodiversity. With the "International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU)" at the backdrop providing the principles and the implementation measures to prevent, deter and eliminate IUU fishing that focus on the State responsibilities, flag State responsibilities, coastal State measures, port State measures, internationally agreed market-related measures, and on the corresponding roles of research and regional fisheries management organizations, SEAFDEC developed the "ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain," which is also being promoted for adoption by the AMSs.

Parallel activities have also been undertaken by SEAFDEC to come up with supportive tools, such as the establishment of the "Database on Regional Fishing Vessels Record (RFVR Database)" starting with vessels 24 meters in length and over, which aims to facilitate the checking and tracking of fishing vessels registered under the AMSs. Development of the "ASEAN Catch Documentation Scheme (ACDS)" is another initiative that promotes the application of traceability system from catch to market or exportation. Regional cooperation and capacity building activities have also been strengthened by SEAFDEC to support the implementation of "Port State Measures," as well as the Port State Measures Agreement (PSMA). Establishment of MCS networks among countries had also been initiated and the Regional Plan of Action for Management of Fishing Capacity (RPOA-Capacity) was also developed.

The "ASEAN-SEAFDEC Joint Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products" was adopted by the representatives from the ASEAN-SEAFDEC Member Countries 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." This instrument has been used by the AMSs in their efforts to combat IUU fishing in their respective waters and enhance the competitiveness of their fish and fishery products bound for the world market.

- ***Addressing transboundary issues and concerns related to IUU fishing***

For the effective management of fisheries in the Southeast Asian region, considering the specificity of the region's fisheries in terms of features and characteristics, SEAFDEC through the SEAFDEC-Sweden Project, has initiated some ways of promoting sustainable fisheries management and addressing transboundary fisheries issues through sub-regional approach. For management considerations, the waters of the Southeast Asian region had been divided into sub-regions (Wanchana *et al*., 2016), such as the Gulf of Thailand (GOT), the Andaman Sea (AS), Sulu-Sulawesi Seas (SSS), and the Lower Mekong River Basin (LMB). During the span of the SEAFDEC-Sweden Project, SEAFDEC initiated bilateral dialogues between and among the neighboring countries of two sub-regions, *i.e.* GOT and AS, with a view to facilitating discussions and seeking cooperation on fisheries-related issues including combating IUU fishing, and establishing the sub-regional network for monitoring, control and surveillance (MCS) with main emphasis on sharing of information on monitoring and control between and among the concerned countries. All of these are meant to support the national efforts to mitigate IUU fishing activities in the Southeast Asian region as well as respond to the concerns of importing countries in Europe and the U.S., and certify the legal status of fish and fisheries products traded by the AMSs.

- ***Other initiatives to address fisheries-related issues***

Aside from the promotion of regional instruments and frameworks to combat IUU fishing in the Southeast Asian region, SEAFDEC in collaboration with the AMSs also addresses the concerns on the listing of commercially exploited aquatic species into the CITES Appendices as this could also possibly impact on the sustainability of the region's fisheries. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) ensures

that the international trade in specimens of wild animals and plants does not threaten their survival. A set of criteria and guidelines had been developed to assist the evaluation of whether or not a species should be listed under the different Appendices of CITES. Considering that discussions on the proposals to amend the lists of species in Appendices I and II will be carried out during the forthcoming CITES CoP18, SEAFDEC convened a forum to discuss the common positions of the Member Countries, and more particularly, that of the AMSs on the listing of economically important aquatic species into the CITES Appendices that would be used as basis for justifying the common positions of the AMSs on the respective proposals. Meanwhile, SEAFDEC has also been undertaking technical activities on the conservation and management as well as on the sustainable utilization of various aquatic species that could be proposed for listing in the Appendices, *e.g.* sharks and rays, seahorses, sea cucumbers, sea turtles, and catadromous eels. These activities aim to come up with data and information on the status and trends of the production and utilization of these species, as well as on the existing conservation and management measures undertaken by the AMSs. The information compiled would support the region's position on the proposed listing of aquatic species into the CITES Appendices.

Southeast Asia's niche in world market of fish and fishery products

FAO (2018) declared that currently, fish and fishery products are among the most-traded commodities in the world, and in fact, about 35% of the world's fish production has been traded in various forms, not only for human consumption but also for other non-food uses. FAO (2018) continued that during the past 40 years, the quantity of fish and fishery products traded for human consumption has increased from 11% in 1976 to 27% in 2016. In terms of value, the global trade in fish and fishery products also increased significantly from US$ 8.0 billion in 1976 to US$ 143.0 billion in 2016 or increasing at an average growth rate of 8% (FAO, 2018).

In the Southeast Asian scenario, the growth of exportation of fish and fishery products seemed to follow an up-down trend, *i.e.* increasing-decreasing every other year during the past six (6) years, especially in terms of quantity from 2011 to 2016 (**Table 4**). In terms of value, however, the trend had been slowly increasing from 2011 to 2014, but decreased in 2015 although the trend started to increase again in 2016 (**Table 5**).

Table 4. Quantity of fish and fishery products exported by the Southeast Asian countries (mt)

Countries	2011	2012	2013	2014	2015	2016
Brunei Darussalam	730	1,271	1,497	1,724	1,540	892
Cambodia	30,000	31,025	32,000	31,684	29,654	26,601
Indonesia	1,100,842	1,216,617	1,225,233	1,249,873	1,049,222	1,040,997
Lao PDR	0	119	43	130	52	16
Malaysia	295,022	266,469	246,024	239,451	252,718	296,626
Myanmar	373,898	387,371	376,848	345,247	338,284	368,970
Philippines	231,711	253,838	317,973	276,455	225,190	234,418
Singapore	57,218	52,786	47,906	35,392	44,032	43,449
Thailand	1,762,955	1,762,131	1,604,445	1,664,372	1,545,968	1,515,437
Viet Nam	1,373,363	1,418,313	1,528,848	1,714,803	1,591,002	1,666,142
Total	**5,225,739**	**5,389,940**	**5,380,817**	**5,559,131**	**5,077,662**	**5,193,548**

Source: FAO Fisheries Global Information System (FIGIS)

Table 5. Value of fish and fishery products exported by the Southeast Asian countries (US$ 1,000)

Countries	2011	2012	2013	2014	2015	2016
Brunei Darussalam	1,701	2,435	4,311	4,146	3,342	3,057
Cambodia	60,000	61,020	62,500	63,900	60,666	54,442
Indonesia	3,360,852	3,752,132	4,024,926	4,499,959	3,788,848	4,009,232
Lao PDR	0	247	107	355	138	73
Malaysia	916,456	846,169	800,030	866,051	688,272	712,732
Myanmar	555,515	654,129	652,840	536,255	482,237	502,630
Philippines	711,155	850,344	1,185,788	1,054,005	804,825	735,786
Singapore	416,096	366,907	338,942	322,822	376,438	363,933
Thailand	8,159,613	8,144,920	7,067,700	6,657,459	5,701,788	5,914,988
Viet Nam	6,259,788	6,291,141	6,900,612	8,046,560	6,774,148	7,344,133
Total	**20,441,176**	**20,969,444**	**21,037,756**	**22,052,307**	**18,680,163**	**19,641,006**

Source: FAO Fisheries Global Information System (FIGIS)

Table 6. Fisheries trade of the Southeast Asian countries in 2016

Countries	Fish Production*		Export of Fish and Fishery Products**		Importation of Fish and Fishery Products**		Trade balance (Export-Import)	
	Qty ('000 mt)	Value (US$ 1,000)	Qty ('000 mt)	Value (US$ 1,000)	Qty ('000 mt)	Value (US$ 1,000)	Qty ('000 mt)	Value (US$ 1,000)
Brunei Darussalam	14.12	50,353	0.89	3,057	10.46	39,783	-9.57	-36,726
Cambodia	808.55	-	26.60	54,442	18.36	14,285	8.24	40,157
Indonesia	23,172.87	19,429,135	1,041.00	4,009,232	205.85	364,353	835.15	3,644,879
Lao PDR	166.88	-	0.02	73	0.57	2,042	-0.55	-1,969
Malaysia	1,987.99	3,181,205	296.63	712,732	408.25	954,079	-111.62	-241.347
Myanmar	5,598.00	9,352,420	368.97	502,630	20.82	38,596	348.15	464,034
Philippines	4,350.76	4,527,093	234.42	735,786	417.02	398,264	-182.60	337,522
Singapore	7.35	64,402	43.45	363,933	206.49	1,126,962	-163.04	-763,029
Thailand	2,425.90	4,368,492	1,515.44	5,914,988	1,808.69	3,179,238	-293.25	2,735,750
Viet Nam	6,803.90	-	1,666.14	7,344,133	478.82	1,366,351	1,187.32	5,977,782
Total	**45,336.32**	**40,973,100**	**5,193.56**	**19,641,006**	**3,575.33**	**7,483,953**	**1,618.23**	**12,157,053**

* *Source: SEAFDEC (2018)*
** *Source: FAO Fisheries Global Information System (FIGIS)*

In terms of value of the trade of fish and fishery products of the Southeast Asian countries in 2016, the data indicated that Viet Nam, Thailand, and Indonesia were the top exporting countries while Thailand, Viet Nam, Singapore, and Malaysia were the top importing countries (**Table 6**). The data also indicates that Thailand, Philippines, Singapore, Malaysia, Brunei Darussalam, and Lao PDR experienced some degrees of deficits in the trade volume of their fish and fishery products, while Singapore, Malaysia, Brunei Darussalam, and Lao PDR experienced some degrees of deficits in the trade value of their fish and fishery products. This implies that their respective exports are not sufficient enough to pay for their imports of fish and fishery products.

In the international arena of trading fish and fishery products, FAO (2018) reported that Viet Nam and Thailand are among the top ten exporters of fish and fishery products. Thailand, which was the third largest exporter in 2006, was overtaken by Viet Nam in 2016 as the world's third biggest exporter, and landed fourth as the biggest exporter of fish and fishery products in 2016 (**Table 7**).

A Glimpse of the Fisheries Trade Profile of Selected Southeast Asian Countries

Brief information with respect to trading of fish and fishery products by the Southeast Asian countries, compiled by the Members of the Regional Fisheries Policy Network (RFPN) assigned at the SEAFDEC Secretariat in Bangkok, Thailand in 2018, is shown below:

- ***Cambodia***

Cambodia lies at the heart of the Southeast Asian region (**Figure 1**), and has good road connections with Thailand,

Table 7. Top ten exporters of fish and fishery products (FAO, 2018)

Countries	2006		2016		APR* (%)
	Value (US$ million)	Share (%)	Value (US$ million)	Share (%)	
China	8,968	10.4	20,131	14.1	8.4
Norway	5,503	6.4	10,770	7.6	6.9
Viet Nam	3,372	3.9	7,320	5.1	8.1
Thailand	5,267	6.1	5,893	4.1	1.1
United States of America	4,143	4.8	5,812	4.1	3.4
India	1,763	2.0	5,546	3.9	12.1
Chile	3,557	4.1	5,143	3.6	3.8
Canada	3,669	4.2	5,004	3.5	3.2
Denmark	3,987	4.6	4,696	3.3	1.7
Sweden	1,551	1.8	4,418	3.1	11.0
Top ten sub-total	**41,771**	**48.4**	**74,734**	**52.4**	**6.0**
Rest of the world total	**44,523**	**51.6**	**67,796**	**47.6**	**4.3**
World total	**86,293**	**100.0**	**142,530**	**100.0**	**5.1**

Figure 1. Map of Cambodia
(Source: Google map)

Viet Nam, and Lao PDR, all of which have rapidly growing economies and growing domestic markets, providing Cambodia with significant regional trade opportunities. The country's trade relations with Viet Nam are particularly strong due to its close proximity to Ho Chi Minh City, which is accessible through rivers, roads, and air transportation. The increasing tourist traffic in Siem Reap and northern part of the country, especially from Bangkok, Thailand, is also underpinning the improved connections and trade potentials.

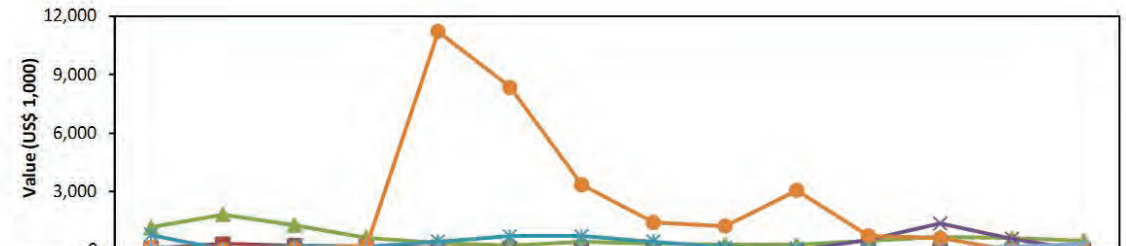
Moreover, entrepreneurs from Myanmar, Thailand, and Viet Nam are now investing in aquaculture in Cambodia, especially in the southern part of the country, bringing in skills and creating trading networks that facilitate the development of its fisheries industry. Nevertheless, the data on the amount and value of exported and imported fish and fishery products from and to Cambodia is limited. The activities of fishers crossing the borders to sell fish and fishery products to Thailand are unrecorded. Furthermore, the country imports relatively cheap feed and seeds when domestic supplies become costly or inadequate. Cambodia supplies a large quantity of freshwater fish species to markets in Thailand and Viet Nam for value-adding and processing for re-export to major importing countries (Rab *et al*., 2006). During the last few years however, the country's export of frozen products has declined due to lack of raw materials for processing. Nonetheless, the decreasing trend of the value of exported fish and fishery products in 2010-2017 (**Figure 2**) could have been caused by changes in the government policies of diverting fish and fishery products to domestic markets to meet the rising local demand (The Phnom Penh Post, 2012). Also, the Kampuchea Fish Import and Export Company, a state enterprise that has the sole distribution rights for all fish and fishery products traded into and out of Cambodia, was immobilized and this could have contributed to the declined value of exports.

As shown in **Figure 2**, the main countries of destination of exported fish and fishery products from Cambodia are Thailand and Viet Nam, and a smaller volume is traded to Singapore, Malaysia, Hong Kong, China, Taiwan, Japan, USA, and Australia (FAO, 2005).

- ***Indonesia***

The international fish trade in Indonesia has been increasing faster during the last decade, as stimulated by the growing demands from global consumers and their increasing awareness on the health benefits of seafood. The country contributes significant volume and value of fish and fishery products in the international fish trade, and thus, is gaining foreign currencies as well as providing employment and income to its fisherfolk. In 2015, Indonesia ranked 11th in the world's top exporting countries of fish and fishery products valued at US$ 2.7 million (ISW Group, 2017). It is predicted that Indonesia would still be able to export fish and fishery products until 2030 including re-exporting of imported products after processing (Chan *et al*., 2017).

Figure 3 shows the dynamics of Indonesia's export and import of fish and fishery products from 2012 to 2017. In terms of quantity and value, the country's exportation was much greater than its importation, and the decrease in the volume and value of exported fishery products could be attributed to the moratorium of the issuance of fishing licenses particularly to foreign fishing vessels in 2015, thus the supply of raw materials to the country's processing plants had decreased

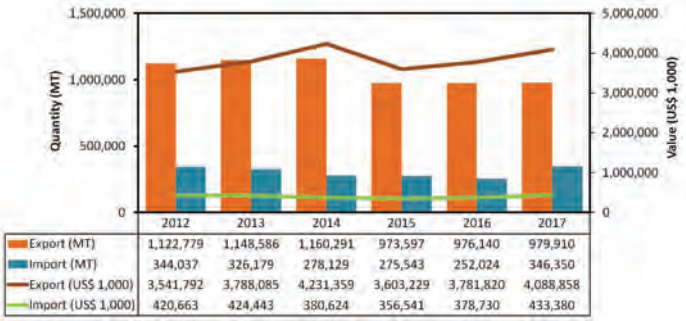


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Australia	89.89	322.82	242.39	188.24	160.06	82.03	40.32	-	-	8.35	17.88	10.48	-	-
China	1,161.18	1,839.07	1,299.12	658.67	393.78	265.02	428.82	351.59	314.87	280.67	510.35	692.51	619.87	507.10
Japan	81.09	13.34	18.29	0.49	0.53	0.02	-	10.90	30.08	-	541.12	1,375.77	593.32	-
Thailand	807.33	44.07	246.40	201.86	460.04	717.41	733.42	462.63	136.97	102.49	-	20.62	51.28	106.48
USA	166.15	36.78	71.12	222.23	11,214.5	8,343.79	3,360.28	1,425.32	1,242.37	3,075.27	745.36	624.51	0.55	-
Viet Nam	211.74	26.64	54.31	116.68	53.63	3.36	41.60	-	-	43.06	81.32	64.92	177.93	359.47

Figure 2. Destination and value of fish and fishery products exported by Cambodia (in US$ 1,000)
Source: UN Comtrade (2018)

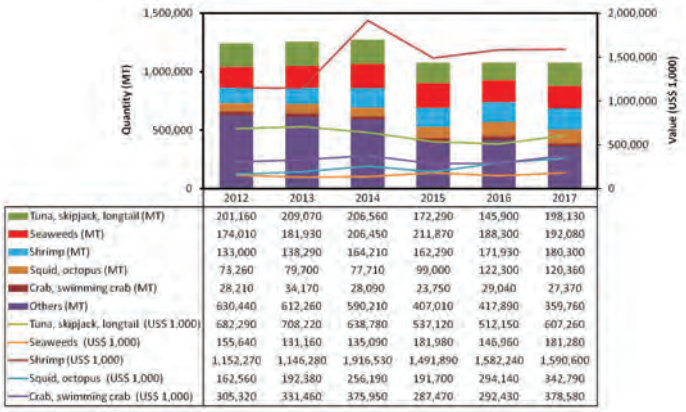
(Idris, 2015). The major exported fisheries commodities of Indonesia include shrimps, tunas, crabs, seaweeds, and others (**Figure 4**). The "others" category comprises low value fishes, pearls, freshwater fishes (eels, *Pangasius*, tilapia), and live fish (ornamental fishes and high value live marine fishes). The major destination of the exported fisheries commodities from Indonesia are USA, Japan, ASEAN, China, and EU (**Figure 5**).

The control and import tariff applied by the U.S. to the fish and fishery products exported from Indonesia is the Generalized System of Preference (GSP) which provides preferential duty-free entry of its export equivalent to about 11% of the total value. For EU countries, the MoU between Indonesia and EU bound the 117 exporters by the Approval Number issued by the EU Authority, after having been verified and enrolled by Indonesia's Competence Authority, which is the Board of Fish Quarantine and Quality Control under the MMAF. For non-food commodities, pearls (*Pinctada maxima* and *Pinctada margaritifera*) contributed a significant amount of export value to the country's coffers. In 2013-2014, the country's production was about 5,400 kg which was almost one-half of the estimated world production of 12,700 kg. Since 2015, pearls from Indonesia shared 43% of the world market with trade value of US$ 29.43 million, putting the country at the 9th place in world ranking (Ditjen, 2016).



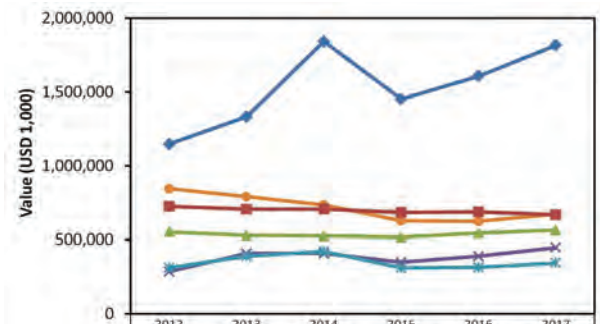
	2012	2013	2014	2015	2016	2017
Export (MT)	1,122,779	1,148,586	1,160,291	973,597	976,140	979,910
Import (MT)	344,037	326,179	278,129	275,543	252,024	346,350
Export (US$ 1,000)	3,541,792	3,788,085	4,231,359	3,603,229	3,781,820	4,088,858
Import (US$ 1,000)	420,663	424,443	380,624	356,541	378,730	433,380

Figure 3. Quantity (mt) and value (US$ 1,000) of fishery products exported and imported by Indonesia in 2012-2017
(Source: KKP, 2018a)



	2012	2013	2014	2015	2016	2017
Tuna, skipjack, longtail (MT)	201,160	209,070	206,560	172,290	145,900	198,130
Seaweeds (MT)	174,010	181,930	206,450	211,870	188,300	192,080
Shrimp (MT)	133,000	138,290	164,210	162,290	171,930	180,300
Squid, octopus (MT)	73,260	79,700	77,710	99,000	122,300	120,360
Crab, swimming crab (MT)	28,210	34,170	28,090	23,750	29,040	27,370
Others (MT)	630,440	612,260	590,210	407,010	417,890	359,760
Tuna, skipjack, longtail (US$ 1,000)	682,290	708,220	638,780	537,120	512,150	607,260
Seaweeds (US$ 1,000)	155,640	131,160	135,090	181,980	146,960	181,280
Shrimp (US$ 1,000)	1,152,270	1,146,280	1,916,530	1,491,890	1,582,240	1,590,600
Squid, octopus (US$ 1,000)	162,560	192,380	256,190	191,700	294,140	342,790
Crab, swimming crab (US$ 1,000)	305,320	331,460	375,950	287,470	292,430	378,580

Figure 4. Major fish and fishery products exported by Indonesia in 2012-2017 by quantity (mt) and value (US$ 1,000)
Source: KKP, 2018a



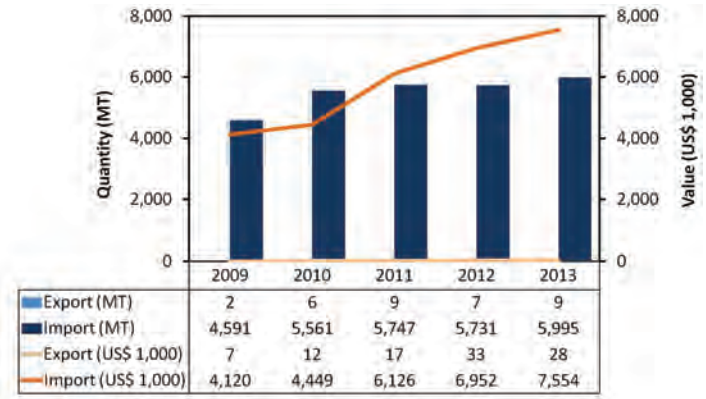
	2012	2013	2014	2015	2016	2017
USA	1,148,000	1,333,000	1,844,000	1,454,000	1,609,000	1,817,000
Japan	845,000	792,000	733,000	626,000	624,000	672,000
ASEAN	553,000	530,000	525,000	517,000	546,000	564,000
China	288,000	410,000	411,000	351,000	392,000	449,000
EU	313,000	390,000	424,000	313,000	315,000	345,000
Others	725,000	706,000	705,000	683,000	687,000	667,000

Figure 5. Major destination countries of fishery products exported by Indonesia in 2012-2017 by value (US$ 1,000)
Source: KKP, 2018b

On the other hand, the major fish and fishery products imported by Indonesia include fish meal (for aquaculture and poultry feeds), mackerel and sardine (for processing), fish oil (for pharmaceutical industries), and salmon and trout (for modern market). The dominant sources of imported mackerels in Indonesia are China, Japan, Norway, and Malaysia. Some of the imported mackerels are meant to augment for domestic supply of fish. The species of imported mackerels include *Scomber japonicas*, *S. scombrus*, and *S. australasicus*. Indonesia produces and exports crabs that include the swimming crabs, but the country still imports these commodities to increase its supply and fulfill the domestic demand as well as sufficiently supply the fish processing industry.

- ***Lao PDR***

The information on export and import of fish and fishery products of Lao PDR from 2009 to 2013 shown in **Figure 6** and **Figure 7**, indicates that the price of fish species vary during peak season (rainy season, August-November) and off-peak season (dry season, December-July). Considerable trading of the fish and fishery products of Lao PDR (**Figure 8**) takes place within the Mekong River Basin and its neighboring catchments. A lively trade takes place between Thailand and



	2009	2010	2011	2012	2013
Export (MT)	2	6	9	7	9
Import (MT)	4,591	5,561	5,747	5,731	5,995
Export (US$ 1,000)	7	12	17	33	28
Import (US$ 1,000)	4,120	4,449	6,126	6,952	7,554

Figure 6. Quantity (MT) and value (US$ 1,000) of fish and fishery products exported and imported by Lao PDR in 2009-2013
Source: SEAFDEC, 2017

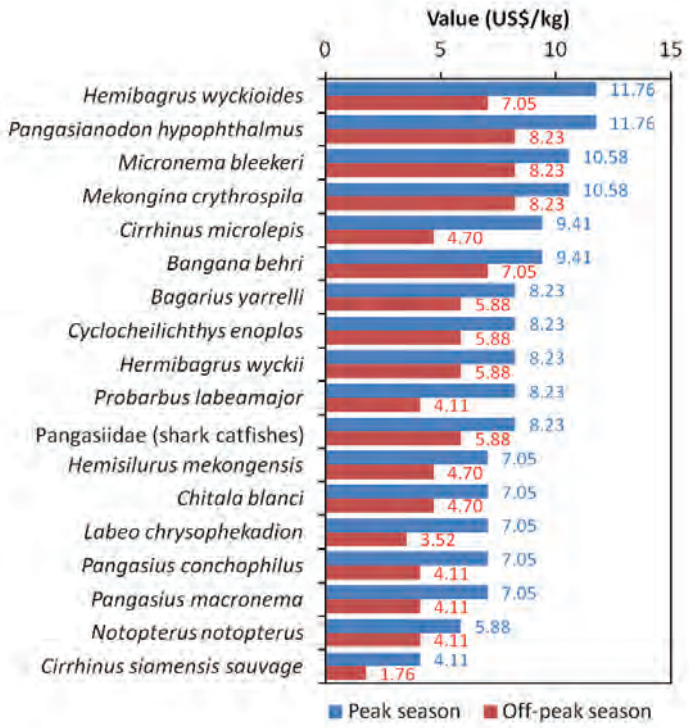


Figure 7. Price (US$/kg) of fish species during peak season and off-peak season in Lao PDR in 2017 *(Source: LFS-DAF, 2018)*

Figure 8. Map of Lao PDR showing the Mekong River *(Source: Google map)*

Lao PDR, with Lao traders sending high-value species to Thailand through the Mekong River, receiving in exchange seeds of tilapia and other species. Cultured fish from Thailand are also found in most markets along the Mekong River.

- ***Myanmar***

Myanmar's trade with other countries began in the 1990s when it adopted the open-door policy and welcomed foreign direct investment, particularly in its oil and gas sectors. Private sector entrepreneurs in the country have already been allowed to engage in external trade and to retain export earnings, when the government started to formalize border trade with neighboring countries. Foreign investment was permitted through the enactment of the Foreign Investment Law. The country's fish and fishery products have been categorized as fish, prawn, and others as shown in **Figure 9**. In 2017-2018, the amount of fish and fishery products exported by Myanmar was around 0.57 million mt valued at about US$ 712 million. The top 10 species and top 10 destinations of the exported fish and fishery products are illustrated in **Figure 10** and **Figure 11**, respectively.

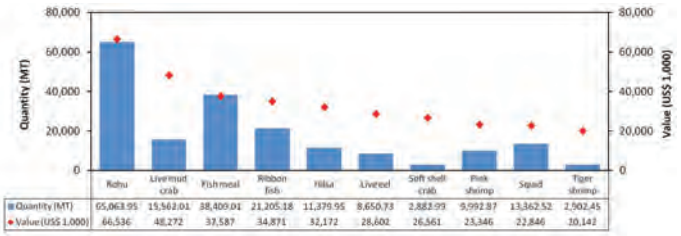


Figure 10. Top 10 species of fish and fishery products exported by Myanmar in 2017-2018 by quantity (mt) and value in US$ 1,000 *(Source: DOF, 2018)*

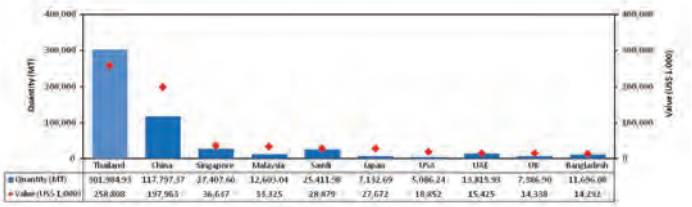
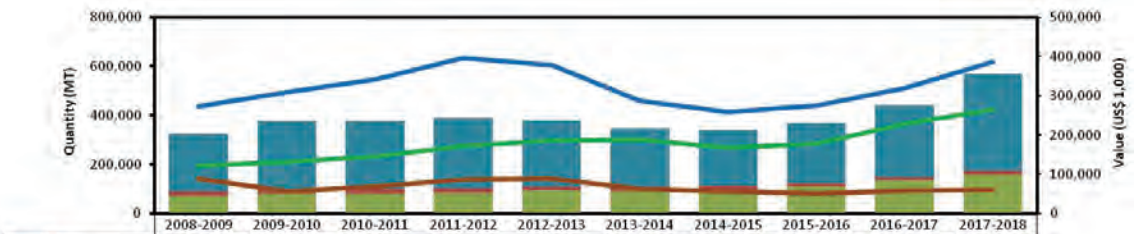


Figure 11. Top 10 destination countries of fish and fishery products exported by Myanmar in 2017-2018 by quantity (mt) and value in US$ 1,000 *(Source: DOF, 2018)*



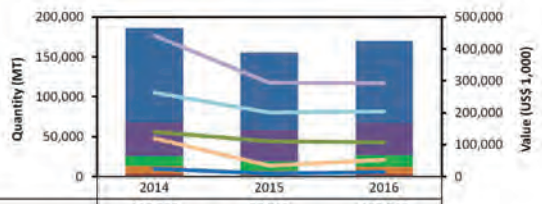
	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Fish	234,060.74	277,823.74	273,043.74	283,688.76	266,464.97	237,142.31	225,974.93	246,970.93	290,580.04	394,135.80
Prawn	18,382.10	17,439.31	19,142.91	17,995.03	17,267.93	16,508.97	17,527.33	13,673.49	13,082.46	15,905.44
Others	72,267.70	79,829.38	81,706.06	85,297.53	93,112.79	91,616.08	94,788.33	108,326.47	135,044.01	158,186.09
Total (MT)	324,710.54	375,092.43	373,892.71	386,981.32	376,845.69	345,267.36	338,290.59	368,970.89	438,706.51	568,227.33
Fish	273,270	309,860	342,440	396,270	378,050	286,930	258,610	274,250	319,040	385,810
Prawn	88,850	56,330	68,660	86,190	89,290	61,980	56,890	49,640	58,210	60,780
Others	121,110	130,400	144,410	171,390	185,500	187,360	166,750	178,740	228,570	265,130
Total (US$ 1,000)	483,230	496,590	555,510	653,850	652,840	536,270	482,250	502,630	605,820	711,720

Figure 9. Fish and fishery products exported by Myanmar from 2008-2009 to 2017-2018 by quantity (mt) and value in US$ 1,000 *(Source: DOF, 2018)*

In terms of import, the country imported around 815.87 mt of fish and fishery products valued at US$ 1.26 million in 2016-2017, which increased to 1,804.24 mt valued at USD 2.22 million in 2017-2018. There are 50 kinds of fishery products imported by Myanmar and among them are saba, salmon, ocean trout, octopus, prawn eggs, mollusks, and shishamo fish. The main countries of origin of imported fish and fishery products into Myanmar are Japan, France, Norway, Russia, Canada, Indonesia, Thailand, New Zealand, Chile, Viet Nam, China, Taiwan, Greenland, UAE, and USA (DOF, 2018).

- ***Philippines***

The major fish and fishery products exported by the Philippines in 2014-2016 (**Figure 12**) indicated that in terms of quantity and value, tuna was the top exported commodity dispensed as fresh/chilled/frozen, smoked/dried, and canned. The major markets for tuna include the USA, Japan, and the UK. Seaweeds ranked second and its major markets are the USA, China, and France. Third in rank were crabs (live, frozen, fresh/chilled) and its fat and meat (prepared/preserved). Shrimp/prawn ranked fourth with Japan, USA, and France as the major destinations. Fifth is the octopus exported as live, fresh/chilled, frozen, and dried/salted or in brine.



	2014	2015	2016
Tuna	117,909	97,815	103,543
Seaweeds	42,469	38,968	39,874
Crabs	12,581	11,464	14,160
Shrimps, prawns	8,917	5,475	8,968
Octopus	4,132	2,041	3,442
Total of major products (MT)	186,008.00	155,763.00	169,987.00
Total of all products (MT)	316,863.00	226,821.00	257,219.00
Tuna	441,991.02	294,896.97	292,100.28
Seaweeds	263,597.20	201,640.81	203,508.10
Crabs	140,423.48	110,596.34	107,559.19
Shrimps, prawns	119,843.19	35,027.50	52,522.37
Octopus	25,352.05	8,956.47	13,753.50
Total of major products (US$ 1,000)	991,206.95	651,118.08	669,443.44
Total of all products (US$ 1,000)	1,270,845.15	909,512.78	977,672.59

Figure 12. Major fish and fishery products exported by the Philippines in 2014-2016 by quantity (mt) and value in US$ 1,000
(Source: BFAR, 2018)

The total quantity of the country's imported fish and fishery products in 2014 was more than 300,000 mt valued at about US$ 300 million, comprising fish (chilled/frozen), prawn feeds, flour, meals and pellets made of fish, crustaceans, and mollusks. The imported chilled/frozen fish consists of tuna, mackerel, and sardines, and tuna was the highest in terms of quantity and value, where tuna is supplied mainly by Papua New Guinea, Taiwan, China, South Korea, and Japan.

- ***Thailand***

During the past decades, the export of fish and fishery products of Thailand had expanded making the country one of the world's top exporters of fish and fishery products. The country is also one of the global top importers of fish and fishery products which are mostly used as raw materials for re-exported processed products (FAO, 2018). The total quantity and value of fishery products exported and imported by Thailand in 2014-2017 are shown in **Figure 13**. For imported fishery products, fish was the major commodity in 2017 and the AMSs were the major suppliers of fishery products to Thailand in terms of quantity and value in 2017.

	2014	2015	2016	2017
Export (MT)	1,793,277.61	1,683,566.81	1,666,248.89	1,521,189.91
Import (MT)	1,628,237.48	1,626,642.45	1,895,436.83	1,939,170.45
Export (US$ 1,000)	7,015,409.13	6,077,330.96	6,247,784.22	6,498,657.12
Import (US$ 1,000)	2,853,291.71	2,635,033.74	3,226,423.41	3,715,517.96

Figure 13. Export and import of fish and fishery products of Thailand in 2014-2017 by quantity (mt) and value in US$ 1,000
(Source: DOF, 2017)

Way Forward

In order to safeguard the niche of the region's fish and fishery products in the world market, it has become necessary that issues and concerns on fish safety and quality are properly addressed. While there are several emerging standards and requirements imposed by importing countries to ensure the safety of the consuming public, the Southeast Asian countries have also their respective national systems of tracing the origin of fish and fishery products being traded. Moreover, at the regional level, SEAFDEC with the cooperation of the Member Countries came up with a traceability system for ASEAN aquaculture products, which is being used in the aquaculture supply chain for checking the safety and quality of aquatic organisms and verifying that such organisms are farmed in compliance with national and international management requirements (Yeap, 2016). Moreover, the ASEAN Catch Documentation System (ACDS) was also developed for marine capture fisheries as a unified framework for ensuring the traceability of fish and fishery products in the supply chain and enhancing the credibility of fish and fishery products for intra-regional and international trade (Siriraksophon *et al*., 2016). The electronic format of the ACDS, known as the eACDS, has also been developed to promote web-based application of the system. SEAFDEC has been initiating capacity building of the AMSs on the application of the ACDS to enable them to monitor and control the trade of fish and

fishery products, and help them in complying with the IUU-related trade measures, since the ACDS was developed taking into consideration the standards and information requirements of importing countries although the ACDS has been simplified to facilitate its applicability by the fisheries sector of the region (Siriraksophon *et al*., 2017).

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Strengthening Sub-regional Cooperation to Enhance the Implementation of MCS in Southeast Asia

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Following the UN Fish Stocks Agreement entered into force in December 2001 ensuring the long-term conservation and sustainable use of straddling and highly migratory fish stocks within the framework of the United Nations Convention on the Law of the Sea (UNCLOS), the Southeast Asian countries through the regional cooperation promoted by SEAFDEC, have intensified their efforts in establishing a common measure through sub-regional based fisheries management. In view of the depleting trend of the stocks in many fishing areas in the Southeast Asian waters, especially the straddling stocks or migratory species, the Southeast Asian countries had deemed it necessary to adopt proper management actions to ensure the sustainable utilization of transboundary fish stocks. SEAFDEC therefore, with support from the SEAFDEC-Sweden Project has established the RPOA-Capacity for regional implementation under the framework of the IPOA-Capacity, and encouraged the Southeast Asian countries to also develop their respective NPOA-Capacity. One of the specific objectives of the RPOA-Capacity is to enhance regional cooperation on fisheries management and in managing fishing capacity by strengthening the aspect of monitoring, control, and surveillance (MCS) at the sub-regional level. Through the SEAFDEC-Sweden Project, four sub-regional areas in Southeast Asia have been defined, *i.e.* Gulf of Thailand, Andaman Sea, Sulu-Sulawesi Seas, and Lower Mekong River Basin. However, the focus for the regional MCS centers is on the Andaman Sea and the Gulf of Thailand. These sub-regions cover several bordering Southeast Asian countries that encounter common management issues as far as migratory species such as anchovies, neritic tunas, blue swimming crabs, and mackerels among others, are concerned. From the series of consultations among the bordering countries, multilateral cooperation was identified as a platform to promote fishing capacity management through the sub-regional cooperation in MCS.

Supported by the SEAFDEC-Sweden Project, SEAFDEC organized several bilateral and sub-regional dialogues among the concerned Southeast Asian countries for the sustainable management of the region's biodiversity and fisheries habitats that play a major role in enhancing the socio-economies and governance of the Southeast Asian region. In this regard, four sub-regions have been given more emphasis by the Project, *i.e.* Gulf of Thailand, Andaman Sea, Sulu-Sulawesi Seas, and Lower Mekong River Basis (**Figure 1**). The approach adopted by the Project is to establish collaborative arrangements in fisheries and habitat management for the Gulf of Thailand and the Andaman Sea, while making efforts also to support the processes of cooperation among the countries bordering Sulu-Sulawesi Seas and the Lower Mekong River Basin (Wanchana *et al*., 2016).

Figure 1. Map of Southeast Asia showing four sub-regions that are given emphasis in the SEAFDEC-Sweden Project

(Adapted from Wanchana et al., 2016)

From the series of bilateral and sub-regional dialogues among the countries concerned, several common areas were identified to ensure the sustainable management of fisheries and combat illegal and destructive fishing activities in the Southeast Asian region. These concerns include among others, the adoption of efficient Monitoring Control and Surveillance (MCS[1]) system for effective control of fishing capacity and combat illegal, unreported and unregulated (IUU) fishing, destructive fishing, and encroachment by larger fishing vessels in coastal waters (Wanchana *et al*., 2016).

The review made by Yleaña and Velasco (2012) indicated that the establishment of a regional MCS network in Southeast Asia is important to strengthen the capabilities of the countries for combating IUU fishing and destructive fishing activities that impact on the sustainability of the region's fishery resources. At the outset, SEAFDEC with support from the SEAFDEC-Sweden Project convened several national consultations in the concerned countries to identify the priorities for cooperation with neighboring countries. These were followed

[1] *Based on definition provided by FAO, the meaning of MCS is as follows (more details are provided in Box 3): Monitoring – the continuous requirement for the measurement of fishing effort characteristics and resource yield; Control – the regulatory conditions under which the exploitation of the resources may be conducted; and Surveillance – the degree and types of observations required to maintain compliance with the regulatory controls imposed on fishing activities (Davis, 2000)*

by sub-regional meetings among the concerned countries to assess the national priorities and develop a workplan for the establishment of the MCS coordination body. Finally, MCS coordination body was established based on the modalities agreed during the sub-regional meetings.

Sustainable Fisheries Production of the Southeast Asian Region by Combating IUU Fishing

In 2016, the Southeast Asian region contributes significantly to the world fish supply. In fact, most of the countries in the region belong to the world's top 10 producers of fish and fishery products. The fisheries production of Southeast Asia during that year totaled 45.3 million metric tons (MT) valued at more than US$ 41.00 billion (SEAFDEC, 2017a), accounting for about 22 % of the world's total fisheries production in terms of volume. In order to maintain such production, SEAFDEC has been promoting several measures to combat illegal, unreported and unregulated (IUU) fishing activities in the region considering that IUU fishing has been recognized as a deterrent to the sustainable development of fisheries in the Southeast Asian region. The many forms of IUU fishing that occur in the region (Ali *et al*., 2015) are shown in **Box 1**.

Box 1. Forms of IUU fishing that occur in the Southeast Asian region (Ali et al., 2015)

- fishing without valid license or registration document
- vessels with specifications that are different from those indicated in the fishing license
- double flagging
- fishing in waters outside the permitted or designated fishing areas
- operating prohibited fishing gears and methods
- landing of fish in unauthorized ports
- transferring of catch at sea, and unreporting or misreporting of catch
- unauthorized transshipment and landing of fish/catch across borders, *i.e.* fishing vessels operating in a country but transshipping or landing their fish/catch across borders without authorization, activities that are carried out not only by small-scale and commercial fisheries, but also double flagged fishing vessels
- poaching in the EEZs of other countries
- capturing and trading of live reef food fish, reef-based ornamental and endangered aquatic species by making use of irresponsible and illegal practices along the whole value chain, e.g. using chemicals and other unregulated practices to collect and trade live reef food fish, as well as reef-based ornamental and endangered aquatic species for consumption and for the aquarium industry
- shipping fish catch directly from fishers to importers without permission and proper documentation
- in the high seas and RFMO areas, fishing without permission or during out-of-season, using outlawed types of fishing gears, disregarding catch quotas, unreporting, and misreporting catch volumes and species

Figure 2. Initiatives of SEAFDEC and the AMSs towards combating IUU fishing in the Southeast Asian region

With the main objective of combating IUU fishing in the Southeast Asian waters, SEAFDEC has been promoting in the ASEAN Member States (AMSs) the ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain. Meanwhile, the AMSs have also made tremendous efforts in implementing several initiatives (**Figure 2**) that include the Regional Fishing Vessels Record for Vessels 24 Meters in Length and Over (RFVR-24 m), the electronic ASEAN Catch Documentation Scheme (eACDS) for Marine Capture Fisheries, and Port State Measures, as well as strengthening cooperation on transboundary issues through bilateral dialogues where the platform for harmonization has been provided by SEAFDEC with support from the SEAFDEC-Sweden Project.

Stabilization of the Utilization of Global Fish Stocks

FAO (2018) reported that the portion of fish stocks (**Box 2**) that is within biologically sustainable levels had decreased from 90.0 % in 1974 to 66.9 % in 2015, while the percentage of stocks fished at biologically unsustainable levels increased from 10 % in 1974 to 33.1 % in 2015, with the largest

Box 2. Classification of fish stock status

Biologically sustainable levels - stocks with abundance at or above the level associated with maximum sustainable yield (MSY)

Biologically unsustainable levels - stocks less abundant than the level needed to produce MSY

Overfished - having abundance lower than the level that can produce MSY

Maximally sustainably fished - having abundance at or close to the level of MSY

Underfished - abundance above the level corresponding to MSY

Source: FAO (2018)

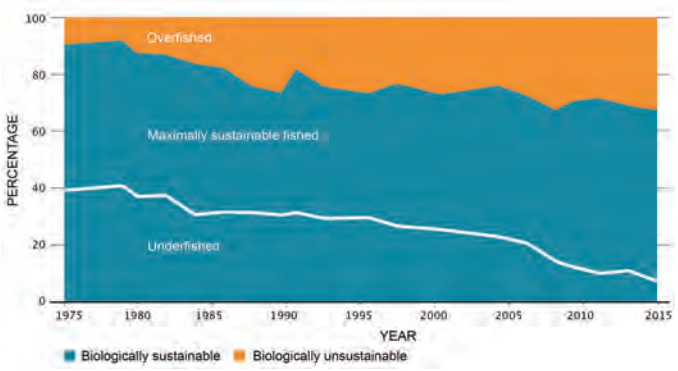

Figure 3. Global trends in the state of the world's marine fish stocks from 1974 to 2015
(Source: FAO (2018))

increases in the late 1970s and 1980s (**Figure 3**). In 2015, the maximally sustainably fished stocks accounted for 59.9 % and underfished stocks for 7.0 % of the total assessed stocks (separated by the white line in **Figure 3**). While the proportion of underfished stocks decreased continuously from 1974 to 2015, the maximally sustainably fished stocks decreased from 1974 to 1989, and then increased to 59.9 % in 2015.

The ASEAN Member States (AMSs) recognize that there is a need to properly manage the fishery resources to sustain their contributions to the nutritional, economic, and social well-being of the world's growing population. Considering that the coastal and marine environments throughout the world have been reported to be overfished (**Figure 3**), especially the commercially important fish stocks while degradation of habitats continues to take place which is exacerbated by the effects of climate change, the AMSs have been conscientiously improving the management of their respective countries' fish stocks through the promotion of monitoring, control, and surveillance (MCS).

Promotion of Monitoring, Control, and Surveillance in the Southeast Asian Region

Recognizing the importance of the commercial fish stocks and their respective fisheries at the global scale, the FAO Member States unanimously adopted in 1995 the Code of Conduct for Responsible Fisheries (CCRF) as set of international standards of behavior for responsible practices with a view to ensuring the effective conservation, management, and development of living aquatic resources, with due respect for the ecosystem and biodiversity (FAO, 1995). These standards had been promoted at the regional, sub-regional, and national levels to ensure that the fisheries sector becomes more responsible in its behavior towards the utilization of the fishery resources. The governments and non-government organizations have considered the CCRF as the global standard for setting out the objectives of sustainable fisheries and aquaculture over the coming decades and as the basis for reviewing and revising national fisheries legislations.

In the Southeast Asian region, SEAFDEC has initiated in 1998 the Regionalization of the Code of Conduct for Responsible Fisheries to assist its Member Countries in the implementation of the CCRF at national levels. Through a series of regional consultations, the Regional Guidelines for Responsible Fisheries in Southeast Asia – Responsible Fisheries

Box 3. The monitoring, control, and surveillance (MCS) concept

Monitoring involves the requirement of continuously observing, collecting, measuring, and analyzing data and information on fishing activities. In this context, monitoring includes the collection of data on all aspects of fisheries activities such as catch and landing data, VMS data, fleet structure, and profitability; monitoring of the status of fish stocks; monitoring of crew (based on lists of national and foreign citizens), and safety and health standards onboard vessels. Regional cooperation is necessary to be able to coordinate catch data collection and landing inspections, which form the basis to coordinate certification and catch data exchange leading to improved traceability of fisheries products and enhanced trade. Coordinated data collection also serves as the basis for flexible trade regulations and tax revenues to the countries. Regional MCS coordination could also build mechanisms for exchange of information on nationals working as crews on foreign vessels. Exchanging information on national measures for the management of transboundary fish stocks could lead not only to increased production of fish but also profits for fishermen and the countries in the region. The authorities involved in monitoring include the Port Authorities, Department of Fisheries, Customs and Trade, Enforcement Authorities, Immigration and Labor Departments of the countries.

Control refers to specifying the regulatory conditions (legal framework) under which the exploitation, utilization and disposition of the resources may be conducted. The aspect of control includes reviewing and revising national laws and regulations on management of vessels and gears, import/export laws, immigration and labor laws, and maritime safety rules. In some cases, national laws should be formulated and/or revised to ensure that these are implementable and controllable. However, for national laws on trade, immigration, maritime enforcement, and national measures referring to trans-boundary species, it is significant and potentially beneficial to strengthen coordination neighboring countries in order that relevant data and information are shared and compared (e.g. crew lists to fight trafficking and crew mistreatment, vessel licenses to stop double flagging, VMS data, suspected IUU fishing vessels, catches of transboundary stocks). Efficient cooperation among concerned countries facilitates all these aspects, improves revenues as well the efficiency of national authorities across borders.

Surveillance involves the degree and types of observations required to maintain compliance with regulations, such as surveillance of the activities connected to maritime enforcement and with regard to fisheries, e.g. port controls, port State measures controls, safety at sea and controls at sea of fishing gear, catch composition, crew and authorizations. Since some forms of cooperation between and among some of the countries in the region have already been established, e.g. bilateral basis, such effort would serve as starting point for a broader regional cooperation. Such regional cooperation is often restricted to enforcement authorities and could also benefit from a broader representation of authorities to increase understanding of areas that are not at the core of enforcement such a gear restrictions, species and catch compositions, crew rights.

Source: SEAFDEC (2003); Yleaña and Velasco (2012); Hagberg (unpublished)

Management was developed taking into consideration the traditions and culture, fisheries structure, and ecosystems at the Southeast Asian context (SEAFDEC, 2003). In promoting the said Regional Guidelines, regional, sub-regional, and/or bilateral dialogues had been organized in the Southeast Asian countries to formulate measures that would enhance fisheries management through the adoption of MCS (**Box 3**). As one of the tools or mechanisms that could be used to keep track of the implementation of fisheries management plans, MCS is specifically aimed at maximizing the economic opportunities and benefits from State's waters within sustainable harvesting limits.

Therefore, through regional cooperation among the AMSs, exchange and sharing of information on MCS of fisheries and fisheries-related activities could be facilitated, which is a fundamental operating principle for the development of MCS networks (SEAFDEC, 2017b). Nonetheless, the responsibilities and institutional arrangements for MCS should start at the national level where national laws and regulations govern and control the fisheries sector. The scope of such a cooperation platform should then be adapted as appropriate as new issues and needs are highlighted by countries. For a sub-regional MCS cooperation, it is necessary that the actual needs of the countries are considered and the scope should be agreed in sub-regional meetings where all relevant authorities from the countries are represented. Moreover, the officers and staff from the respective countries should have the capability to exercise all the responsibilities under international laws.

Establishment of MCS Networks in Southeast Asia

One of the required urgent measures for regional fisheries management in implementing the ASEAN Regional Plan of Action for Management of Fishing Capacity (RPOA-Capacity) is strengthening regional and sub-regional MCS networks among the AMSs (SEAFDEC, 2017b). The RPOA-Capacity supports the need to enhance regional cooperation on fisheries management and/or management of fishing capacity in sub-regional areas such as the Andaman Sea, Gulf of Thailand, South China Sea, and Sulu-Sulawesi Seas. The RPOA-Capacity has been developed through dialogues, regional technical consultations, and expert meetings among the AMSs, organized by SEAFDEC with the funding support from the Japanese Trust Fund and the SEAFDEC-Sweden Project.

A special project implemented by SEAFDEC in cooperation with the ASEAN (under the ASEAN-SEAFDEC Strategic Partnership) and the AMSs, the SEAFDEC-Sweden Project had been implementing regional collaborative programs to clarify the relevant regional policies and priorities as well as support the national efforts in addressing habitat and fisheries management and the management of fishing capacity. Specifically, SEAFDEC and the SEAFDEC-Sweden Project had been promoting the importance of strengthening the MCS of fisheries-related activities through improved cooperation within and among the AMSs with focus on establishment of MCS networks in the sub-regions of Southeast Asia (**Figure 4**), namely: the Gulf of Thailand (involving Cambodia, Malaysia, Thailand, and Viet Nam), the Northern Andaman Sea (Myanmar and Thailand), and the Southern Andaman Sea (Malaysia, Indonesia, and Thailand).

MCS Network in the Gulf of Thailand Sub-region

The Gulf of Thailand (**Figure 4**) is an inlet of the South China Sea surrounded by Cambodia, Malaysia, Thailand, and Viet Nam (SEAFDEC, 2018a). The Gulf is around 560 km wide and 725 km long covering an area of roughly 320,000 km². It is relatively shallow where the average depth is 45 m and the maximum depth is 80 m. The Gulf is an important resource to the economies of the surrounding countries that benefit from fishing and aquaculture, tourism and recreation, agriculture, lumber, ports and shipping, oil rigs, among others. However, the coastal and marine environments in the Gulf of Thailand are now threatened because of overexploitation of the fishery resources, loss of habitats, and pollution as result of natural calamities as well as human activities.

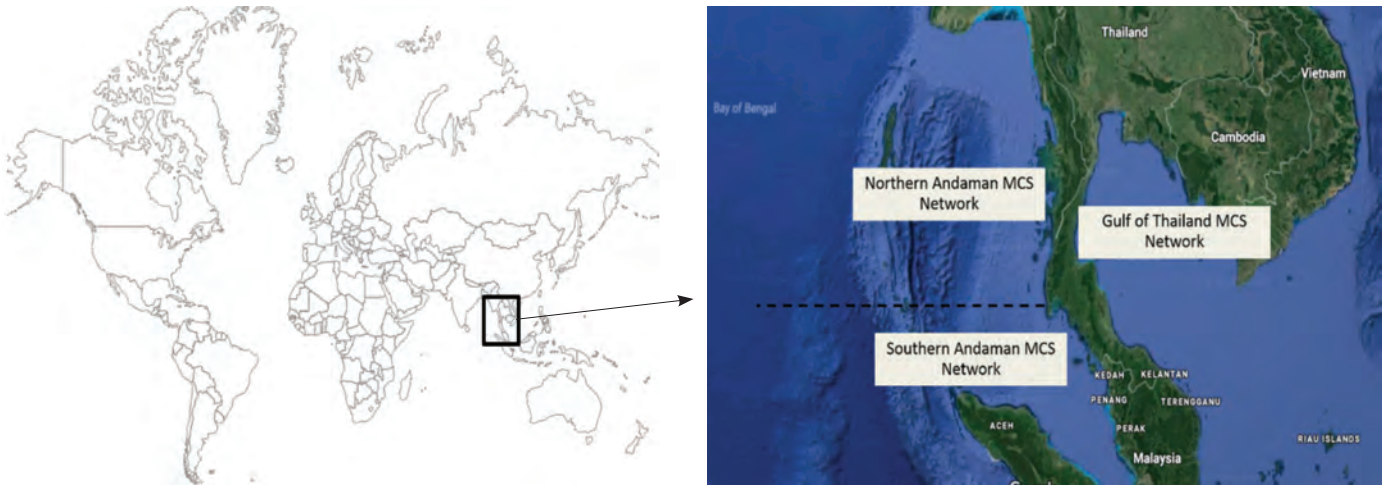

Figure 4. The Gulf of Thailand and the Andaman Sea sub-regions where regional MCS networks are being established

Since 2008, the SEAFDEC-Sweden Project had been organizing series of regional meetings and consultations among AMSs to address the environmental concerns in the Gulf of Thailand in order to protect, conserve, and rehabilitate important habitats and to maintain and improve the status of commercially important fish stocks by reducing fishing pressures in and around mangroves, sea grass beds, and corals reefs. The Project facilitated the management of fishing capacity as well as the promotion of cooperation on priority transboundary stocks through the integration of fisheries and habitat management.

Dialogues have been convened between Cambodia and Thailand, Cambodia and Viet Nam, Malaysia and Thailand, Malaysia and Viet Nam, Cambodia and Malaysia, and Thailand and Viet Nam. Special meetings with experts from the four Gulf of Thailand countries were also organized to assess the stock status and geographical distribution of anchovy, Indo-Pacific mackerel, and blue swimming crab, also known as AIB species in the Gulf of Thailand. From the results of such consultations and dialogues, the MCS network in the Gulf of Thailand Sub-region had been developed. This is meant to serve as platform for the concerned countries to enhance collaboration for the effective management of fishing capacity through exchange of information on fishing operations, fish stock status, as well as on catch and landing (SEAFDEC, 2018a). The potential benefits from the implementation of MCS network among the concerned countries are described in **Table 1**.

Table 1. Potential benefits of MCS Network in the Gulf of Thailand Sub-region

Issues	Cambodia	Malaysia	Thailand	Viet Nam
Improved control of IUU fishing and reduce IUU fishing	✓	✓	✓	✓
Facilitate import of raw materials		✓	✓	
Improved fishers welfare, well-being, and safety at sea	✓	✓	✓	✓
Improved control over the catches and income/taxes	✓	✓	✓	✓

Source: SEAFDEC (2018a)

MCS Network in the Andaman Sea Sub-region

The Andaman Sea is a marginal sea of the northeastern Indian Ocean. It is 1,200 km long and 645 km wide with an area of 798,000 km^2. About 5 % of the sea is deeper than 3,000 m and its northern and eastern part is less than 180 m deep because vast quantities of silt have been deposited by the Irrawaddy River at its delta, while the western and central half is 900-3,000 m deep. The Andaman Sea is well-recognized for its important habitats, rich biodiversity, and abundant aquatic resources that provide a wide variety of fishery products in addition to employment opportunities for the peoples of the surrounding countries. However, the fishery resources are being threatened by overfishing and degradation of habitats. Among the Andaman Sea countries (Indonesia, Malaysia, Myanmar, and Thailand), there is an understanding on the need to cooperate on the management and utilization of transboundary stocks, conservation and protection of important habitats, and resilience and capacity building for climate change adaptation. Furthermore, the importance to improve the management of fishing capacity, including the initiation of sub-regional MCS networks together with development of port monitoring capacity and coordinated efforts to combat IUU fishing is well recognized. Under the SEAFDEC-Sweden Project, the Andaman Sea Sub-region had been divided into the Northern Andaman Sea and Southern Andaman Sea Sub-regions (**Figure 4**).

Since 2009, with cooperation with the Bay of Bengal Large Marine Ecosystem (BOBLME) Project, the SEAFDEC-Sweden Project organized series of Andaman Sea sub-regional meetings and consultations to develop mechanisms for regional cooperation among the Andaman Sea countries. Then, bilateral meetings for Northern Andaman Sea (Myanmar and Thailand) and trilateral meetings for Southern Andaman Sea (Indonesia, Malaysia, and Thailand) were convened. Several ongoing activities and working groups (mackerels and MPAs, genetic studies on mackerels, and promotion of EAFM) of the BOBLME Project and the ASEAN-SEAFDEC programs (RPOA-Neritic Tuna, RPOA-Fishing Capacity, and promotion of EAFM) are linked with the active involvement of all Andaman Sea countries including India through the BOBLME Project (SEAFDEC, 2017c).

The roadmap of the MCS network in the Northern Andaman Sea covers: management of transboundary stocks, migration patterns and spawning seasons/area; and fishing capacity and MCS. The target priority species are kawakawa and long-tail tuna, as well as Indo-Pacific mackerel and anchovies.

Table 2. Institutions and agencies in Myanmar and Thailand involved in MCS networking in the Northern Andaman Sea Sub-region

Myanmar	Thailand
• Department of Fisheries • Navy • Marine Police • Customs • Immigration • Forestry Department • Kaw Thaung Provincial Department • Ministry of Environment as coordinating body for Myanmar	• Department of Fisheries • Navy • Marine Department • Marine Police • Port Authority • Thai Maritime Enforcement • Customs Department • Labor Department • Department for Marine and Coastal Resources (DMCR) • Ranong Provincial Authority • Thailand Maritime Enforcement Coordinating Center (Thai-MECC) as coordinating body for Thailand

Source: SEAFDEC (2018b)

Table 3. Institutions and agencies in Indonesia, Malaysia, and Thailand involved in MCS networking in the Southern Andaman Sea Sub-region

Indonesia	Malaysia	Thailand
• Ministry of Marine Affairs and Fisheries - Directorate General (DG) Capture Fisheries - DG Marine Fisheries Surveillance - Belawan Fishing Port - Sibolga Fishing Port • Provincial Office of North Sumatra • Provincial Office of Banda Ache • Special Task Force 115 as coordinating body for Indonesia	• Department of Fisheries • Navy • Malaysian Maritime Enforcement Agency (MMEA) Marine Police • Fisheries Development Authority (FDAM) • Jawatankuasa Bertindak Operasi Marin (Marine Operation Action Committee) or JBOM Committee (maritime task force Malaysia) as coordinating body for Malaysia	• Department of Fisheries • Navy • Marine Department • Marine Police • Port Authority • Customs Department • Labor Department • Department for Marine and Coastal Resources (DMCR) • Thai Maritime Enforcement Coordinating Center (Thai-MECC)

Source: SEAFDEC (2018c)

The members of the MCS National Technical Group (NTP) were designated based on existing national MCS networks (SEAFDEC, 2018b). Institutions and agencies in Myanmar and Thailand involved in MCS networking in the Northern Andaman Sea sub-region are shown in **Table 2**.

The MCS requirements of the Southern Andaman Sea sub-region cover not only fisheries management issues but also maritime security concerns (*e.g.* piracy, shipping lanes, and smuggling). The roadmap for MCS network in the Southern Andaman Sea comprises: management of transboundary fish stocks, migration patterns and spawning seasons/area; and fishing capacity and MCS. The target priority species are anchovies, mackerels (*Rastrelliger brachysoma* and *R. kanagurta*), and neritic tunas (kawakawa and tonggol). Members of the National Technical Group (NTP) were designated based on existing national MCS Networks (SEAFDEC, 2018c). **Table 3** shows the institutions and agencies in Indonesia, Malaysia, and Thailand involved in MCS networking in the Southern Andaman Sea Sub-region.

Conclusion and Way Forward

In the establishment and promotion of MCS networks, coordination among the countries concerned is essential for sharing and exchange of information, especially with respect to the countries' efforts in implementing the UNCLOS/UN Fish Stock Agreement. Moreover, the countries could also gain several benefits from such coordination, *e.g.* improved product traceability and certification, improved data for stock assessment, enhanced knowledge on national implementation of RPOA-Capacity by neighboring countries, improved management of shared stocks resulting in higher catch and increased profits, enhanced knowledge on the relevant regulations of neighboring countries gained by fishers and control agencies, and reduced costs for surveillance activities. However, the countries have their respective legal systems and mandates for fisheries management in national waters, which should be considered in establishing and promoting the MCS networks. For such reason, the sub-regional agreements established through the SEAFDEC-Sweden Project may not be considered legally-binding but had been built on mutual trust and recognition of the shared benefits that could be gained by the concerned countries. In addition, prior to the establishment of such sub-regional agreements, sharing of data that are mutually useful and those that would simplify national fisheries management works had been facilitated through the Project.

The SEAFDEC-Sweden Project also ensured that there is harmony among the concerned AMSs in the establishment of the MCS networks in the Gulf of Thailand, as well as in the Northern Andaman Sea and Southern Andaman Sea. Series of consultations and dialogues had therefore been organized by the Project for the development of the MCS networks, and meant to enhance the sub-regional cooperation and identify the priorities for the establishment of the MCS networks for improving transboundary fisheries management in the Gulf of Thailand and the Andaman Sea sub-regions. During the consultations, the concerned countries unanimously raised several concerns that need immediate action, such as overfishing, degraded coastal and marine environments, increasing demand for land and coastal areas, and negative impacts of climate change.

More particularly, the Gulf of Thailand countries agreed on the following aspects: enforcement of MCS practices and combat illegal (IUU) fishing through coordination of existing national mechanisms; development of sub-regional MCS network is a major force to keep track of the implementation of fisheries management plans as this would positively reduce long term damages on fish stocks and the marine ecosystems; and collaboration with responsible agencies to secure the mandate and approach for the establishment of the sub-regional MCS network which should be linked with the existing national networks and put into motion as early as possible. Meanwhile, countries in the Andaman Sea Sub-region confirmed that the efficiency and effectiveness of fisheries-related MCS activities could be sustained through enhanced cooperation, coordination, information collection and exchange among national organizations and institutions. The initial steps for framing out MCS network for the Northern Andaman Sea toward sustainability of fisheries had been undertaken while the common concerns and requirements of each M, C and

S had been addressed with the collaboration of respective responsible agencies of the concerned countries.

In conclusion, in establishing the MCS networks for sub-regional fisheries management coordination, the following considerations should be taken into account: common understanding among designated national agencies; enhanced cooperation among neighboring countries, clarification of national priorities, and the scope of cooperation which should be agreed upon by the countries concerned. The concerted efforts among the Gulf of Thailand and the Andaman Sea countries to cooperate in fisheries management had facilitated the successful establishment of the MCS networks. These countries have moved towards sustainability in their fisheries, facilitating fish trade and improving revenues and incomes. The key for such a cooperation to be successful is the active involvement of relevant authorities in the cooperation, nationally and regionally.

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Addressing the Issues and Concerns on Anguillid Eel Fisheries in Southeast Asia

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The SEAFDEC Inland Fishery Resources Development and Management Department (SEAFDEC/IFRDMD) has been mandated to "*monitor the state of exploitation and utilization of inland fishery resources and to come up with scientific basis for the sustainable development and management of such resources*." After its establishment in 2014, SEAFDEC/IFRDMD was tasked to address one of the concerns that need immediate attention, *i.e.* the conservation and management of the tropical Anguillid eels considering that this resource could be proposed for listing in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and as such, could impact on the fisheries of this economically important species of the Southeast Asian region. It was therefore deemed necessary for SEAFDEC/IFRDMD to initiate a compilation of the available data and information on the biology, population status, use, and trade of these species, which had been carried out through the "Regional Study on Tropical Anguillid eels in Southeast Asia" with the collaboration of concerned ASEAN Member States (AMSs). With funding support from the Japan-ASEAN Integration Fund (JAIF) for three-year period from 2017 to 2018 and the Japanese Trust Fund (JTF) from 2015 to 2018, the regional study is specifically aimed at understanding the status and trends of tropical Anguillid eel fisheries as well as information on trade and management policies in the Southeast Asian region, for the conservation and sustainable utilization of the resource.

Current Status of the Tropical Anguillid Eels

Reports have indicated that a total of 19 freshwater eel species/subspecies (16 species, two subspecies and one new species discovered in 2009) are known to exist worldwide, especially in the Pacific, Atlantic, and Indian Oceans, and of these 19 eel species, eight species/subspecies are known as the Southeast Asian Anguillid eels that inhabit the Southeast Asian waters, especially in the waters of Indonesia (Arai *et al*., 1999). Among the eight tropical Anguillid eels distributed in Southeast Asia, the most economically important species/subspecies are the Indonesian shortfin eel (*Anguilla bicolor bicolor* and *A. bicolor pacifica*) and giant mottled eel (*A. marmorata*). The common names and scientific names of the eel species found worldwide are shown in **Table 1**.

As part of the regional study, data collection was done in the AMSs where tropical Anguillid eel fisheries are practiced, *e.g.* in Cambodia, Indonesia, Myanmar, Philippines, Thailand, and Viet Nam (**Figure 1**), by interviewing the eel consolidators, fishers, farmers and local officers, as well as recording the statistics from country reports. The results had been shared with relevant stakeholders during the International Technical Workshop on Tropical Anguillid Eels in Southeast Asia in June 2018 in Bangkok, Thailand.

Table 1. Eel species known to inhabit the Pacific, Atlantic, and Indian Oceans

Common name	Scientific name	Tropical eel	Southeast Asian eel
European eel	*Anguilla anguilla*		
Southern shortfin eel	*A. australis australis*		
Southern shortfin eel	*A. australis schmidtii*		
Indian mottled eel	*A. bengalensis bengalensis*	*	*
African mottled eel	*A. bengalensis labiata*		
Indonesian shortfin eel	*A. bicolor bicolor*	*	*
Indonesian shortfin eel	*A. bicolor pacifica*	*	*
Indonesian longfin eel	*A. borneensis*	*	*
Celebes longfin eel	*A. celebesensis*	*	*
New Zealand longfin eel	*A. dieffenbachi*		
Highlands longfin eel	*A. interioris*	*	*
Japanese eel	*A. japonica*		
Luzon mottled eel	*A. luzonensis*	*	*
Giant mottled eel	*A. marmorata*	*	*
Pacific longfin eel	*A. megastoma*	*	
African longfin eel	*A. mossambica*	*	
Pacific shortfin eel	*A. obscura*	*	
Speckled longfin eel	*A. reinhardti*	*	
American eel	*A. rostrata*		

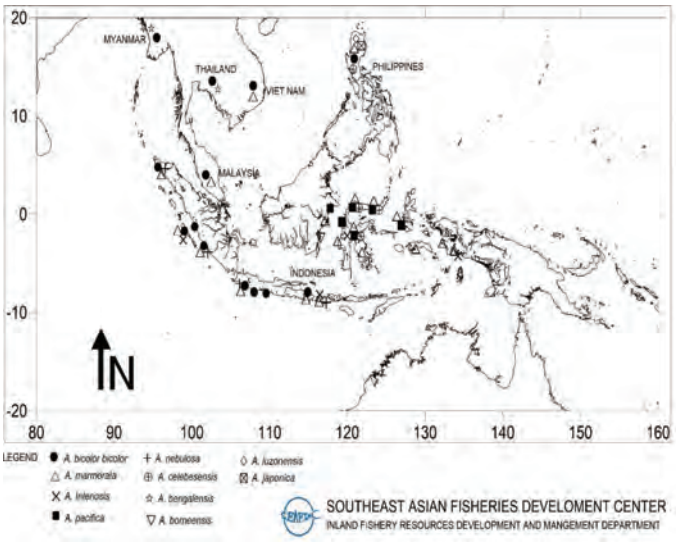


Figure 1. Geographical distribution of *Anguilla* spp. in Southeast Asia

Anguillid Eel Fisheries in Southeast Asia

In establishing a regional cooperation for exchange of information on Anguillid eels in the region, data on eel capture fisheries and eel farming in Southeast Asia were also compiled as these information would lead to the immediate actions that need to be tackled in the future (Honda *et al*., 2016a). However, this led to another concern on the reliance of eel farming on wild-caught eel seeds such as glass eels, elvers and yellow eels that are used for eel aquaculture (Crook and Nakamura, 2013). Since eel seeds are also natural resources, overfishing could occur leading to the decrease and collapse of eel resources (Honda *et al*., 2016b). Information on the catch of glass eels and yellow eels as well as catch effort were therefore compiled and used to analyze the trend of the tropical Anguillid eel resources. Such information was established by collecting production data on catch and aquaculture directly from eel consolidators and eel farmers. Information on the catch and aquaculture of tropical Anguillid eels in Cambodia, Indonesia, Myanmar, Philippines, Thailand, and Viet Nam, is shown in **Figure 2**.

- ***Cambodia***

There is no capture fishery that exploits tropical Anguillid eels in Cambodia, although the culture of elvers of *A. marmorata* (70%) and *A. bicolor pacifica* (30%) had been reported, using seeds imported from the Philippines (1.0 metric tons (mt) in 2017). Nevertheless, the fishers also reported that they can catch Anguillid eels from the wild oftentimes by using crab traps set at night in rivers and hauling the traps the next morning. Moreover, fishers also use hooks to catch eel species in the shallow waters of the rivers. This fishing operation usually takes the whole day during low tide and sometimes, long line is used in the rivers during the whole day, but the main target is not only eel species.

- ***Indonesia***

Capture fishing operations as well as farming of tropical Anguillid eels are more active in Indonesia than in other Southeast Asian countries. There are four main fishing areas for eels in Indonesia, *i.e.* in Palabuhan Ratu Sub-district, Manado District, Poso District, and Cilacap District. Glass eels, elvers, and yellow eels of *A. bicolor* or *A. marmorata* are caught from these areas. In Palabuhan Ratu Sub-district, glass eels are mainly caught between September and December uisng scoop net. While in Cilacap District, elvers and yellow eels are mainly caught by scoop net or PVC trap from October to November. Glass eels, elvers, and yellow eels in Poso District are mainly caught using fyke net or barrier trap from July to August. In Manado District, glass eels are caught by scoop net but the peak fishing season is still unknown. Annual catches in these areas had remained at around 10.0 mt of glass eels for the recent years, and less than 80.0 mt for elvers and yellow eels. The country's production from farming of

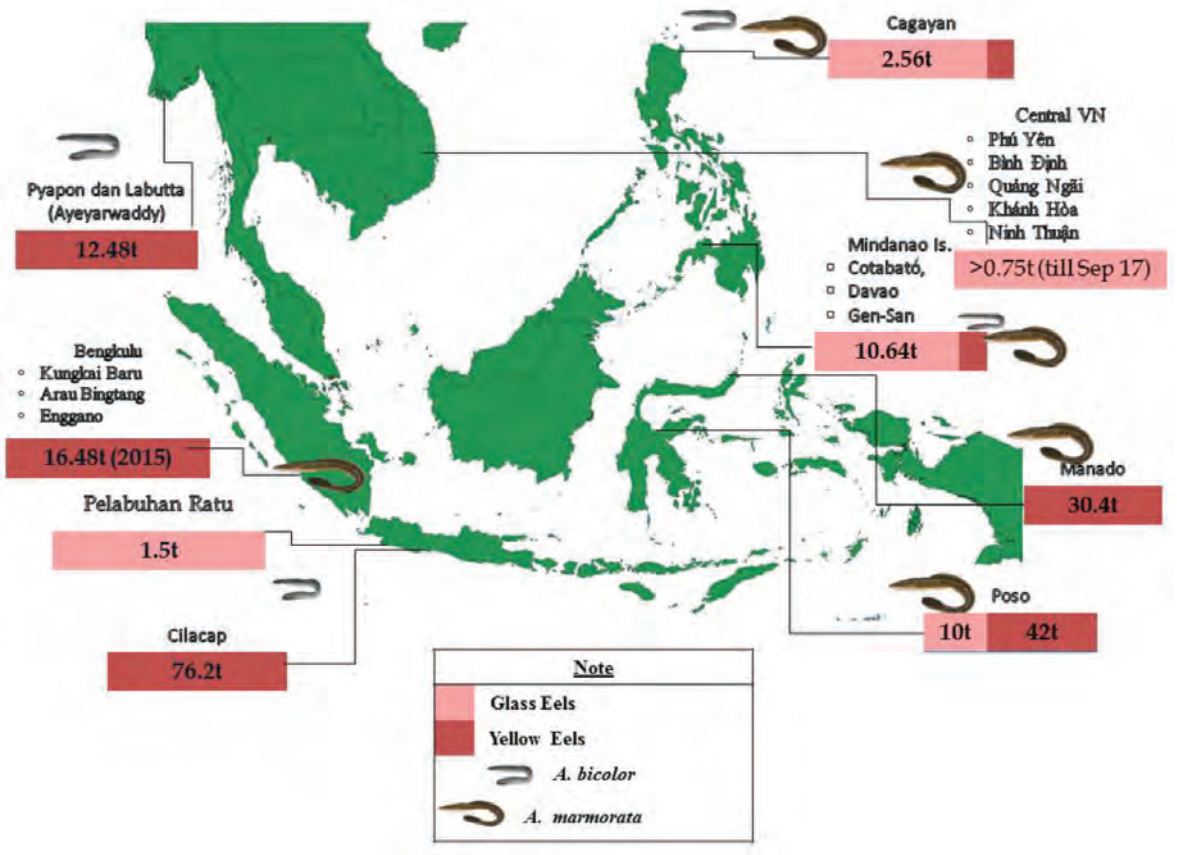


Figure 2. The total production from capture fisheries of glass eels and yellow eels (*Anguilla bicolor* and *A. marmorata*) in Southeast Asia

A. marmorata and *A. bicolor* is usually exported to China, Korea, Japan, Taiwan, and other countries.

- ***Myanmar***

There are no specific fishing operations in Myanmar that target the Anguillid eels. Yellow eels of *A. bicolor* (90%) and *A. bengalensis* (10%) are accidentally caught by stow net, crab trap, or longline hook during the rainy season. *Anguilla bicolor* is the main species farmed in Myanmar, by only one fish farmer, producing about 15.0 mt in 2017, all of which was exported to China.

- ***Philippines***

Anguilla marmorata is the main species of glass eels and elver/yellow eels caught in Luzon and Mindanao Islands of the Philippines. Glass eels are mainly caught by fyke net, stow net, scoop net, or push net between April and August. The country's annual catch of glass eels fluctuated yearly since 2007, where the catch from Luzon in 2007 was about 2.0 mt and 10.0 mt from Mindanao. The fishing gears for elver/yellow eels are seine net, bamboo trap, hook line, and spear gun. The main fishing season for elver/yellow eels is between December and February, and the annual catch from both islands in 2017 was about 0.3 mt. There are 28 fish farmers culturing the Anguillid eels in the Philippines. Production volume of farmed *A. marmorata* and *A. bicolor* in Mindanao is about 100.0 mt based on local official data in 2017, and about 20.0 mt in Luzon. *Anguilla bicolor* is exported to Japan, Korea and Taiwan; while *A. marmorata* is bound for Korea, China and Taiwan.

- ***Thailand***

Elvers and yellow eels of *A. marmorata* and *A. bicolor bengalensis* are caught by trap as by-catch in Ranong Province, Satun Province, and Phangnga Province between May and October. Glass eels imported from China, and elvers and yellow eels from Indonesia are farmed in several provinces of Thailand, the production of which is exported to China.

- ***Viet Nam***

Glass eels of *Anguilla marmorata* (95%) and *A. bicolor pacifica* (5%) are mainly caught in Ky Lo River, Phu Yen Province although there are also few catches in Bin Dinh Province, Auar Ngai Province, Khan Hoa Province, and Nah Tuan Province. The main fishing gears for glass eels are FADs (Fish Aggregating Devices) and scoop net, and the fishing season peaks from November to May in Phu Yen Province. The average annual catch of glass eels was recorded at 0.60-0.75 mt (or 4,000,000-5,000,000 tails). Information on catch of elvers and yellow eels is still being compiled from the survey. Several farmers are culturing eels in Phu Yen Province and Khan Hoa Province. One of the largest eel farms in Khan Hoa Province produces 200,000-300,000 tails of elvers and yellow eels. Meanwhile, information on the import and export of Anguillid eels by the country is still being compiled from the survey.

Types of Fishing Gears Used to Capture Anguillid Eels

In the Southeast Asian region, there are many types of fishing gears used to catch Anguillid eels, depending on the location, as shown in the **Table 2**.

Utilization of Anguillid Eels

Anguillid eels are utilized in many ways in Southeast Asia, however, the high diversity of tropical fishes in the region and the perception that Anguillid eels look like snake, many people in the region prefer to eat other fishes, except in Viet Nam, which uses 50% of its Anguillid eel production for domestic consumption. There are three components and steps in the commodity chain of glass eels in Southeast Asia, *e.g.* fishers, consolidators and shippers. Fishers catch glass eels then send them to consolidators, who after collecting the glass eels from fishers, send these to the shippers. Finally, the shippers send the glass eels to the eel farms, both domestic and overseas, and also to the market. Some consolidators also simultaneously play the role of shippers.

Table 2. Eel fishing gears in the Southeast Asian countries

Country	Fishing gear	Target size	Specification/Information
Indonesia	PVC pipe trap 	Elvers and yellow eels	• Set in rivers, tributaries, irrigation canals, swamp areas, at 5 PM and hauled at 5 AM. • Made of PVC pipe with additional net in the bottom part • Snails put in small bag net are used as bait
	Stow net 	Yellow eels	• Set in irrigation canals and small rivers during rainy season (especially during floods or when water current is strong), hauled every 30 minutes but operation is completed when the catch starts to decline • The frame is made of bamboo with 10 m net attached at the back side

Table 2. Eel fishing gears in the Southeast Asian countries (Cont'd)

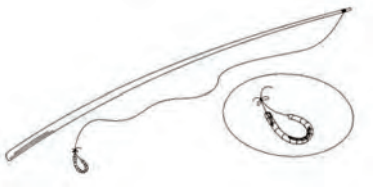
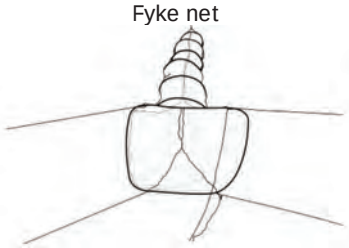
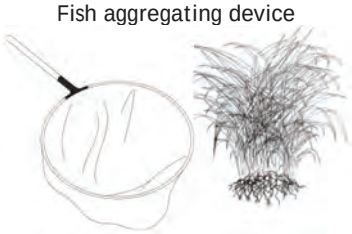
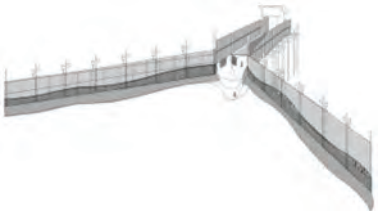
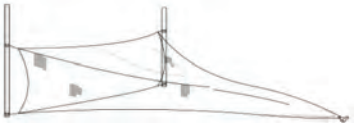
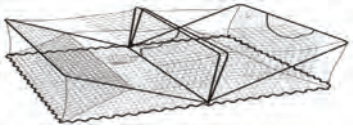
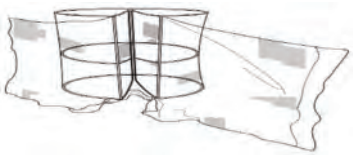
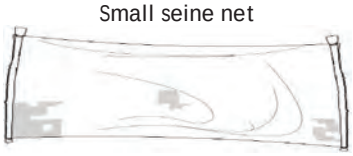
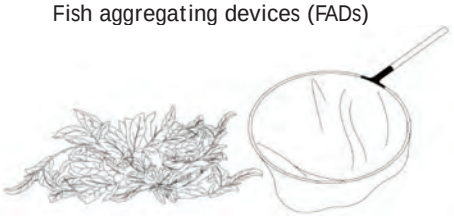
Country	Fishing gear	Target size	Specification/Information
Indonesia	Stick and line 	Yellow eels	• Set in rivers, tributaries and canals, operated at night, especially during new moon from 9 PM until 2 AM • Wooden stick and a line are used to catch yellow eels • Big earthworms are used as the bait
	Triangle scoop net 	Glass eels and elvers	• Set in mouth of rivers and downstream of dams • Glass eel catch activity operates from 9 PM until 2 AM, while the elvers catch operates from 8 PM until abundance declines. • Made of wooden sticks and small mesh-size net.
	Fyke net 	Glass eels and elvers	• Set in mouths of rivers and downstream of dams, at 8 PM and hauled from 2 AM until 5 AM • The frame is made of iron and covered with small mesh-size net; a wing, 2 m in length is attached to each side; diameter of net is 1.5 m and length is 10 m
	Fish aggregating device 	Elvers	• Set in shallow waters of irrigation weirs, and operated from 8 PM until 12 PM during rainy season • Small scoop nets are used to scoop the elvers hiding under grasses
	Barrier trap 	Yellow eels	• A traditional fishing gear set in the middle of rivers, operated only 2 days per month, set at night, and hauled at 6 AM • Made from pieces of bamboo formed into a barrier with additional bag net at the center of the trap
Myanmar	Crab trap 	Yellow eels	• Set in rivers at night and hauled in the next morning • The main target is crab, but eels are also often caught
	Stow net 	Yellow eels	• At sides of rivers, set the whole day and hauled 4 times a day • The main target species is shrimps, but eels are also often caught
Philippines	Fyke net 	Glass eels	• Set in middle sides of rivers at 5 PM and hauled at 3 AM. • The frame is made of circled iron and covered with small mesh-size net • The net is 6 m in diameter and 30 m in length, and a 12 m wing is attached on each side

Table 2. Eel fishing gears in the Southeast Asian countries (Cont'd)

Country	Fishing gear	Target size	Specification/Information
Philippines	Fence net 	Glass eels	• Set at sides of rivers for the whole day and hauled 4 times a day • Made of small mesh-size net and two wings with wooden stick to keep the wings and the mouth standing
	Scoop net 	Glass eels	• Set in mouth of rivers and operated during the night for 3 hours, like that of Indonesia, this gear also has a triangle shape • Made of wooden sticks and covered with a small mesh-size net
Thailand	Crab trap 	Yellow eels	• Set in rivers and mangrove areas at night and hauled the next morning • The main target is crab, but eels are oftentimes caught accidentally
Viet Nam	Fence net 	Glass eels	• Set in rivers and operated from 5 PM until 10 PM • The frame is made of circled iron with a diameter of 50 cm and has a small mouth at the center • The net has a wing of 1.5 m on each side
	Scoop net 	Glass eels	• Set in mouth of rivers and downstream of dams from 6 PM until 2 AM. • Similar in Indonesia and Philippines, the shape of scoop net is triangle • The net is made of wooden sticks and covered with a small mesh-size net
	Small seine net 	Glass eels	• Set in downstream of dams, from 6 PM until 2 AM • Made of two wooden sticks and a small mesh-size net, operated by two fishers
	Fish aggregating devices (FADs) 	Glass eels	• Set in downstream of dams, operated two times per day (from 3 PM until 5PM, and from 5 AM until 8 AM) • Made from branches of trees (Ky Lo River) and grasses (Ba River) • Small scoop net is used to scoop the glass eels hiding under the FADs

Farmers in Indonesia, Philippines, and Myanmar use locally collected seeds for growing eels in their domestic eel farms. While Cambodia imports seeds (> 15 cm and 150 g) from the Philippines and Indonesia, respectively, but the country's Anguillid eel market is not as popular as with the other countries. There is only one eel farm established in Cambodia as of May 2016 which produces 700 kg (since 2017) and supports a local Korean Restaurant. Indonesia, the leading country in Southeast Asia that produces Anguillid eel products such as roasted eel (kabayaki) and crispy roll, exports its products to Japan.

Furthermore, Indonesia also exports live eels to East Asia. In the Philippines, where the dominant cultured species is *A. marmorata*, the country's eel farms send the live eels to other East Asian countries except Japan which prefers *A. japonica* and *A. bicolor.* Frozen eels (*Anguilla* spp.) are traded from the AMSs except Brunei Darussalam.

Trade of Anguillid Eels

In Indonesia, the data on live eels bound for the international export in terms of quantity particularly in 2012-2014 was higher than that of the previous years and the year after due to the high demand of live eels from the East Asian countries. Similar increasing trends were also noted in the Philippine export data and those of Thailand's. On the overall, the export data from Southeast Asia indicated that three countries have been ranked as top exporters of live eels (*Anguilla* spp.), namely: Philippines, Myanmar and Indonesia.

In 2016, the total quantity of eel products, *i.e.* live and frozen eels exported by six AMSs was about 27,220 mt with trade value at US$ 82.94 million. Philippines provided the largest export quantity of live eels at 8,423 mt valued at US$ 30.18 million, followed by Myanmar at 7,242 mt, and Indonesia at 3,593 mt. However, comparing only the export of frozen eel, Indonesia exported the highest quantity at 6,152 mt valued at US$ 15.31 million. Furthermore, trading of eels in Singapore and Malaysia was active during the past three decades, but became inactive during the last decade when the export of live eels (*Anguilla* spp.) was less than 1.0 mt for Malaysia, and no export from Singapore since 2008.

Recommendations and Way Forward

In 2017, the estimated production from capture fisheries of both glass eels and yellow eels (or young eels) for *Anguilla bicolor* (including *A. bicolor bicolor*, *A. bicolor pacifica*) and *A. marmorata*, compiled from the baseline survey, indicated that Indonesia is the largest fishing country of eels in Southeast Asia. Taking into account the project objective which is to understand the actual status of capture fisheries by annual basis, therefore, all harvest data particularly those from Indonesia which is the largest eel producing country should be covered in the next phase of the study.

Furthermore, considering that the geographic distribution of *Anguilla bicolor* in Southeast Asia indicates many locations where the *A. bicolor* is found, such information should be verified and the actual status assessed. However, since the Anguillid eel resources are very dynamic, the status should be evaluated every year to also take into consideration the utilization potentials of the eel resources.

Acknowledgement

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Exploring the Sustainable Development of Demersal Fishery Resources in the High Seas

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The Southeast Asian Fisheries Development Center (SEAFDEC) is an autonomous inter-governmental body established as a regional treaty organization in 1967, to promote sustainable fisheries development in Southeast Asia. Currently, SEAFDEC has 11 Member Countries: Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam. In order to fulfill its mandate, SEAFDEC established five Technical Departments: Training Department (TD) in Thailand which focuses on R&D on marine capture fisheries, Marine Fisheries Research Department (MFRD) in Singapore for the development of fisheries post-harvest technology, Aquaculture Department (AQD) in the Philippines focusing on aquaculture R&D, Marine Fishery Resources Development and Management Department (MFRDMD) supports the sustainable development and management of marine fishery resources in the region's EEZs; and the Inland Fishery Resources Development and Management Department (IFRDMD) focusing on the sustainable development and management of inland capture fisheries. Specifically and in accordance with their respective mandates, TD and MFRDMD have been conducting R&D with respect to the sustainable development and management of the region's marine fishery resources. While the former undertakes R&D on fishing grounds, fishing gear improvement, and socio-economic aspects, among others, to facilitate sustainable utilization of the region's marine fishery resources; the latter gives priority to fish stocks management that support the sustainable development and management of such fishery resources. Basically, TD in collaboration with the SEAFDEC Member Countries and concerned international and regional organizations has been conducting fisheries research surveys in the South China Sea, Gulf of Thailand, and the Andaman Sea, using the SEAFDEC research and training vessels: the M.V. SEAFDEC and the M.V. SEAFDEC 2. While the M.V. SEAFDEC, a 1178-GT purse seine research vessel, is used to provide services towards the conduct of marine fishery resources surveys, the M.V. SEAFDEC 2, a 211-GT vessel, is mainly used to explore the fishery resource potentials in the Southeast Asian region. Both vessels were provided to SEAFDEC by the Government of Japan.

Many countries in the Southeast Asian region have increasingly attempted to expand their fishing activities to the offshore areas in their respective Exclusive Economic Zones (EEZs) and also in the high sea areas, where the fishery resources appear to be still under-utilized. These efforts are meant not only to reduce the pressure of over-exploiting the fishery resources in near shore areas and find alternative sources of fishery resources, but also to respond to the Resolution and Plan of Action No. 18, which encouraged SEAFDEC and the ASEAN Member States (AMSs) to "*investigate the potential of under-utilized fisheries resources and promote their exploitation in a precautionary manner based upon analysis of the best scientific information*" (SEAFDEC, 2011). In this connection, SEAFDEC has therefore been providing technical support to the AMSs in their efforts to explore such under-utilized fishery resources through technical consultations as well as collaborative research surveys that have been undertaken under the current five-year project "Offshore Fisheries Resources Exploration in Southeast Asia." Implemented by TD from 2014 to 2019, this project receives funding assistance from the Japanese Trust Fund (JTF) and technical support from collaborating partners at national, sub-regional, and regional levels, and makes use of the SEAFDEC research and training vessels: the M.V. SEAFDEC and the M.V. SEAFDEC 2.

Anchored at the TD Pier in Samut Prakan, Thailand, these two research and training vessels have been utilized mainly to support three specific R&D aspects: fisheries resource and oceanographic research surveys; human resource development on fishery resources development and management, development of sustainable fishing technology, navigation, marine engineering, and fish handling onboard fishing vessels; and assessment of national fishery resources in the respective EEZs of the AMSs. From the time it started its operations in 1993 up to the present, the M.V. SEAFDEC has been utilized for the conduct of regional collaborative research survey activities in several waters of the Southeast Asian countries, *e.g.* Gulf of Thailand, Andaman Sea, eastern Indian Ocean, as well as regional research activities in collaboration with relevant agencies. The M.V. SEAFDEC is also being tapped by the Government of Thailand to deploy and maintain a tsunami warning system in the Andaman Sea and Indian Ocean under the technical arrangement with the National Disaster Waning Center (NDWC) of Thailand.

The M.V. SEAFDEC 2, on the other hand, which started its operations in 2004 focuses mainly on the assessment of fishery resources through extensive scientific surveys of the coastal and offshore fishery resources of the AMSs. The vessel is also used during the implementation of the various fishery training courses arranged by TD, especially those that deal with the utilization of fishery resources in offshore and deep sea areas, and on the exploration of un-trawlable grounds in the waters of the AMSs.

Role of SEAFDEC in exploring the fishery resources in offshore and deep sea areas

Through the utilization of the M.V. SEAFDEC from 1993 to date, TD has been able to conduct marine fishery resources surveys in the waters of the Southeast Asian countries in collaboration with concerned countries, as well as short-term training courses on responsible fishing technology, and sustainable fishing techniques and practices. From the resources surveys, oceanographic data on the Southeast Asian waters and information on the region's marine fishery resources have been compiled. Moreover, a number of technical persons from the Southeast Asian countries have been trained on fishing gear technology, techniques, and practices. The collaborative fishery resources surveys carried out by TD had therefore been enhanced with the arrival of the M.V. SEAFDEC 2 at TD, especially the activities on coastal and marine resources surveys in the waters of the Southeast Asian region, *e.g.* South China Sea, Gulf of Thailand, Sulu-Sulawesi Seas. From those surveys, substantial data had been compiled, especially from the activity "Assessing the Demersal Fishery Resources in Southeast Asian Waters" carried out from 2004 to 2007, and the TD Project "Development of Demersal Fishery Resources Living in Un-trawlable Fishing Grounds in Southeast Asian Waters: Deep-sea Fisheries Exploration in Southeast Asia," which was implemented during 2007-2010. The results from such activities had been compiled and disseminated in the region through sets of guidelines and standard operating procedures for scientific surveys and fishing operations. All samples collected from the surveys using the M.V. SEAFDEC and the M.V. SEAFDEC 2 had been catalogued and maintained by TD. Through the years, the utilization of these research and training vessels has helped in strengthening the technical cooperation in effective fisheries and environmental management in the region through enhanced research and training capabilities.

Abundance of demersal fishery resources in Southeast Asian waters

Using the M.V. SEAFDEC 2, surveys were conducted by TD with the collaboration of concerned Member Countries from 2004 to 2007 to collect data on the relative abundance of demersal resources in the un-trawlable areas of Southeast Asia (Yasook, 2008). Covering the un-trawlable areas of the Andaman Sea of Thailand; West Coast of Borneo in the waters of Brunei Darussalam, and Sabah and Sarawak of East Malaysia; West Coast of Luzon and Sulu Sea of the Philippines; and East Coast of Viet Nam, and using the bottom vertical longline, the distribution and abundance of demersal fish species in these areas were determined. From the results, Yasook (2008) concluded that high-value demersal fishery resources, such as groupers and snappers, are found in these un-trawlable waters. Specifically, 20 species of groupers and 15 species of snappers were found but only the grouper *Epinephelus areolatus* was distributed in the sampling areas. He added that the highest CPUE was in the Andaman Sea, followed by the West Coast of Borneo and East Coast of Viet Nam, and the lowest CPUE was in the West Coast of Luzon in the Philippines. These results could imply that such fishery resources have the potentials for the development and management of deep sea fisheries in the Southeast Asian region.

Many reports have indicated that several surveys of the deep sea areas of the Southeast Asian waters had been conducted in the past years (Sukramongkol, 2011), specifically covering the South China Sea as well as the Andaman Sea. Although the compilation shown in the **Table** might not be very extensive, the results showed high diversity of species found in these waters. SEAFDEC also reported that during the survey cruises carried out by TD using the M.V. SEAFDEC 2, the waters off the Philippines and Indonesia with depths that range from

Table. Historical surveys of deep sea areas in the Southeast Asian region (adapted from Sukramongkol, 2011)

The survey	Year of survey	Research vessel used	Area of coverage	Important findings
US Bureau of Fisheries deep sea sampling expeditions	1908-1910	The ALBATROSS	Pacific and Hawaiian Islands (including Philippines and Indonesia)	New crustacean species of were found in Philippine waters (185 m deep) including the living fossil of the glypheoid, *Neoglyphea inopinata*
Fifth Thai-Danish Expedition (FTDE)	1966	R.V. THANARAT	Andaman Sea at depths 16 and 85 m	Recorded 80 species of fishes from 41 families
Deep sea explorations by the French National Museum of Natural History	1976, 1981, 1985	R.V. VAUBAN, R.V. CORIOLIS	Southwest waters off Luzon, Mindoro, Marinduque	Recapture of *Neoglyphea* sp. (glypheod lobster specimens)
Deep sea demersal resources survey	1975	Fisheries No. 2 or FR.V. Thanarat	Andaman Sea: in waters with depths from 100 to 450 m. off Myeik Coast (Myanmar), and off southwest of Phuket to Adang Island (Thailand)	With the main objective of exploring the deep sea for spiny lobster (*Puerulus sewelli*) and deep sea shrimp *Linuparus trigonus* at depths ranging from 100 to 450 m, results revealed high abundance of the species and the possibility of developing deep sea trawl fisheries at sea depths ranging from 130 to 350 m

Table. Historical surveys of deep sea areas in the Southeast Asian region (adapted from Sukramongkol, 2011) (Cont'd)

The survey	Year of survey	Research vessel used	Area of coverage	Important findings
Viet-Xo Joint Otter Trawl Survey	1978-1988		Viet Nam waters with depths more than 200 m	Catch rate fluctuated from 30 kg/hr to 460 kg/hr
FAO-assisted deep sea fishery resources survey (using bottom trawl)	1979-1980	Norwegian research vessel, the R.V. FRIDTJOF NANSEN	Countries bordering the Indian Ocean (waters of Indonesia, Malaysia, Myanmar, Thailand)	Substantial resources of deep sea shrimps and lobsters in the unexploited zone that with depths that range from 200 m to 300 m of the EEZs of Myanmar and Thailand
Bottom trawl survey	1980	R.V. FRIDTJOF NANSEN	West Coast of Sumatra	Standing stock was estimated ta 65,000 metric tons
Joint Thai-Japanese-SEAFDEC survey	1981	R.V. NAGASAKI MARU	Continental slope off Myanmar and Thai waters in Andaman Sea in depths 200 to 400 m	Deep sea shrimps and lobsters, cephalopods, Nemipteridae, Synodontidae, Elasmobranchii
Deep sea survey (SEAFDEC)	1987	M.V. PAKNAM	Southwestern waters off Phuket Island, with depths between 400 and 421 m	Max CPUE was 181.8 kg/hr of which CPUE of useful fishes was 20.3 kg/hr, 11.5 kg/hr for crustaceans, and 150 kg/hr of trash fish
Survey of un-trawlable waters between Myanmar and Thailand	1990	R.V. CHULABHORN	Areas between Myanmar and Thailand	Commercial species comprise yellow snapper at 1.7 kg.100 hooks, banded grouper at 0.9 kg/100 hooks
Survey under "Biodiversity of the Andaman Sea Shelf" of Denmark and Phuket Marine Biological Center	1996-2000	R.V. CHAKRATONG TONGYAI	Areas bordering Myanmar in the north to the Malaysian border in the south of the waters of Thailand	More than 1,000 deep-sea fish specimens were collected during this expedition at water depths that were deeper than 200 m
Fishery research survey of Brunei Darussalam	2004	M.V. SEAFDEC 2	Continental shelves and slopes off Brunei Darussalam waters (depths: 100 and 400 m)	Fish density along the continental slope: 0.63 to 1.53 mt/km^2, species composition from demersal trawl on continental shelf and upper slope (100-200 m) dominated by lizardfish (*Saurida tumbil*) and nemipterids (*Nemipterus* sp.)
Survey of fishery resources of Indonesia	2004-2005	R.V. BARUNA JAYA IV	West Coast of Sumatra and Java	High diversity: 456 fish species, 52 crustacean species, 42 cephalopod species; the area also serves as habitat of red roughy (*Hoplostethus crassispinus*), black roughy (*H. rubelloterus*), Alfonsino (*Beryx splendens*) and blackthroat seaperch (*Doederleinia berycoides*)
Survey of Malaysian EEZ	2004-2005	K.K. MANCHONG	Off Sarawak waters, with depths 92 and 185 m	Dominant species in deep sea; *Priacanthus macrocanthus*, *Saurida tumbil*, *S. longimanus*, *Decapterus kurroides*; *Lophiomus* spp., *Malakichthys elegens*; In un-trawlable waters (using bottom vertical longline): Ariidae, Lutjanidae, Squalidae, Lethrinidae, Nemipteridae, Portunidae, Muraenidae
Deep sea resource surveys in Philippine waters: Census of Marine Life	2005-2008		Panglao Island, Western Pacific off Luzon Island, Lubang and Mindoro: sea depths from 100 to 2,250 m	Compilation of taxonomic and morphological; significant catches of pandalid shrimps (*Heterocarpus woodmasoni*, *H. hayashii*, *H. dorsalis*) at depths of 200 and 600 m
Bottom trawl survey	2007	M.V. SEAFDEC 2	Continental shelf at the eastern central part off Myanmar waters up to 100 m deep	Highest catch: lizardfish (*Saurida undosquamis*) about 20% of total catch at 91 kg/hr
Deep sea fishery resources survey (SEAFDEC-BFAR survey using beam trawl)	2008	M.V. SEAFDEC 2	Lingayen Gulf (northwest of Luzon, Philippines)	50% of catch belong to family Macrouridae, Colocongridae, Sternoptychidae

200 m to 1,000 m, have highly-diverse fishery resources that are still less exploited (SEAFDEC, 2012). Nonetheless, these resources are also highly vulnerable to human demand for seafood, especially the low-productivity species and the sensitive deep-sea habitats. Commercial deep-sea fishing practices, *e.g.* gill-net, trawl, bottom longline, multiple hook and line, and trap, had been tried in Indonesia and the Philippines but their impacts have not yet been assessed. Concerns have therefore been raised on the absence of specific regulations related to deep-sea fishing practices in the region including the sustainable utilization of the deep-sea resources and the management requirements for deep-sea fisheries in the EEZs. Moreover, the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas that were adopted in 2008 might not have been considered and adopted by the countries' national jurisdictions.

Opportunities for Southeast Asian countries to explore the demersal fishery resources in the high seas

As adopted by the United Nations in the 1982 United Nations Convention on the Law of the Sea (UNCLOS), high seas in international and maritime law, refer to the open ocean that are not part of the Exclusive Economic Zone, territorial sea or internal waters of any State. Therefore, oceans, seas and waters outside national jurisdictions are referred to as the high seas. In the Convention on the High Seas signed in 1958 and used as the foundation of the 1982 UNCLOS, high seas had been defined as "*all parts of the sea that are not included in the territorial sea of in the internal waters of a State*" and where "*no State may validly purport to subject any part of them to its sovereignty*."

During the Fifth Meeting of the Parties to the Southern Indian Ocean Fisheries Agreement (SIOFA) on 25-29 June 2018 in Phuket, Thailand, it was noted that there are positive opportunities for SEAFDEC Member Countries to explore the demersal fishery resources in the high seas, especially in the area of competence of SIOFA (**Figure 1**). However, this could mean applying as one of the SIOFA Contracting Parties to be able to understand the Agreement and related Resolutions complied by all Contracting Parties, *e.g.* Resolution on Interim Arrangement Concerning the High Seas in the Southern Indian Ocean, Resolution on Data Collection Concerning the High Seas in the Southern Indian Ocean.

Figure 1. Area of Competence of SIOFA
(Source: https://www.apsoi.org)

SIOFA was established as a Regional Fisheries Management Organization (RFMO) to manage the fisheries of non-tuna species and to combat illegal fishing in the southern Indian Ocean. Signed on 7 July 2006 and entered into force in June 2012, SIOFA aims to ensure the long-term conservation and sustainable use of the fishery resources in its area of competence through cooperation among the Contracting Parties, and promote the sustainable development of fisheries, taking into account the needs of developing States bordering its competence area, and in particular the least-developed among them and small island developing States (FAO, 2018). SIOFA has nine (9) Contracting Parties: Australia, The Cook Islands, The European Union, France on behalf of its Indian Ocean Territories, Japan, The Republic of Korea, Mauritius, The Seychelles, and Thailand. Five (5) States around the Indian Ocean: Comoros, Kenya, Madagascar, Mozambique and New Zealand are also signatories to this SIOFA but have not yet ratified it, so they only the meetings of the Parties as observers. There are few organizations that technically coordinate with SIOFA, *e.g.* International Union for Conservation of Nature IUCN, Convention for the Conservation of Antarctic Marine Living Resources (CCALMR), Deep Sea Conservation Coalition (DSSC), Agreement on the Conservation of Albatrosses and Petrels (ACAP), Steinmetz Archive & the Dutch Social Science Information and Documentation Centre (SWIDCO).

Considering that the SEAFDEC Member Countries have already acquired the sufficient technology to conduct fishing operations, these countries could also explore the fishery resources in the SIOFA fishing grounds (**Figure 2**), like Thailand and Japan that are already Parties to SIOFA and have been fishing in such fishing grounds. Trawl, trap or pot, and bottom longline which are the general fishing gears and practices operated in SIOFA fishing grounds could also be used by the Southeast Asian countries in exploring the high seas under the competence of SIOFA because these countries have already developed the skills and experiences in the operations of such fishing practices.

However, there are still certain aspects that the Southeast Asian countries need to enhance, *e.g.* suitable fishing techniques in deeper fishing grounds, efficient safety at sea procedures and communication systems as the fishing grounds are far from ports. Another concern is the development of fish handling techniques onboard since in offshore areas, fishing vessels must be able to adopt efficient techniques for fish preservation.

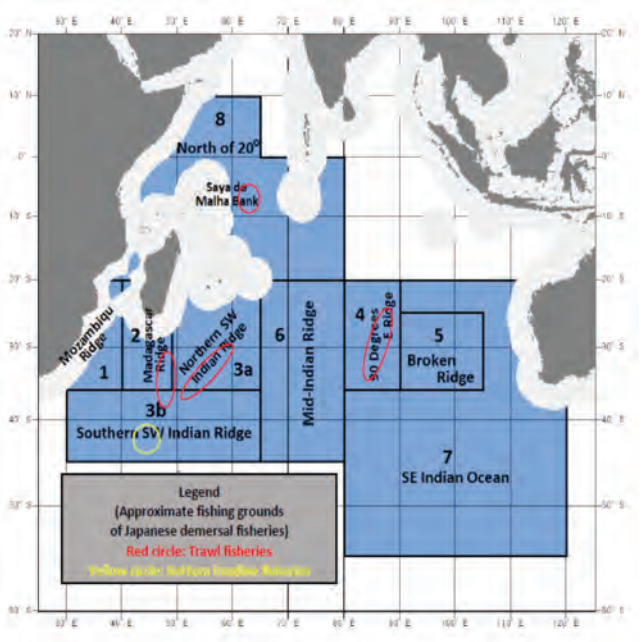

Figure 2. Major fishing grounds in SIOFA area used by Japanese fishing operations in 2017
(Source: Modified from Annual National Report of Japan on the 3rd Meeting of the Southern Indian Ocean Fisheries Agreement (SIOFA) Scientific Committee)

Other concerns include monitoring control and surveillance system that must be installed onboard fishing vessels, and following the regulations of SIOFA, Vessel Monitoring System (VMS), Logbook system and observers onboard must also be complete. Nonetheless, the other SEAFDEC Member Countries could learn from the experience of Japan and Thailand on fishing practices and fisheries management being part of the Contracting Parties SIOFA.

Box: Fishing experience of Japan and Thailand in the fishing grounds under the area of competence of SIOFA

Japan used two different types of fisheries discontinuously for 41 years (1977-2017), *i.e.* trawl fisheries targeting splendid Alfonsino (Beryx splendens), and bottom longline fisheries targeting the Patagonian toothfish (*Dissostichus eleginoides*). Based on accumulated information in the 12 years of trawl fisheries operations in three periods: 1977-1978, 2001-2002 and 2009-2017, the total catch (without 2017) of trawl fisheries ranged from 352 to 4,416 metric tons (1,340 tons on the average) with 1-2 vessels. Bottom longliners operated by the same vessel for nine (9) years 2004-2010, 2013 and 2017, the total catch (without 2017) ranged from 5 to 87 metric tons (28 tons on the average).

Thailand reported its fisheries operations during 2015-2017 using 62 vessels with 58 available logbooks. The fishing gears were trawling nets and portable traps with total effort of 9,455 fishing sets. The highest input fishing effort was in 2016 from the total of 4,560 sets. The total catch during 2015-2017 was 35,916.67 metric tons. The dominant catch species comprised the round scad (*Decapterus* spp.) - 29.78%, lizard fish (*Saurida* spp.) - 25.66%, threadfin bream (*Nemipterus* spp.) - 11.62%, goat fish (*Parupeneus* spp.) - 5.59%, bigeye scad (*Selar* spp.) - 4.79%, and Indian mackerel (*Rastrelliger* spp.) - 4.29%. The highest catch of 23,118.05 metric tons was recorded in 2015. Based on the observers' data and report, the average sizes of two dominant species of fish including the lizardfish (*Saurida undosquamis*) and round scad (*Decapterus russelli*) are larger than their sizes at maturity. They found no ETP species, coral or sponge. For latest fishing period in 2017 (January to February 2017), there were 14 vessels operated in the above mentioned area.

The major fishing practices operated in the area of competence of SIOFA are trawl fishing (midwater and bottom trawl), line fishing (longline, dropline) gillnets fishing, and pot fishing. These are the same gears that the Southeast Asian countries used in operating demersal fisheries in the waters of Southeast Asia. In the case of Japan and Thailand, which are Member Countries of SEAFDEC and also Contracting Parties to SIOFA, their fisheries activities in SIOFA fishing grounds (SIOFA, 2018) are summarized in the **Box**.

Important fishery resources in the area of competence of SIOFA

The major fishery resources that are being utilized by the Contracting Parties to SIOFA are shown below. These are the same resources that are considered commercially-important to the Southeast Asian countries.

Splendid alfonsino (*Beryx splendens Lowe*, 1834)
Photo source: http://www.fishbase.org/summary/1320

Orange roughy (*Hoplostethus atlanticus Collett*, 1889)
Photo source: http://www.fishbase.org/summary/334

Patagonian toothfish (*Dissostichus eleginoides Smitt*, 1898)
Photo source: http://www.fishbase.org/summary/467

Wreckfish (*Polyprion* spp.): In photo is *Polyprion americanus* (Bloch & Schneider, 1801)
Photo Source: https://www.fishbase.de/summary/Polyprion-americanus.html

Portuguese dogfish (*Centroscymnus coelolepis* Barbosa du Bocage & de Brito Capello, 1864)
Photo source: https://www.fishbase.de/summary/Centroscymnus-coelolepis.html

Southern boarfish (*Pseudopentaceros richardsoni* Smith, 1844)
Photo Source: https://www.fishbase.de/summary/Pseudopentaceros-richardsoni.html

Rat tails grenadiers (*Macrourus* sp.): In photo is *Macrourus berglax Lacepède*, 1801
Photo source: http://fishbase.org/summary/331

Blue antimore (*Antimora rostrata* (Günther, 1878))
Photo source: https://www.fishbase.de/summary /2005

Round scad (*Decapterus russelli*)
Photo source: https://www.fishbase.de/summary/374

Lizard fish (*Saurida undosquamis*)
Photo source: http://www.fishbase.de/summary/1055

Threadfin bream (*Nemipterus* spp.): In photo is *Nemipterus japonicus*
Photo source: http://www.fishbase.org/summary/4559

Bluenose warehou (*Hyperoglyphe antarctica* (Carmichael, 1819))
Photo source: http://www.fishbase.org/summary/496

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Website *https://www.apsoi.org/* accessed on 15 January 2019

Website *http://www.fishbase.org* accessed on 8 January 2019

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Application of Molecular Techniques for Sustainable Management of Inland Fisheries: the Experience of Indonesia

Arif Wibowo and *Virgilia T. Sulit*

Indonesia embraces large areas of inland water resources with potentials for development of its inland capture fisheries. To obtain the optimal and sustainable benefits from these resources for the benefit of present and future generations, an appropriate and systematic fisheries management effort is necessary. Application of the molecular approach through the DNA mitochondrial sequencing techniques could be used as basis for the management of the fishery resources in inland waters. For example, in an attempt to manage the fisheries habitat at the Merang Peat Swamp, information on the eleven freshwater fish species that spawn in this unique ecosystem was first established using molecular technique. The findings led to the identification of the fish species that inhabit the area based on the analysis done during the early stages of the life cycles of the species. These findings also imply that peat swamps are also important habitat of various fish species, especially during spawning, despite having extreme water conditions that might not even be ideal to sustain fish life. Results of the study on the use of molecular approach also provided the information needed for the management of belida fish or giant featherback (*Chitala lopis*). Specifically, the findings indicated that management of this fish species must be focused regionally because of the existence of more than one population in one river, which is not the same as in the case of the semah fish or mahseer (*Tor tambroides*). Nonetheless, the analysis made on these two species using molecular markers has led to the information on the presence of genetic diversity in belida and semah fish species in two separate rivers in Sumatra, a phenomenon which should be considered in the conservation efforts of these two fish species.

As defined, inland waters are those parts of the earth's surface that are permanently or periodically flooded with water (aquatic ecosystems), like fresh, brackish or salty water, formed naturally or artificially, and do not belong to any individual nor business entities. Moreover, the topography of inland waters is distinguishable from those of mainland waters or private ponds and marine waters (Anon, 2010), and according to some definitions provided by experts (Nontji *et al*., 1996; Hartoto, 2005), inland waters are all forms of water bodies located above the lowest tide line to the mainland.

It has been reported that the inland waters throughout Indonesia comprise various types of ecosystems, namely: lakes, reservoirs, rivers, and estuaries, with a total area of about 54 million ha (Manggabarani, 2005; Sukadi, 2005). There are also a total of 5,590 major rivers with streams having a total area of 1.5 million km^2 (Husnah *et al*., 2008) with total biomass potential which is assumed to be about 15,336 metric tons (Anon, 2010). The potentials of large inland waters are very important for the life of a nation and if managed appropriately, could be used optimally and sustainably for its people's wellbeing. However, appropriate resource management requires knowledge that underlies the biological principles, especially the ecology of the resource (Yusron, 2005). Nevertheless, the rapid development of molecular biology technology provides the biological information that could be used as basis for efforts to manage the fishery resources, specifically the application of mitochondrial DNA sequencing techniques that serves as guide in the management of the fishery resources in inland waters.

Identification of species during the early stages of the fish life cycle

An activity to identify fish species during the early stages of their life cycles was carried out at the Musi River (**Figure 1**) in South Sumatra, Indonesia. Musi River flows from South-West to North-East, from Barisan Mountain range forming the backbone of Sumatra, in Kepahiang, Bengkulu, to the Bangka Strait that extends to the South China Sea. After flowing through Palembang, the capital City of South Sumatra, this 750 km-long river joins with the several other rivers, including the Banyuasin River, forming a delta near the city of Sungsang. Musi River is host to at least 233 species of fish (Utomo *et al*., 2007; Husnah *et al*., 2008) with a total annual fish production estimated at 12,500 metric tons (Utomo, 2006; Anon, 2010). An attempt was made to use DNA barcodes to

Figure 1. The Musi River of Sumatra Island, Indonesia

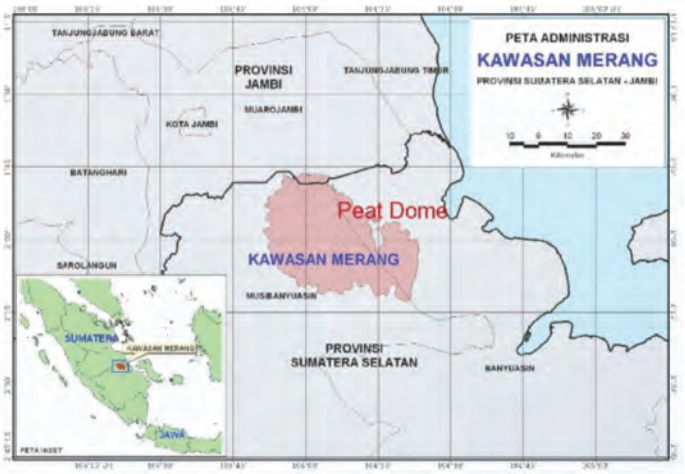

Figure 2. The Merang Peat Dome in South Sumatra, Indonesia

identify the fish larvae from the South Sumatra black water peatland forest, *i.e.* the Merang Kepayang Peat Dome (**Figure 2**) as the results could also be used to correctly identify the fish larvae specimens collected from Musi River at species level. After the activity, only about 66% of the samples could be analyzed, which could be due to the inappropriate barcode approach adopted or because of the insufficient number of reference sequences for the ichtyofauna study of this peat swamp.

This activity which is meant to identifythe fish species during the early stages of their life cycles, is a pioneering study of the ichtyofauna in the lowland eastern part of Sumatra Peatland using the molecular approach. The samples used in the study were extracted based on a total of 72 eternal sequences of COI (~ 376 bp) from 35 fish larvae, and 13 adult samples with sequential reference sequences and 24 NCBI Genbank and BOLD database for species identification.

The Merang Kepayang Peat is located precisely between the Medak and Kepahiang Rivers. The nearest village to the Dome forest is Muara Merang Village, which is 225 km or about 4-5 hours by car or boat from Palembang. These Rivers are the main access used by the villagers to go to neighboring villages, the nearest small city or to the forest. The Merang Peat Swamp Forest with an area of about 150,000 ha, is the last contiguous peat swamp forest in South Sumatra Province. It is part of a larger peat swamp area which is linked to the Sembilang National Park in the eastern part of Sumatra, the Muaro Jambi Peat Swamp Forest in the northern part next to Jambi Province, and Berbak National Park in the northwest.

The initial analysis indicated that at least eleven fish species complete their life history in this unique ecosystem. These are: the eyespot rasbora *Rasbora pauciperforata*, *Rasbora dorsiocellata*; kissing gourami *Helostma temminckii*; three-spot gourami *Trichogaster trichopterus*; rasbora *Rasbora cephalotaenia*, snakeskin gourami *Trichogaster pectoralis*, croaking gourami *Trichopsis vittata*; climbing perch *Anabas testudineus*; and other species of gourami *Pectenocypris korthusae*, *Parosphromenus deissneri*; and the Asian redtail catfish *Hemibagrus nemurus*. The species sequence reference of adult fish in the Merang Kepayang Peat represents 57% of the known species of the area.

The result of the study also explains the importance of the peat swamp ecosystem, *i.e.* in Merang Kepayang Peat, as a major part of biodiversity and their main role in maintaining the existence of at least eleven species of fish. Knowledge of the early stages of life cycles of fishes from fish eggs to larvae is very important for fisheries management. However, data interpretation problems could continue to occur, mainly because of the limited availability of key identification and rapid changes of morphological characters in the development of the initial larval phases, *i.e.* from preflexion to postflexion to the prejuvenary phase, contributing to the main challenges for species identification (**Figure 3**). The DNA barcoding approach that has a valid sequential reference sequence can increase the taxonomic resolution of larval identification at species level. This makes the existence of accurate and reliable sequences of DNA sequencing libraries for freshwater fish species very important in species-rich regions, such as Sumatra Island of Indonesia, which has around 285 species of freshwater fishes (Husnah *et al*., 2008). Scientific efforts to provide the sequence for the sequential libraries of the Sumatran freshwater fish species had been made but the results are still spatial and uncoordinated.

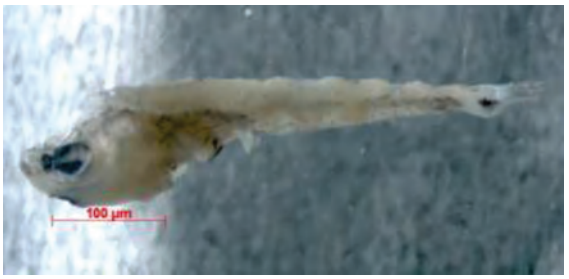

Figure 3. Unidentified fish larvae found in Merang peat dome, South Sumatra

Results from the DNA barcode study focusing on freshwater fish species in the Danau Laut Tawar System of Aceh Province, using the cytochrome oxidase subunit I (COI) gene mitochondrial DNA and 30 nucleotide species-specific sequence, have been compiled and together with a collection of at least 12 species of fish, are already made available in the Province' GenBank Database (Muchlisin, unpublished). Some information on reference sequences is also available for 20 Sumatran freshwater fish species (Wibowo, unpublished).

The first real effort to study DNA barcode applications for fisheries management in Sumatra was carried out by Wibowo *et al*. (unpublished) and intended for the conservation of the fishery resources. The local people catch freshwater fishes on location by small-scale fishing operations and the catch is sold at very low prices in local markets. Fish originating from the waters of the black aqueous peat forest are not brought to

other areas as these are mainly used for domestic consumption, notwithstanding the very high commercial potential of the fishes in the aquarium fish trade (Ng *et al*., 1994). This situation is common in most black water peat swamp forest areas that are located in very remote or inaccessible places. With abundant fishery resources and as the ornamental fish trade flourishes and becomes very profitable and lucrative business, Indonesia now ranks as the second highest exporter of ornamental fishes, contributing at least 7% of world's ornamental fish trade (Lim and Ling, 2005). In 2003, this trade exceeded US $298,000,000 and although some ornamental fish species are cultured, a big portion still comes from the wild (Ng, 1991 in Ng *et al*., 1994), and thus, could be affected by the conversion of many black swamp land areas that has reached an alarming stage. In fact, the loss of peat swamp forests in the lowlands of Sumatra and Kalimantan has been estimated at 70% during the period 1990-2005 (Hansen *et al*., 2009).

Belida fish management strategy based on a regional approach

Morphological approaches have limitations when used in detecting species variations especially for those species with vague taxa, for example in the case of belida fish or giant featherback (*Chitala lopis*), which has very high economic and socio-cultural value in Indonesia (Wibowo, 2011). This fish is very popular not only for its meat which is delicious but also for its high fat content making it nutritious (Sunarno, 2002), especially its high protein and Vitamin A contents (Mno, 2005). The belida fish, a very exclusive freshwater fish, commands a price that is quite expensive (more than Rp. 50,000/kg or US$ 3.50/kg). Traders classify the price of belida fish according to weight, with the lowest price for belida fish weighing less than 1.0 kg/tail), medium price for fish between 1.0 to 2.0 kg/tail, and the highest price for fish weighing more than 2.0 kg/tail. In Palembang, South Sumatra, Indonesia, the market price of belida fish in traditional fish markets is Rp. 200,000/kg (US$ 14.27/kg) for the highest price category and becomes even more expensive if the fish is alive and traded as ornamental fish. The uncontrolled catching of large-sized belida fish from the wild puts much pressure on the sustainability of this fishery resource.

Currently, the demand for belida fish by the processing industries is estimated to be about 200 kg/day and for the ornamental fish trade and human consumption, as much as 40 kg/day. Although fishers could only supply less than 2% of the market requirement (Anon, 2003), the population of belida fish in nature is decreasing due to fishing and human activities. The annual production of belida fish has declined not only at the national level but also at the regional scene. For example, in Kampar River, Riau Province, the catch of belida fish had been decreasing: from 8,000 mt in 1991 to 5,000 mt in 1995, and to 3,000 mt in 1998 (Directorate General of Fisheries, 2000). The annual production of belida fish in Kampar River had decreased further from 50.2 mt in 2003 to 7.6 mt in 2007 (Department of Marine and Fisheries, 2008). This condition is likely to continue because of the high demand for this fish. As a consequence, an appropriate fisheries management strategy to maintain and conserve this species is really necessary.

Belida or chitala fish (**Figure 4**) belongs to the Class Actinopterygii (ray fishes), Order Osteoglossiformes (bony tongues), Family Notopteridae (knife fish), Genus Chitala, and species *Chitala lopis* (Nelson, 1976; Kottelat *et al*., 1993). At present, there are 4 types of notopteridae in the Genus Chitala, namely: *Chitala lopis*, *C. blanci*, *C. ornate*, and *C. chitala* (Inoe *et al*., 2009).

Figure 4. Belida Fish (*Chitala lopis*)

There are no valid taxonomic records for chitala fish in Indonesia, but Kottelat and Widjanarti (2006) initially mentioned that the chitala fish in Indonesia belong to the species *C. hypselonotus*, *C. borneensis*, *C. lopis*, and *Chitala* sp., while *Chitala hypselonotus* and *C. borneensis* are found in Sumatra. Wibowo (2011) identified *Chitala lopis* in Sumatra Island based on partial mitochondrial DNA sequences. However, the mitochondrial sequence analysis, based on 12 bi-directional sequences (600-721 bp) from COI, 15 bi-directional sequences (496-1147 bp) from cytochrome b and 51 bi-directional sequences (566-936 bp) from non-coding (control region), shows that *Chitala lopis* in Indonesia can be distinguished by at least four groups of cryptic species (Wibowo, 2011; Wibowo and Farajallah, 2014 in press). This analysis was based on samples taken from rivers, reservoirs, lakes, swamps, ditches, and ponds, comprising almost all the distribution areas for belida fish in their natural habitat in Indonesia.

Although the result might not be comprehensive enough, but it indicated that the existence of belida fish in Indonesia is still poorly understood because some unidentified species tend to represent the evolutionary units and biological characters of the belida fish. The latest information from genetic population and life history studies however indicated that there are several belida fish populations that live in integrated rivers (Wibowo, 2011). Belida fish is a slow swimmer as can be seen from its shape. The fish inhabits the lakes, oxbow swamps, ditches, and ponds (Rainboth, 1996) and the eggs are not easily spread because belida fish eggs are usually attached to some submerged vegetations (Talwar and Jhingran, 1991).

As a consequence, gene flow will be inversely proportional to the local conditions. Therefore, for belida fish, a regional management strategy would be necessary.

For example, with a panmictic population structure, belida fishing in one area may not affect the subsequent recruitment in that area because new tillers (recruits) will come randomly from the parents originating from other areas. However, in the case of local populations, such as in the Kampar River (Wibowo, 2011), each local population tends to have certain migration circles and recruitment processes that almost none had occured in the other regions. Overfishing of belida fish in Kampar River might have real influence on the recruitment of returning fish to certain areas by each local population. The loss or degradation of habitats together with overfishing can lead to the extinction of the local belida fish, so that management of belida fish in Indonesia, where the life history of most species is still not fully understood, must be seriously considered.

Semah fish management

Another iconic fish species besides belida is the semah fish (*Tor tambroides*), belonging to the important group of freshwater cyprinids. Semah fish (**Figure 5**) is classified under the Class Actinopterygii, Order Cypriniformes, Family Cyprinidae, Genus Tor, and species *Tor tambroides*. The synonyms for semah fish in Indonesia are *Labeobarbus tambroides* and *Barbus tambroides* (Kottelat *et al*., 1993). Semah is one of the most popular freshwater fishes in Indonesia both for domestic consumption and for traditional cultural functions. This fish is also sold for around Rp. 50,000/kg (US$ 3.50/kg) in the local markets.

Figure 5. Semah fish (*Tor tambroides*)

Local fishers prefer to catch the large size fish compared to small size because of the higher price for bigger fish. The market price of semah fish in Malaysia ranges from Rp. 200,000 to 750,000/kg (Rachmatika and Haryono, 1999). Reports have indicated that the abundance and distribution of semah fish in their natural habitat has substantially decreased due to overfishing, pollution and deforestation (Kottelat *et al*., 1993). *Tor tambroides* usually inhabits the fast-flowing waters, has a long flat and large torso with long lobes and small head, green brown and large scales, and this fish is sexually mature when the abdomen enlarges and the silvery fin color is yellow, orange, pink or pale red (Pollar *et al*., 2007). It has also been reported that domestication and breeding of the semah fish is difficult to undertake and reproduction in captivity is also a challenge. In spite of such constraints, artificial propagation through induced ovulation and spawning using hormonal treatment techniques had been tried (Ingram *et al*., 2005). Also, the life history strategies and migration patterns of semah fish in river systems are not widely studied and not widely known.

Furthermore, efforts to study the genetic population of plants in Sumatran watersheds were also carried out by Wibowo and Husnah (2012); Wibowo (2012); Wibowo (unpublished) to study the ecology of watersheds with respect to the fishery resources, *e.g.* belida and semah fishes, that these areas possibly host. Results of the study in Sumatra River for example, revealed that the morphological characters could not clearly show the variations in character due to geographical and ecological variability in and between the Sumatra River, while DNA barcoding was based on 87 sequences of sequential bi-directional sequences (~ 654 bp) providing sufficient information on various types of gene profiles COI of these fish species.

The results also indicated that each population in the River system consists of a single panmictic population but has different genetic characteristics among the other rivers in Sumatra. Semah fish management strategies must therefore ensure that the semah fish in each local river must be protected so that the undiscovered biodiversity from these economically important freshwater fish can be conserved.

Conclusion

The molecular approach through the application of DNA mitochondrial sequencing techniques can be used as basis for managing the fish resources in inland waters. Specifically, the use of such technique would provide information on the importance of peat swamp habitat as place for fish spawning despite having extreme water conditions that might not be ideal for the fish survival in the long run. Based on the results of the adoption of the molecular approach, the management of belida fish (*Chitala lopis*) should be focused regionally considering the existence of more than one population in one river, which is not true for the semah fish (*Tor tambroides*). As a result of the analysis using molecular markers, the genetic diversity in belida and semah fishes could be detected because most rivers in Sumatra are not interconnected.

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Bringing Fish Catch to Homes Fresh *via* Fish Liner or Walkathon: Agusan del Norte, Philippines in Focus

Joseph Christopher C. Rayos, Ciara Mae B. Eom, and *Cathleen D. Dela Cruz*

In many rural areas in the Philippines, fresh fish catch does not usually reach the communities and homes because of transportation and accessibility constraints. As a result, the fish catch that comes to rural areas had already been either smoked or pickled or salted or processed in some other ways. Many enterprising sellers, not only the big-time traders but also retailers, have made several attempts to reach the rural communities in the Philippines immediately upon getting their share of fresh fish catch, but these only resulted in heavy competitions to the disadvantage of the retailers or the small-scale vendors who could not easily access the rural areas due to inaccessible road conditions. For this reason, retailers or small-scale vendors have rethought of the ways on how to reach the rural consuming public in no time, and this paved the way for the conceptualization of the "fish liner" or "walkathon." Innovation and a showcase of modern Filipino resiliency, a simple motorcycle which is eventually the most convenient transportation that could easily reach the rural areas, has been remodeled into a vehicle for transporting fresh fish for sale. Although "walkathon" refers to a walking marathon, the locals in Agusan del Norte use it to denote an ingenious means of transporting and vending fresh fish catch. A "fish liner" on the other hand, is also a coined term to denote transportation of fish by land, just as an airliner is an air transportation system or a sea liner for sea transport. For the "walkathon" or "fish liner," two styrofoam boxes which could accommodate a maximum of 50 kg each of fresh fish, are set on the right and left sides of the motorcycle and another on the posterior edge. Using a plastic straw, a weighing scale is tied in the middle of the two boxes. A megaphone is also set in between the right box and the box on the edge. A wooden frame is constructed and fitted on the motorcycle to provide stable support for the boxes. These "walkathons" could be found roaming not only around the streets and main thoroughfares of Agusan del Norte but most especially in the rural areas of the Province.

The Province of Agusan del Norte (**Figure 1**) in the Philippines is located in Mindanao, specifically in Region XIII, also known as CARAGA Region of Mindanao. CARAGA Region encompasses four provinces: Agusan del Norte, Agusan del Sur, Surigao del Norte, Surigao del Sur; and Dinagat Islands. Facing Butuan Bay and part of the Bohol Sea to the northwest, Agusan del Norte is bordered on the northeast by Surigao del Norte, in the mid-east by Surigao del Sur, on the southeast by Agusan del Sur, and southwest by Misamis Oriental. Its capital city is Cabadbaran.

In Agusan del Norte, tilapia (**Figure 2**) is an important and cheap source of animal protein for families with limited spending power. The Philippines where the population is now roughly 104 million, demands a large market for tilapia, which has been listed as second in volume in terms of aquaculture

Figure 1. Province of Agusan del Norte in Mindanao, Philippines *(Source: Google Map)*

Figure 2. Nile tilapia (*Oreochromis niloticus*)

production after milkfish (cultured in brackishwater), and the most cultured freshwater fish in the country. It was noted that the Philippines was a global top producer of tilapia until the early 1990s although most of the produce is meant for domestic consumption. It was said that small family businesses that operate one or two ponds/cages are the major tilapia producers in the country.

Specifically, Nile tilapia *Oreochromis niloticus* (Linnaeus) is considered as one of the most important freshwater fishes in world aquaculture (Coimbra and Reis-Henriques, 2005). It is widely cultured in many tropical and subtropical countries of the world. Nowadays, tilapia is cultured in freshwater and marine environments. Fast growth rates, hardiness to adverse environmental conditions, efficient feed conversion, ease of spawning, resistance to disease, and good consumer acceptance make tilapia a suitable fish for culture (El-Saidy and Gaber, 2005). Production of tilapia in cages has been practiced for many years in various countries worldwide. The earliest record of cage culture practice in Southeast Asia dates back to the late 1800s.

Since then, similar culture practices have been reported in both freshwater and marine environments, including in open oceans, estuaries, lakes, reservoirs, ponds, and rivers (Eng and Tech, 2002). Since tilapia is produced throughout the different regions in the Philippines, most of the tilapia harvested are consumed locally and are sold directly to local markets. The "fish liner/walkathon" (**Figure 3**), with the luxury of working with a smaller amount of capital and lesser inventory, is one means of making fresh tilapia catch reach the remote

Figure 3. The "fish liner" or "walkathon" of Agusan del Norte, Philippines

corners of Agusan del Norte. Such marketing system has proven to be agile in their approach by testing the waters of a particular market first before committing to do something more permanent either in terms of location or with inventory.

Sell it Easy, Save Big: the marketing of tilapia

The Province of Agusan del Norte is dominantly agricultural and produces major terrestrial crops such as rice, corn, coconut, abaca, banana, and mango, but its fishery resource is also one of the sources of livelihood for its people. Tilapia production of the Province is considered to be medium-scale, and intended mostly for local consumption, and is usually sold in market live, fresh or frozen, and readily available in wet market areas all over the Province the whole year round.

Transportation is one of the major problems when it comes to reaching the remote areas of Agusan del Norte. In some areas, residents have to walk a couple of kilometers just to reach the marketplace. With the Filipino's resilience in most situations, small roadside marketplaces called "*talipapa*" had been set-up. However, one of the easiest ways for the people in the rural areas of the Province to obtain fresh fish is through the remodeled vehicle, which has been termed as the "fish liner" or "walkathon."

Selling of goods in the Philippines with the use of a motorcycle could be considered very common practice. In many provinces, it is a means of peddling various products and wares for consumers' convenience. In the country's Provinces of Nueva Ecija and Davao, the homemade bread locally known as "*pandesal*" is sold in the streets with the use of a bicycle or motorcycle (**Figure 4**). In such a situation, baskets or similar containers are attached to the vehicle being used as means of delivery. The products are placed inside the baskets, where a horn or "*potpot*" is sounded to announce their presence for consumers to purchase their goods.

(Source: http://davaogastronomicadventures.blogspot.com/2008/05/vendors-in-my-subdivision.html)

Figure 4. Local "*habal habal*" (motorcycle) in Davao Province being used to sell homemade bread "pandesal"

Such a system of vending goods and wares is not just a local practice as this is also common in countries like Thailand, Cambodia, and Indonesia. A variety of products are sold using motorcycles as a means of transportation. For example in Thailand, handmade rattans are carted from one place to another using a motorbike, while in Cambodia and Indonesia, fresh goods and produce are transported with the use of motorcycles. These scenarios have shown how a motorcycle or a motorbike can be used effectively to reach the consumers, especially those in remote areas. The difference with a "fish liner/walkathon" is that it carries wet goods or newly harvested fresh fish because noticeably, the previously-mentioned systems are selling products that are usually in forms of dry goods. When it comes to marketing *per se*, the "fish liner" has a better way of advertising or drawing attention because of the blaring megaphone which alerts the consuming public. The megaphone contains a pre-recorded announcement where the vendor beckons the consumers to purchase their goods.

The "walkathon" made its way

In a place where all transactions happen before dawn, *Mang Erning* a fish vendor is up early to purchase tilapia from farms or from "bagsakan" (small trading areas) to offer his regular customers. At 5:00 AM, *Mang Erning* would kick-start his motorcycle and be on his way to his delivery areas while sounding his megaphone. This has been a usual daily routine for four years of a simple fish vendor, *Mang Erning*. In his first two years of fish vending, *Mang Erning* found it difficult to sell fish due to lack of a convenient means of transportation that would enable him to sell fish from house to house. He would hire a tricycle just to get him to his pick-up market and

Box: Arranging the pieces for "fish liner/walkathon"

For a "fish liner/walkathon," the following are needed:

Motorcycle - the most convenient and efficient transportation used in Agusan del Norte that mainly uses gasoline and runs by a motor, and could also be called a bike, motorbike or cycle (**Figure 5**)

Megaphone - an advertisement tool for the walkathon, it is an innovation with a recorder and a speaker, playing the pre-recorded call over and over during the vending hours

Weighing scale - traditional weighing scale used in Philippine markets and is calibrated in kilograms with a plate over its top used to hold the fish to be weighed

Styrofoam boxes - serve as the storage of the fish, and retain the freshness of whatever is stored because it is made of polystyrene thus, sustaining the coldness of the product inside topped with ice cubes or crushed ice

Skeletal structure - made of wood, it is designed in the shape of the boxes and used to sustain and hold the styrofoam boxes in place, and mainly serving as the support structure of the walkathon.

Figure 5. A typical motorbike being trnsformed into a "fish liner/ walkaton" in Agusan del Norte, Philippines

it would take him hours to sell his fish stored in a small pail. These struggles motivated *Mang Erning* and his co-vendors to re-model their motorcycles to better serve their purpose of vending fish, giving birth to the "fish liner" or "walkathon" (**Box**) with which vendors like *Mang Erning* are now in a position to offer a unique and cost-efficient retail experience that stands apart from fixed storefronts.

Travel light, sell bigtime

'*Bili na po kayo, isda, mura lang*' (Come, buy some fresh fish for a cheap price!) is the usual phrase playing over and over in a megaphone attached to a motorcycle. This has been an early routine for fish vendor *Mang Erning* in the remote areas of Jabongga in Agusan Del Norte. Fish vending has been his means of livelihood. He has raised his household and had sent his children to school through this source of living. Every day, *Mang Erning* would get up before the first hint of morning sunlight to prepare himself and proceed to the busy markets of Jabongga in Cabadbaran City reaching even the markets of Butuan City, the Capital City of CARAGA Region in Mindanao, Philippines.

Walkathon has been a big help for fish vendors in the Province of Agusan del Norte, as it has leveled up fish vending in terms of transport time reduction from hours to minutes, from a kilometer walk to a fast-paced bike, from hours of vending to a revised marketing strategy using a megaphone, and from just about 15-20 kg of fish in pails now to more than 100 kg of fish to sell. This "fish liner/walkathon" has therefore provided a big aid to fish vendors, especially that personal selling has a greater impact on buyers than through retail stores. The customer does not have to wait to get his questions answered. He can learn what he needs to know right then and there. Through the "fish liner/walkathon," the fish vendor also gets a better feel of what the customers want. Although the Philippines might have been seen with a high rate of poverty incidence, such a situation has not stopped the Filipinos from improving on what is readily available for their convenience, demonstrating how resilient and innovative the Filipinos could be!

The usual old new way

Fish liner/walkathon is making its name in the local markets and streets of Agusan Del Norte. It has made its branding and is now widely used by fish vendors for fish retail. It is inevitably paving its way because of how fish vendors have benefited greatly from this remodeled retailing. According to *Aling Pearl*, a market fish vendor who owns a stall at Jabongga Fish Market, she has her 'pros' and 'cons' about the fish liner/ walkathon. As a stall owner, *Aling Pearl* pays monthly stall rental, electricity and water bills to the sole owner of the Fish Market. Although she exerts less effort because the consumers would only reach out to her to buy fish, waiting for hours and longer is one of the struggles she encounters, "*hindi ko alam kung kailan mayroong bibili at isa pa marami kaming dikit-dikit na nagbebenta rito*," (I don't even know when my buyers will come and besides, with my competitors around, it can be a challenge), said *Aling Pearl*. Sometimes they rely on their 'suki' as what they call those who are their consistent customers, just to have someone buy their produce. "*Nauubos rin, pero minsan kailangan buong araw pa ang hintayin eh dun sa walkathon nauubos agad kasi ibinabahay bahay nila*" (Our fish are sold out but sometimes it would take us hours or even one whole day to wait). The good thing about the fish liner/ walkathon is that the fish is being sold from one house to the other. The observations of *Aling Pearl* are valid because fish liner/walkathon vendors, such as *Mang Erning* for example, sells fish perhaps for few hours only, and it only cost them the gasoline used and the batteries for the megaphone, and could have their tilapia produce sold out in a short time. Therefore, if the unit effort would be calculated, fish liner/walkathon would provide lesser selling time, lesser effort and lesser expenses.

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Harnessing the Benefits of Breeding the Asian Medicinal Leech

Nutthapong Wannapat

The Asian medicinal leech (*Hirudinaria manillensis* (Lesson, 1842)) can be found in freshwater environments including swamps and paddy fields. In Thailand, the Asian medicinal leech is most abundant in the Northeastern Provinces such as in Nakhon Phanom and Sakhon Nakhon. In Na Wa District, Nakhon Phanom Province for example, where the villagers have been capturing leeches in swamps during the rainy season (June-September) for more than 30 years as an alternative for rice farming. The people from Na Wa District also go to other provinces such as in Udon Thani, Nong Khai, and Khon Kaen to gather leeches. Wearing rubber boots, long pants, and long-sleeved shirts to protect themselves from leech attacks, the leech gatherers use scoop nets to capture the leeches attached in aquatic plants. Live leeches are sold to middlemen for THB 300-400/kg (400-500 leeches/kg) or about US$ 10-12/kg, while dried leeches are sold for THB 1,500-2,000/kg or about US$ 500-700/kg. For 30 years, Thailand exports dried *H. manillensis* to China, and in 2018 about 20 tons valued at THB 20 million or USD 590 thousand. The current price of powdered dried leech in the international market ranges between USD 10/kg and USD 200/kg. Currently, the only source of this medicinal leech in Thailand is from the wild and there are no leech farms to support the increasing demand. Consequently, *H. manillensis* population, like other populations of medicinal leeches, could be at risk of overexploitation and extinction. This study on the breeding and hatching of *H. manillensis* is therefore conducted with the aim of providing useful information on the possibility of establishing leech farms to increase the production and prevent the depletion of Asian medicinal leech population from the natural environment.

Many centuries ago, medicinal leeches have been used for phlebotomy (blood-letting) with records from ancient Egypt, Rome, and Greece. Leeching was one of several remedies used to restore the balance of the four humours (blood, phlegm, choler, melancholy). However in 1836, the renowned French physician, *Pierre Charles Alexandre Louis*, one of the earliest to assess statistically the value of various therapies, concluded that blood-letting was harmful rather than beneficial. Regardless of the negative effects of phlebotomy, medicinal leeches were continually used for other medical purposes such as counter-irritation, a treatment in which something was applied to irritate the skin or gut, and thereby counteract the effects of a disease. Also, these annelids are used to drain a hematoma (a collection of partially clotted blood) from a wound, the most obvious examples being a black eye, cauliflower ear, gum boils, and minor ulcers. Medicinal leeches are also used to remove post-operative occlusions to enhance the success of tissue transplants and the surgical joining of amputated appendages such as fingers and ears (Elliott & Kutschera, 2011). At present, many products are derived from leeches for pharmaceutical and medicinal purposes. For *H. medicinalis*, its saliva contains hirudin, the most powerful natural anti-coagulant, but the extraction of hirudin from whole *H. medicinalis* necessitates the destruction of large numbers of leeches and at least 12,000 kg of leeches are used for this purpose in Europe each year (Wells & Coombes, 1987).

Characteristics of *Hirudinaria manillensis*

Hirudinaria manillensis (Phylum: Annelida, Class: Hirudinea) is a tropical warm-water annelid which has been used in India and neighboring countries of Southeast Asia for medicinal purposes, thus it was named the "Asian medicinal leech" (Kutschera & Roth, 2006). This species was introduced from India to Europe and is now widely distributed in the Caribbean. These large, aggressive leeches arrived through ships that carried laborers from colonial India starting around 1845 and leeches were brought onboard for medicinal purposes (Sawyer *et al*., 1998).

Moreover, *H. manillensis* is proved to have close phylogenetic relationship with two of the most important European medicinal leeches *Hirudo medicinalis* and *Hirudo verbena* (Elliott & Kutschera, 2011). Adult specimens of *H. manillensis* can reach a body length of up to 18 cm (**Figure 1**). Some individuals of this species reach an enormous body length and therefore have been described as "buffalo leeches" (Kutschera & Roth, 2006). Leeches are hermaphrodites (**Figure 2**), *i.e.* they are bisexual with each mature individual producing both male and female gametes (Shain, 2009).

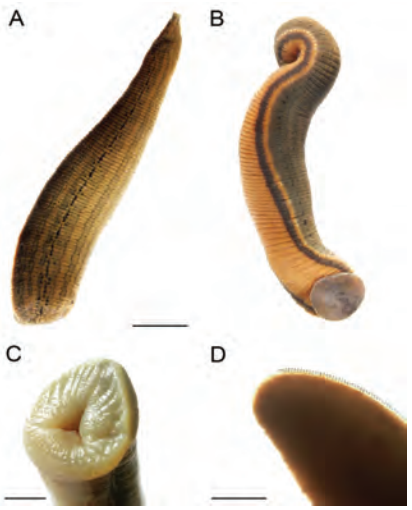

Figure 1. Live adult individual of *Hirudinaria manillensis*. Dorsal (A) and ventral (B) view; bar = 1 cm. The anterior sucker (mouth) of a preserved individual is characterized by a furrow in the upper lip (C); bar = 0.2 cm. Light micrograph of an isolated jaw, showing numerous monostichodont teeth (D); bar = 100 µm.

(Source: Kutschera & Roth, 2006)

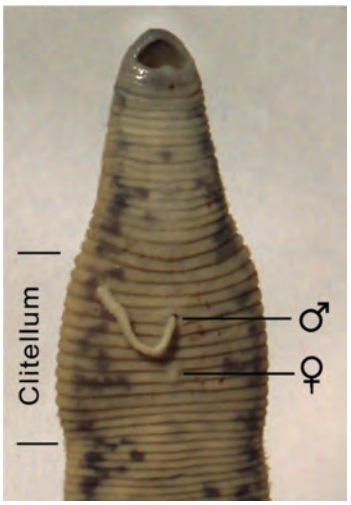

Figure 2. Ventral side of the head and clitellar region of an adult, alcohol-preserved *Hirudo verbana*. The male (♂) and female (♀) gonopores are visible, with the tube-like male copulatory organ outside of the body.

(Source: Elliott & Kutschera, 2011)

All leeches are predatory or parasitic carnivores, and their brain and sense organs combined with a flexible, muscular body enable them to actively pursue their prey, thus they have been described as "worms with character" (Kutschera & Elliott, 2010). In their natural habitat, these large blood-sucking leeches could be found attached to the belly and feet of cows, where they cause bleeding wounds and hence severely impairing the vitality of their hosts. Also, it was reported that humans are regularly attacked by *H. manillensis* (Elliott & Kutschera, 2011) and these leeches attach to and pierce the skin of humans in the laboratory (Kutschera & Roth, 2006).

Overexploitation and Reviving Leech Populations

During the first half of the 19th century, the trade in medicinal leeches (*H. medicinalis* and related species) became a major industry (Kutschera & Roth, 2006). European leech gatherers typically collected blood-sucking worms by wading in natural, shallow ponds and allowing the Hirudo-individuals to attach themselves to their legs. As many as 2,500 leeches per day could be harvested in this way so that the medicinal leech became almost extinct in Europe (Sawyer, 1986). As medicinal leeches became more difficult to find in Europe, the indigenous supply was supplemented by importations from abroad. Reduced populations *H. medicinalis* in Europe due to over-collection from the wild led to the need to import other species, especially the closely related *H. verbana* from Turkey and, more recently, the *H. manillensis*.

One way to combat the decline of the supply of wild leeches is the development of leech farming, particularly in France and Germany. In 1890, a leech farm in Germany was breeding 3-4 million leeches per year. Presently, culture and breeding of leeches in many countries are increasing in order to meet the demand for pharmaceutical and clinical use, Chinese traditional medicine, and for other scientific studies. Throughout Asia, many local leech farms (such as the Agro Medic Enterprise in Penang, Malaysia) are breeding and marketing large quantities of *H. manillensis* (Elliott & Kutschera, 2011). Thailand exports considerable quantities of dried *H. manillensis* (**Figure 3**) to China.

Figure 3. Dried *Hirudinaria manillensis* exported by Thailand to China (6 kg live leeches = 1 kg dried leeches)

Leech Culture in Thailand

Since leech farms are not yet established in Thailand, this study was conducted to gather information on the basic reproductive biology of *H. manillensis* at different broodstock densities. This study was conducted at the Nakhon Si Thammarat Inland Aquaculture Research and Development Center of the Department of Fisheries of Thailand from 1 September 2017 to 30 June 2018.

Leech Broodstock Management

Hirudinaria manillensis broodstock were gathered from the swamp in Nakhon Phanom Province in Northeastern Thailand, acclimatized in two-liter glass bottles with water (five leeches per bottle) on 1 September 2017, and kept in the laboratory at room temperature of 19-35 °C. The leeches were fed with animal blood (approximately five times the weight of leech) for four hours (9:00-13:00 h) every 15 days. The water in the bottle was changed after feeding the leeches.

On 1 October 2017, the broodstock leeches were selected randomly and transferred to plastic boxes (35.0 cm × 56.0 cm × 16.5 cm) for breeding. The broodstock densities (number of

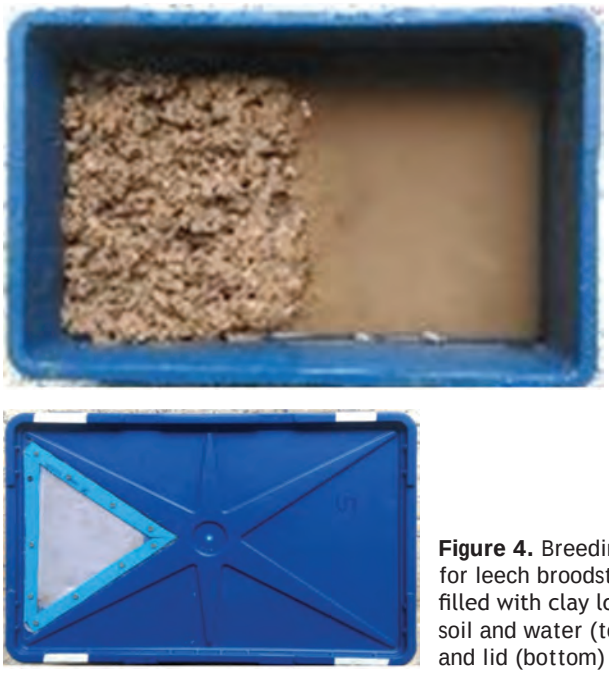

Figure 4. Breeding box for leech broodstock filled with clay loam soil and water (top) and lid (bottom)

leech per box) were two, three, and four leeches per box, and three replicates were set up for each density. Each breeding box (**Figure 4**) was filled with ten-centimeter thick clay loam soil sloping down to one side and five-centimeter deep water. The breeding box is covered with a lid that has a hole with screen for air ventilation. The body length and body weight of each leech were measured before putting them in the breeding box.

Leech Hatchery and Nursery

Cocoons (**Figure 5**) were deposited in the breeding boxes on 3 and 4 January 2018. The leech broodstock were kept in the breeding boxes until 30 June 2018 but no cocoons were deposited after January 2018. The cocoons were transferred to five-liter hatchery bottles with soil and water (one cocoon per bottle). The length, width, and wet weight of each cocoon were measured. The cocoons hatched on 18 and 19 January 2018 and the hatching rate was calculated using the formula below.

$$\text{Hatching rate} = \frac{(\text{no. of deposited cocoons} - \text{no. of dead cocoon}) \times 100}{\text{no. of deposited cocoons}}$$

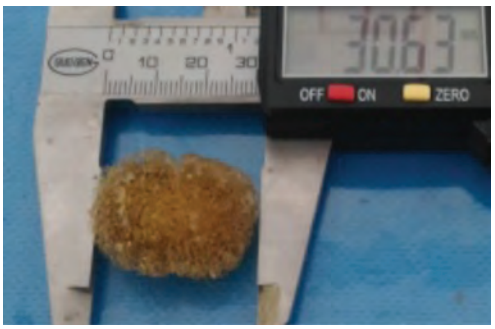

Figure 5. Spongy cocoon of *Hirudinaria manillensis*

The juvenile leeches were removed from hatchery bottles and cultured from 1 February to 2 May 2018 in nursery boxes similar to the breeding boxes described above. The densities (number of juvenile leech per box) were 10 and 20 juveniles per box. Animal blood (about three times of leech weight) was fed to juvenile leeches for four hours (9:00-13:00 h) every 15 days. The water in the nursery box was changed after feeding the leeches. The initial and final body length and body weight of each juvenile leech were measured. The specific growth rate and weight gain of each juvenile leech were calculated using the following formula.

$$\text{Specific growth rate} = \frac{(ln\ \text{final weight} - ln\ \text{initial weight}) \times 100}{\text{nursery period}}$$

$$\text{Weight gain} = \frac{(\text{final weight} - \text{initial weight}) \times 100}{\text{initial weight}}$$

Statistical Analysis

The Duncan New Multiple Range Test at 95 % confidence interval was used to analyze the cocoons (number, length, width, and wet weight) and leech offspring (number). Moreover, the T-test at 95 % confidence interval was used to analyze the offspring (body length, body weight, specific growth rate, and percentage weight gain).

Results and Discussion

For broodstock leeches (n = 27), the average body length was 6.46 ± 0.25 cm and the average body weight was 6.91 ± 0.10 g. The density of two leeches per box (n-6) had the highest average number of cocoons (1.33 ± 2.31). In terms of average length, width, and wet weight of cocoons, the results are almost similar among broodstock densities and there were no statistical differences (**Table 1**). The hatching rate was 100% for all densities of broodstock.

Zulhisyam *et al*. (2015) bred *H. manillensis* in different densities per tank (30 cm × 19 cm × 26 cm) and their results showed that the average number of cocoons developed in

Table 1. Cocoons and offspring produced by leech broodstock *Hirudinaria manillensis* after 94-95 days breeding

	Density (number of broodstock leech per box)		
	2	3	4
Number of cocoons per box	1.33 ± 2.31	0.67 ± 1.16	0.67 ± 1.16
Cocoon length (mm)	30.57 ± 0.07	30.43 ± 0.02	30.46 ± 0.13
Cocoon width (mm)	20.63 ± 0.19	20.54 ± 0.11	20.64 ± 0.21
Cocoon wet weight (g)	2.95 ± 0.06	2.96 ± 0.09	2.95 ± 0.05
Number of offspring per cocoon	13.50 ± 0.58	13.50 ± 0.71	13.00 ± 0.00

Note: Data in the table are mean and standard deviation (mean ± SD)

5, 10, 20 leeches per tank were 6.61 ± 1.00, 3.00 ± 1.00, and 1.33 ± 0.58, respectively. While in densities of 15, 25, and 30 leeches per tank, the average number of cocoons developed were 0.67 ± 1.16, 0.61 ± 1.26, and 0.67 ± 0.58, respectively; which are almost equal with the results of this study where the average number of cocoons developed in 2, 3, and 4 leeches per box (35.0 cm × 56.0 cm × 16.5 cm) were 1.33 ± 2.31, 0.67 ± 1.16, and 0.67 ± 1.16, respectively. Although the differences in leech densities were large between the two studies, the average number of cocoons that were developed was almost similar. Zhang *et al*. (2008) explained that the number of cocoons was influenced by leech density resulting to competition in food and space. The competition could stress the leeches and affect their reproductive behavior. Furthermore, feeding quantity and quality are other factors that could affect the number as well as length and weight of cocoons. The cocoon length and weight in low leech density were greater than in high leech density (Davies & McLoughlin, 1996; Elliott & Kutschera, 2011; Zulhisyam *et al*., 2015). For the number of leech offspring, the results of this study were the same with other studies using more than 10 offspring per cocoon (Zulhisyam *et al*., 2011; Ceylan *et al*., 2015; Davies & McLoughlin, 1996; Sawyer, 1986).

Table 2. Average initial and final body length and body weight, specific growth rate, and weight gain of juvenile leeches, *Hirudinaria manillensis* after 90 days of culture

	Density (number of juvenile leech per box)	
	10	20
Initial body length (cm)	1.12 ± 0.02	1.02 ± 0.00
Final body length (cm)	2.61 ± 0.04	2.59 ± 0.02
Initial body weight (g)	0.05 ± 0.00	0.05 ± 0.00
Final body weight (g)	0.59 ± 0.01	0.58 ± 0.00
Specific growth rate (%)	2.69 ± 0.04	2.68 ± 0.06
Weight gain (%)	1,024.98 ± 40.72	1,013.37 ± 62.10

Note: Data in the table are mean and standard deviation (mean ± SD)

The average initial and final body length and body weight of juvenile leeches are shown in **Table 2**. The values were comparable between densities of 10 and 20 juvenile leeches per box and did not show any statistical difference except in the initial average body length. The specific growth rate and weight gain of juvenile leeches were also similar between two densities. Within 90 days of culture, both densities of juvenile leeches had 100 % survival rate at the temperature of 24-27 °C, pH between 7.8-8.0, dissolved oxygen at 4.0-6.0 ppm, and total NH_3 at 0.0-0.5 ppm.

Different species of leeches have different body weights of juveniles. This study showed lower average body weight of *H. manillensis* juveniles than *H. medicinalis* juveniles but higher than *H. orientalis* and *H. verbena* juveniles (Ceylan *et al*., 2015; Petrauskienè, *et al*., 2011; Sawyer, 1986). The specific growth rates (2.69 ± 0.04 % and 2.68 ± 0.06 %) of *H. manillensis* in this study were lower than *Hirudinea* sp. (4.04 ± 0.03 %) (Zulhisyam *et al*., 2011). In this study, *H. manillensis* juvenile was fed with animal blood while in the study on *Hirudinea* sp., the juvenile was fed with blood of live eel (Zulhisyam *et al*., 2011). The differences in the specific growth rates could have been influenced by the nutritional values of the feed that affected the digestive system of the juvenile leeches.

Production Cost

Table 3 summarizes the production cost of breeding the Asian medicinal leech, *H. manillensis*. Among different densities, the breeding of two leeches per box (n = 6) which produced a total 54 offspring had the lowest production cost at THB 4.65 (USD 0.15) per leech offspring. This means that the lower the breeding density, the greater number of offspring is produced and the lower production cost is spent. Considering that labor

Table 3. Detailed production cost of breeding Asian medicinal leech, *Hirudinaria manillensis*

	Leech density (number of leech per box)		
	2	3	4
Total number of leech broodstock	6	9	12
Total number of leech offspring	54	27	26
Total number of box	3	3	3
Variable costs (THB)			
Feed[1]	11.2	16.8	22.4
Labor[2]	225	225	225
Opportunity cost[3]	2.02	2.09	2.16
Total variable cost	***244.22***	***252.89***	***261.56***
Fixed costs (THB)			
Opportunity cost[3]	0.06	0.06	0.06
Depreciation cost per box[4]	6.64	6.64	6.64
Total fixed cost	***6.70***	***6.70***	***6.70***
Total cost = total variable cost + total fixed cost (THB)	**250.92**	**259.59**	**268.26**
Production cost (total cost/leech offspring) (THB)	**4.65**	**9.61**	**10.32**
Production cost (excluding labor cost) (THB/leech)	**0.48**	**1.28**	**1.66**
Production cost (total cost/ leech offspring) (USD[5])	**0.15**	**0.31**	**0.33**
Production cost (excluding labor cost) (USD[5]/leech)	**0.02**	**0.04**	**0.05**

[1] *THB 10 per 500 g of animal blood*
[2] *THB 300 per day or THB 37.50 per hour (minimum wage rate in Nakhon Si Thammarat for 8 hours per day), 1.5 h × THB 37.50 × 4 months = THB 225 for feeding and changing water every 15 days*
[3] *Interest rate of fixed deposit at the rate of 2.25 % of the Bank for Agriculture and Agricultural Cooperatives in 2017*
[4] *THB 200 per box, average lifespan of 10 years and used for four months; depreciation cost was calculated using straight-line method by setting the value to zero after the end of use*
[5] *USD 1.00 = THB 33.94, average exchange rate in 2017*

cost (84-90 %) covers the highest percentage of the total cost, and if labor cost is excluded, the production cost would become much lower and ranges from THB 0.48 to THB 1.66 (USD 0.02-0.05) per leech offspring. Labor includes only the feeding and changing of water every 15 days, which can be easily done by the leech farmer and there is no need to hire a worker.

Conclusion and Way Forward

This study on the breeding, hatching, and culture of Asian medicinal leech, *H. manillensis* was conducted for the first time in Thailand. Because of its high hatching and survival rates, cheap production cost, high market value, and continuously increasing demand, medicinal leeches are excellent alternative for farmed aquatic animals. Through leech farming, the soaring market demand could be fulfilled without relying on leech stocks from the wild.

Therefore, the governments of the Southeast Asian countries, especially in the countries where *H. manillensis* and other species of medicinal leeches can be found, could utilize the results of this study to encourage and support stakeholders in establishing leech farms. Nonetheless, it is also recommended that further studies should be conducted, particularly on exploring other feed alternatives in order to enhance the growth rate of cultured juvenile leeches.

Acknowledgment

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CALENDAR OF EVENTS

Date	Venue	Event	Organizer(s)
2019			
9-11 January	Bangkok, Thailand	5th Meeting of the Scientific Working Group (SWG) for Stock Assessment on Neritic Tunas in the Southeast Asian Region	SEAFDEC/MFRDMD & Secretariat
15-17 January	Iloilo, Philippines	SEAFDEC Training Workshop on Sharks Data Collection	SEAFDEC/Secretariat & MFRDMD
30-31 January	Bangkok, Thailand	Regional Consultation for Development of the ASEAN-SEAFDEC Common Position on the Proposed Listing of Commercially-exploited Aquatic Species into the CITES Appendices	SEAFDEC/Secretariat
1-2 February	Samut Prakan, Thailand	Inception Meeting for the Project "Strengthening the Effective Management of Inland Fisheries and Aquaculture in ASEAN Member States and with GIS and RS Technologies"	SEAFDEC/Secretariat
26 Feb -2 Mar	Thailand	Training Course on Essential Ecosystem Approach to Fisheries Management (E-EAFM) for Inland Fisheries	SEAFDEC/TD
18-22 March	Surabaya, Indonesia	51st Meeting of the SEAFDEC Council	SEAFDEC/Secretariat
25 Mar-7 Apr	Tigbauan, Iloilo, Philippines	Training Course on Sandfish Seed Production, Nursery, and Management	SEAFDEC/AQD
4-5 April	Bangkok, Thailand	1st ASEAN Meeting on Combating IUU Fishing	ASEAN, DOF Thailand in collab. with EU
22-26 April	Phetchaburi, Thailand	Workshop: Development of the Fisheries Management Plan for Aung Kra Dein, Lao PDR	SEAFDEC/TD
23 April	Manila, Philippines	Workshop on Statistic of Tropical Anguillid Eel in Southeast Asia	SEAFDEC/Secretariat
24-25 April	Manila, Philippines	Workshop on Aquaculture of Tropical Anguillid Eel in Southeast Asia	SEAFDEC/Secretariat
29 April-1 May	Samut Prakan, Thailand	Training on Age Determination Using Vertebra for Sharks and Rays	SEAFDEC/TD
1-2 May	Bangkok, Thailand	Meeting on Way Forward of the Resolution & Plan of Action 2020	SEAFDEC/Secretariat
14-16 May	Myanmar	Development of the Ecosystem Approach to Fisheries Management Plan for Koh Song, Myanmar	SEAFDEC/TD
22-23 May	Bangkok, Thailand	Inception Meeting on the Development of an ASEAN General Fisheries Policy Feasibility Study	ASEAN, DOF Thailand in collab. with EU
27-31 May	Chiang Mai, Thailand	Training Course on Essential Ecosystem Approach to Fisheries Management (E-EAFM)	SEAFDEC/TD
28-30 May	Cambodia	Development of the Ecosystem Approach to Fisheries Management Plan for Tongle Sap, Cambodia	SEAFDEC/TD
16-20 June	Kuala Terengganu, Malaysia	Regional Training and Workshop on Chondrichthyan Taxonomy, Biology and Data Collection	SEAFDEC/MFRDMD
24 Jun–7 Jul	Tigbauan, Iloilo, Philippines	Training Course on Marine Fish Hatchery Operations	SEAFDEC/AQD
25-26 June	Viet Nam	11th Meeting of the ASEAN Fisheries Consultative Forum (AFCF)	ASEAN
27-29 June	Viet Nam	27th Meeting of the ASEAN Sectoral Working Group on Fisheries (ASWGFi)	ASEAN
22-23 July	Bangkok, Thailand	3rd Regional Meeting on Enhancing Sustainable Utilization and Management Scheme of Tropical Anguillid Eel Resources in Southeast Asia	SEAFDEC Secretariat
22-26 July	Samut Prakan	Regional Training Course on Port State Measures Implementation for Inspector	SEAFDEC/TD
3-5 September	Kuala Lumpur, Malaysia	Terminal RTC for Combating IUU Fishing in the Southeast Asian Region through Application of Catch Certification for International Trade in Fish and Fishery Products Project	SEAFDEC/MFRDMD
11-13 Nov (Tentative)	Chiang Mai, Thailand	42nd Meeting of SEAFDEC Program Committee	SEAFDEC
14-15 Nov (Tentative)	Chiang Mai, Thailand	22nd Meeting of the Fisheries Consultative Group of the ASEAN-SEAFDEC Strategic Partnership (FCG/ASSP)	SEAFDEC

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. SEAFDEC currently comprises 11 Member Countries: Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.

Vision

Sustainable management and development of fisheries and aquaculture to contribute to food security, poverty alleviation and livelihood of people in the Southeast Asian region

Mission

To promote and facilitate concerted actions among the Member Countries to ensure the sustainability of fisheries and aquaculture in Southeast Asia through:

i. Research and development in fisheries, aquaculture, post-harvest, processing, and marketing of fish and fisheries products, socio-economy and ecosystem to provide reliable scientific data and information.
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iii. Technology transfer and capacity building to enhance the capacity of Member Countries in the application of technologies, and implementation of fisheries policies and management tools for the sustainable utilization of fishery resources and aquaculture.
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The third prize winner, *Adil Hakeem bin Mohammad Kamarul*, from the national drawing contest in Brunei Darussalam

National Drawing Contests were organized in all ASEAN-SEAFDEC Member Countries as part of the preparatory process for the ASEAN-SEAFDEC Conference 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.