THE SOUTHEAST ASIAN STATE OF FISHERIES AND AQUACULTURE 2017

Southeast Asian Fisheries Development Center

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SEC/ST/49

August 2017

Preparation and Distribution of this Document

The Southeast Asian State of Fisheries and Aquaculture 2017 was prepared by the Secretariat of the Southeast Asian Fisheries Development Center (SEAFDEC), in collaboration with the SEAFDEC Departments, namely: the Training Department (TD), Marine Fisheries Research Department (MFRD), Aquaculture Department (AQD), the Marine Fishery Resources Development and Management Department (MFRDMD) and the Inland Fishery Resources Development and Management Department (IFRDMD) as well as contribution from Member Countries in Southeast Asia. The document is distributed to the SEAFDEC Member Countries and Departments, partner agencies and other fisheries-related organizations, and to the public to promote the activities and visibility of the Center.

Bibliographic Citation

SEAFDEC. 2017. Southeast Asian State of Fisheries and Aquaculture 2017. Southeast Asian Fisheries Development Center, Bangkok, Thailand. 167 pp.

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The production of this publication is supported by **the Japanese Trust Fund to SEAFDEC.**

PREFACE

The sustainable development and management of fisheries needs to be corroborated with comprehensive information on fisheries status and trends. The 2011 ASEAN-SEAFDEC Conference highlighted the same need to "*strengthen knowledge/science-based development and management of fisheries," and therefore adopted the "Resolution on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020*." The provision to "*strengthen national statistical mechanisms for fisheries and aquaculture and the exchange of statistical data and related information; and include other non-routine data and information such as fish consumption surveys as well as mobilizing local and indigenous knowledge with the aim of improving the valuation of fisheries and monitoring their performance, to address the needs of the ecosystem approach to fisheries and adaptation to climate change*" is emphasized in the "Plan of Action."

SEAFDEC, during the past decades, accumulated a variety of fisheries data such as regional fishery statistics obtained from the national statistics of the ASEAN Member States (AMSs) and information generated from several SEAFDEC programs and projects. SEAFDEC then integrated and analyzed these data and information in "**The Southeast Asian State of Fisheries and Aquaculture**" or "**SEASOFIA**" to support the sustainable fisheries development and management in the region. SEASOFIA is published with the aim to provide better understanding on the status and trends of fisheries and aquaculture of the region. This publication also aims to raise awareness and preparedness, and enhance the capacity of the AMSs to respond to issues and challenges in fisheries.

SEASOFIA was first published in 2012 and this publication is issued every five years. This year, SEASOFIA 2017 covers the Southeast Asian fishery statistics for the period 2000-2014 and highlights the accomplished and ongoing programs and projects of SEAFDEC dealing with important pelagic fishery resources such as transboundary fish stocks; species under international concern including eels, sea cucumber, among others; illegal, unreported, and unregulated (IUU) fishing; emerging transboundary aquatic animal diseases; vulnerability of fisheries to climate change and natural disasters; and labor issues in the fishing industry.

It is hoped that this publication containing comprehensive information on the state of fishery and aquaculture in Southeast Asia will incite a meaningful awareness on the condition of fisheries in the region. In aspiring sustainable fisheries and ensuring food security, may the scientific details presented in SEASOFIA 2017 encourage the fisheries managers and policy makers in addressing the present and future challenges.

Kom Silapajarn, Ph.D.
SEAFDEC Secretary-General

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List of Acronyms

ACDS	ASEAN Catch Documentation Scheme
AFCF	ASEAN Fisheries Consultative Forum
AMAF	ASEAN Ministers on Agriculture and Forestry
AMSs	ASEAN Member States
AQD	SEAFDEC/Aquaculture Department
AR	Artificial Reef
ASEAN	Association of Southeast Asian Nations
ASWGFi	ASEAN Sectoral Working Group on Fisheries
CBFM	Community-based Fisheries Management
CCRF	FAO Code of Conduct for Responsible Fisheries
CF	Community Fisheries
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CM	Co-management
CPUE	Catch Per Unit Effort
CTI-CFF	Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security
DOF	Department of Fisheries
EAFM	Ecosystem Approach to Fisheries Management
EC	The European Commission
EEZs	Exclusive Economic Zones
EU	The European Union
FADs	Fish Aggregating Devices
FAO	Food and Agriculture Organization of the United Nations
GAP	Good Aquaculture Practices
GLP	Good Labor Practices
GMP	Good Manufacturing Practices
GoT	Gulf of Thailand
HACCP	Hazard Analysis and Critical Control Point
IFRDMD	SEAFDEC/Inland Fishery Resources Development and Management Department
ILO	International Labour Organization
IMO	International Maritime Organization
IMTA	Integrated Multi-Trophic Aquaculture
IOTC	Indian Ocean Tuna Commission
IPCC	Intergovernmental Panel on Climate Change
IPOA-Capacity	International Plan of Action for the Management of Fishing Capacity
IPOA-IUU	International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing
IPOA-Sharks	International Plan of Action for the Conservation and Management of Sharks
IUU Fishing	Illegal, Unreported and Unregulated Fishing
JAIF	Japan-ASEAN Integration Fund
JIRCAS	Japan International Research Center for Agricultural Sciences

JTEDs	Juvenile and Trash Excluder Devices
JTF	Japanese Trust Fund
LRFF	Live Reef Food Fish
MCS	Monitoring, Control and Surveillance
MFRD	SEAFDEC/Marine Fisheries Research Department
MFRDMD	SEAFDEC/Marine Fishery Resources Development and Management Department
MPAs	Marine Protected Areas
MRC	Mekong River Commission
MRL	Maximum Residue Level
MSY	Maximum Sustainable Yield
NACA	Network of Aquaculture Centres in Asia-Pacific
NDFs	Non-detriment Findings
NGO	Non-governmental Organization
NPOA	National Plan of Action
OIE	World Organization for Animal Health
PSM	Port State Measures
REBYC	Project on Reduction of Environmental Impact from Tropical Shrimp Trawling through the Introduction of Bycatch Reduction Technologies and Change of Management
RFMOs	Regional Fisheries Management Organizations
RFVR	Regional Fishing Vessels Record
RPOA-Capacity	Regional Plan of Action for the Management of Fishing Capacity
RPOA-IUU	Regional Plan of Action to Promote Responsible Fishing Practices (including Combating IUU Fishing) in the Region
RPOA-Neritic Tunas	Regional Plan of Action on Sustainable Utilization of Neritic Tunas in the ASEAN Region
SEAFDEC	Southeast Asian Fisheries Development Center
SEASOFIA	The Southeast Asian State of Fisheries and Aquaculture
SFGs	Stationary Fishing Gears
SPS	Sanitary and Phytosanitary
TAC	Total Allowable Catch
TAE	Total Allowable Efforts
TD	SEAFDEC/Training Department
TEDs	Turtle Excluder Devices
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environmental Programme
US	The United States of America
VMS	Vessel Monitoring System
WCPFC	Western and Central Pacific Fisheries Commission
WWF	World Wide Fund for Nature

PART I
Status and Trends of Capture Fisheries and Aquaculture in Southeast Asia

I. GLOBAL PRODUCTION AND UTILIZATION OF FISH

For over one and a half decades, the global fisheries production has continued to grow from 136.2 million metric tons in 2000 to 195.7 million metric tons in 2014, increasing at a rate of approximately 3.12% annually (**Table 1**). During the same period, the utilization of fish for human consumption and non-food uses also increased from 131.0 million metric tons to 167.2 million metric tons or an increase of 1.97% annually (FAO, 2016a). During the period from 2000 to 2009, the percentage of fish produced for human consumption had risen from 74% to approximately 85%, slightly declined during 2010-2011, and remained rather steady at approximately 75% until 2014 (**Table 1** and **Figure 1**). Meanwhile, the human population as major consumer of fish products also increased from approximately 6.1 billion in 2000 to 7.3 billion in 2014, while the per capita fish consumption also increased from an average of 15.9 kg in 2000 to 20.1 kg in 2014 (**Figure 2**). From the aforesaid data, it could be visualized that the increased supply of fish through enhanced fisheries production has contributed to elevated consumption and other utilization, and as the human population grows the demand for fish and fishery products will also rise. It is quite clear that for developing countries, fish consumption trends depend on the availability of local and seasonal supply of fish and fishery products, which

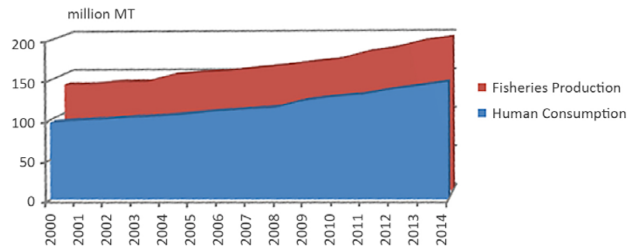


Figure 1. Quantity of fisheries production utilized for human consumption from 2000 to 2014

Source: *FAO Fisheries and Aquaculture Information and Statistics Service*

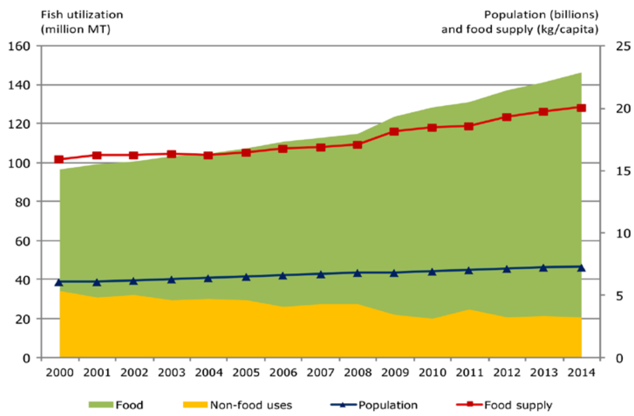


Figure 2. Global fish utilization, food supply and human population in 2000-2014

Source: *FAO Fisheries and Aquaculture Information and Statistics Service*

Table 1. World fisheries production and utilization from 2000 to 2014

Year	Production (million metric tons)			Utilization (million metric tons)		Human population (billions)	Percentage of production for human consumption (%)	Per capita fish consumption (kg)
	Capture	Aquaculture	Total	Human consumption	Non-food uses			
2000	94.5	41.7	136.2	96.8	34.2	6.1	73.9	15.9
2001	91.8	44.3	136.1	99.5	31.1	6.1	76.1	16.2
2002	92.0	47.4	139.4	100.7	32.2	6.2	75.7	16.2
2003	89.3	50.3	139.6	103.0	29.2	6.3	77.9	16.3
2004	94.0	54.6	148.6	104.4	29.8	6.4	77.7	16.2
2005	93.6	57.8	151.4	107.3	29.7	6.5	78.7	16.5
2006	91.3	61.6	152.9	110.7	26.3	6.6	80.7	16.8
2007	91.9	64.9	156.8	112.7	27.1	6.7	80.6	16.9
2008	91.2	68.9	160.1	115.1	27.2	6.8	80.9	17.1
2009	91.3	73.0	164.3	123.8	22.0	6.8	85.3	18.1
2010	90.2	78.0	168.2	128.1	20.0	6.9	80.0	18.5
2011	94.7	82.6	177.3	130.8	24.7	7.0	73.7	18.6
2012	92.4	90.0	182.4	136.9	20.9	7.1	75.0	19.3
2013	93.9	97.2	191.1	141.5	21.4	7.2	74.0	19.7
2014	94.6	101.1	195.7	146.3	20.9	7.3	74.8	20.1

Source: *FAO Fisheries and Aquaculture Information and Statistics Service* also sets the direction of the fish supply chain (FAO, 2014a). Food fish is important as inexpensive source of high-quality protein as well as all essential amino acids, essential fats (omega-3), vitamins, and minerals including calcium, iodine, zinc, iron, and selenium (FAO, 2016a), and thus, is necessary for human health.

The Population Division of the United Nations predicted that global human population will reach 8.5 billion by 2030 and 9.7 billion by 2050 (UN, 2015), increasing at 16.4% and 32.9%, respectively, compared with that in 2014. The world food producing sector must therefore secure the availability of food and nutrition for the growing human population by increasing production and reducing wastes and discards. In this connection and with the assumption that per capita consumption of fish could be maintained at its present level, the global demand for fish would increase by 33% in 2050. Nevertheless, other factors that are likely to affect the demand for fish include level of wealth, urbanization, fish price, prices of substitutes or complementary foods, eating habits and tastes, and the level of subsistence fishing.

The world fisheries production from 2000 to 2014 by continent which is shown in **Table 2** and **Figure 3** indicated a continued annual increase at an average rate of 2.6% or 4.3 million metric tons per year. The major producers are the countries from Asia, contributing about 53.0% to the total production throughout the past decade. The Southeast Asian region which contributed approximately 21.6% to the world's production maintained an increasing trend from 16.9 million metric tons in 2000 to 42.2 million metric tons in 2014 or an average increase of 1.8 million metric tons or 6.8% per year. On the contrary, fisheries production from the Americas after reaching the highest peak of 28.5 million metric tons in 2004 has declined and its total production in 2014 was 20.8 million metric tons. For Europe, the production has also decreased from 18.6 million metric tons in 2000 to around 16.0 million metric tons from 2004 onwards.

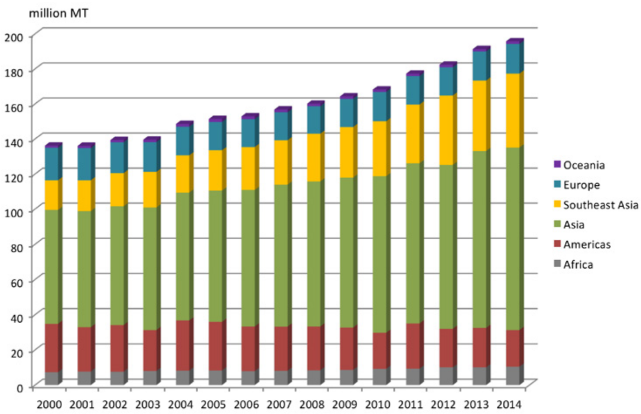


Figure 3. Trends of fisheries production of each continent from 2000 to 2014 by quantity
(**Note:** Asia does not include data of Southeast Asia)

II. FISHERIES PRODUCTION OF SOUTHEAST ASIA

The Southeast Asian region (**Figure 4**) is bordered by the Andaman Sea and the Indian Ocean in the west, and by the western part of the Pacific Ocean in the east. The region comprises 11 countries, namely: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Timor-Leste, Thailand, and Viet

Table 2. Fisheries production of each continent from 2000 to 2014 by quantity (million metric tons)

Year	World Total* (million metric tons)	Continents					
		Africa*	Americas*	Asia*	Southeast Asia**	Europe*	Oceania*
2000	**136.2**	7.3	27.5	64.7	16.9	18.6	1.2
2001	**136.6**	7.7	25.2	65.8	18.2	18.4	1.3
2002	**139.4**	7.6	26.5	67.5	18.9	17.6	1.3
2003	**139.7**	8.0	23.3	69.6	20.4	17.0	1.4
2004	**149.4**	8.2	28.5	72.7	22.0	16.4	1.6
2005	**151.8**	8.3	27.6	74.5	23.5	16.2	1.7
2006	**153.3**	7.9	25.4	77.6	24.9	15.9	1.6
2007	**158.2**	8.1	25.0	80.6	26.9	16.0	1.6
2008	**160.2**	8.4	24.9	82.5	27.3	15.7	1.4
2009	**163.3**	8.6	24.1	85.1	28.0	16.1	1.4
2010	**168.2**	9.2	20.5	89.0	31.4	16.7	1.4
2011	**177.3**	9.3	25.7	91.1	33.5	16.3	1.4
2012	**182.4**	10.1	21.9	93.2	39.6	16.1	1.5
2013	**191.1**	10.1	22.4	100.4	40.2	16.6	1.4
2014	**195.7**	10.5	20.8	103.8	42.2	16.9	1.5

Note: *Asia does not include data of Southeast Asia*
* ***Source:*** *FAO Fisheries and Aquaculture Information and Statistics Service*
** ***Source:*** *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a) for data from 2000-2007; and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a) for data from 2008 to 2014*

Figure 4. Map of Southeast Asia
*(**Source:** Google)*

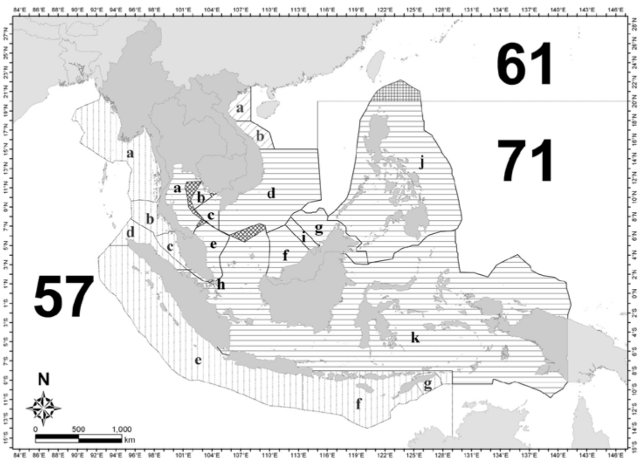


Figure 5. FAO Major Fishing Areas in Southeast Asia
*(**Source:** SEAFDEC, 2008c)*

Nam. Although Timor-Leste may have its own fisheries data, SEAFDEC has no mandate to include the country's statistics in this publication as the scope of this publication focuses mainly on the ten ASEAN Member States (AMSs). In terms of fishery statistics for both capture fisheries and aquaculture, the total fisheries production of the Southeast Asian region covers the waters under FAO Major Fishing Areas 57 (Indian Ocean, Eastern), 61 (Pacific, Northwest), 71 (Pacific, Western Central), and 04 (Asia, Inland Waters) as shown in **Figure 5**.

All inland waters of the Southeast Asian countries have been identified under the Area 04 (Asia, Inland Waters) as shown in **Figure 6**. However, there is no sub-area for Asia (Fishing Area 04) that is recognized for the collection of catch and effort data for the Southeast Asian region (SEAFDEC, 2008c). The data presented by Lao PDR, which is the sole landlocked country in the region, are therefore reported under Area 04 only. The fisheries production of the Southeast Asian region from 2000 to 2014, summarized in **Table 3**, was compiled by SEAFDEC based on inputs of the AMSs, and published in the Fishery Statistical Bulletin for the South China Sea Area 2000-2007 and the Fishery Statistical Bulletin of Southeast Asia 2008-2014.

In compiling the data for the Fishery Statistical Bulletin of Southeast Asia, the retained catches officially submitted by the AMSs and various sources had been used as inputs to make the data as complete as possible while utilization of regional inputs had also been maximized. These include the data collected through statistical surveys and from government records as well as those of semi-governmental organizations. In addition, data and information derived

Table 3. Fisheries production of the Southeast Asian countries from 2000 to 2014 by quantity (thousand metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	2.6	298.8	5,120.5	71.0	1,457.1	1,309.8	2,993.3	10.0	3,713.3	1,961.2	**16,937.6**
2001	1.6	441.2	5,490.5	81.0	1,411.7	1,474.5	3,166.5	7.8	3,648.4	2,434.7	**18,157.9**
2002	2.2	424.4	5,515.7	93.0	1,467.5	1,606.2	3,369.5	7.8	3,797.0	2,647.4	**18,930.7**
2003	2.2	390.7	6,005.6	95.0	1,484.0	1,987.0	3,619.3	7.1	3,914.0	2,859.2	**20,364.1**
2004	3.1	343.5	6,647.0	95.0	1,538.0	2,148.6	3,926.2	7.6	4,137.1	3,150.6	**21,996.7**
2005	3.1	546.0	7,183.6	107.8	1,421.4	2,581.8	4,161.9	7.8	4,132.8	3,397.2	**23,543.4**
2006	3.1	661.5	7,510.8	107.8	1,644.5	2,818.0	4,408.5	11.7	4,051.8	3,656.2	**24,873.9**
2007	3.2	525.1	9,054.9	91.7	1,654.2	2,808.0	4,711.3	8.0	3,675.4	4,315.5	**26,847.3**
2008	2.8	536.3	9,054.9	93.5	1,753.3	3,147.6	4,966.9	5.1	3,204.2	4,559.7	**27,324.3**
2009	2.4	515.0	10,064.1	105.0	1,870.0	3,491.1	4,080.0	5.7	3,137.7	4,782.4	**28,053.4**
2010	2.8	555.0	11,662.3	113.0	1,806.6	3,902.0	5,155.7	5.2	3,113.3	5,127.6	**31,443.5**
2011	2.5	631.7	13,626.2	129.6	1,665.8	4,149.8	4,973.6	6.0	2,870.1	5,432.9	**33,488.2**
2012	5.1	728.0	18,763.9	136.0	1,760.8	4,417.7	4,865.7	6.2	3,068.4	5,816.1	**39,567.9**
2013	3.4	728.0	19,245.6	164.2	1,749.3	4,715.9	4,695.4	7.2	2,900.6	6,019.7	**40,229.3**
2014	4.0	745.3	20,600.8	150.6	1,988.3	5,040.3	4,681.4	6.7	2,667.3	6,332.5	**42,217.2**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a) for data from 2000-2007; and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a) for data from 2008 to 2014*

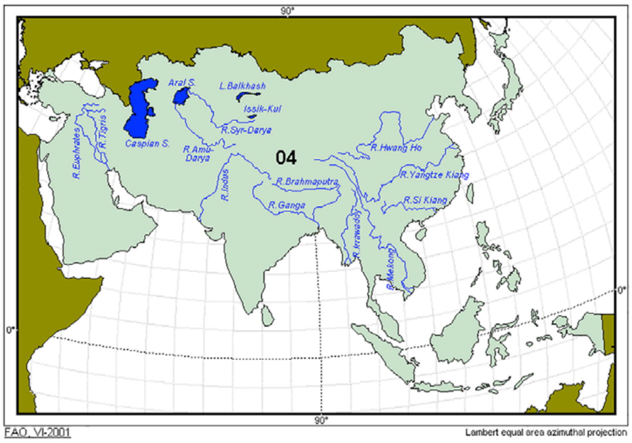


Figure 6. Area 04: Asia-Inland Waters (SEAFDEC, 2008c)

from new statistical techniques, *e.g.* small-scale surveys had also been sourced to provide inputs to the Bulletin.

In 2014, the total fisheries production of the Southeast Asian region was reported to be 42.2 million metric tons, with an average increase of 7% annually over the past 15 years. Indonesia consistently contributed the highest portion at 20.6 million metric tons or nearly 49% of the region's total production, followed by Viet Nam, Myanmar, and Philippines at 6.3 million metric tons (15%), 5.0 million metric tons (12%), and 4.7 million metric tons (11%), respectively. The annual production of the Philippines during the period changed as catches were primarily affected by the reduced fishing activities due to typhoons and rough seas[1]. The highest increase in production came from Indonesia at an average annual rate of approximately 11% over the past 15 years, followed by Myanmar, and Viet Nam at 10% and 9%, respectively. Thailand showed declining trends, particularly from 2006 until 2014 at an average rate of 4% annually, which could be mainly due to the decrease in the production of marine capture fisheries (**Figure 7**). The fisheries production of the Southeast Asian region comes from three sub-sectors, namely: marine capture fisheries, inland capture fisheries, and aquaculture.

Table 4. Production of the fisheries sub-sectors of Southeast Asia in 2014 by quantity (metric tons) and value (US$ thousand)

Sub-sector	Quantity (MT)	Value (US$ 1000)	Value (US$/MT)
Marine Capture Fisheries	16,655,092	21,635,256	1,300
Inland Capture Fisheries	3,028,233	3,693,300	1,220
Aquaculture	22,533,831	17,409,322	775
Total	**42,217,156**	**42,737,878**	

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016)*

As shown in **Table 4**, the total volume of fisheries production of the region by sub-sector in 2014 indicated that the largest portion came from aquaculture accounting for approximately 53%, followed by marine capture fisheries at about 40%, and inland capture fisheries at 7% (**Figure 8**). In terms of value, marine capture fisheries contributed the highest production value accounting for 50% followed by aquaculture which contributed approximately 41%, and inland capture fisheries at about

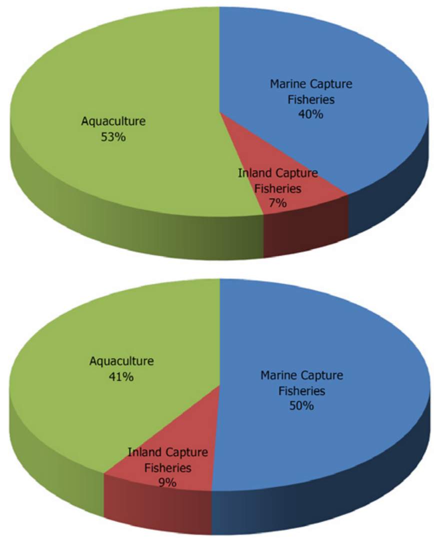


Figure 8. Percentage contribution of the fisheries sub-sectors to the total fisheries production of Southeast Asia in 2014: by quantity *(above)* and value in US$ *(below)*

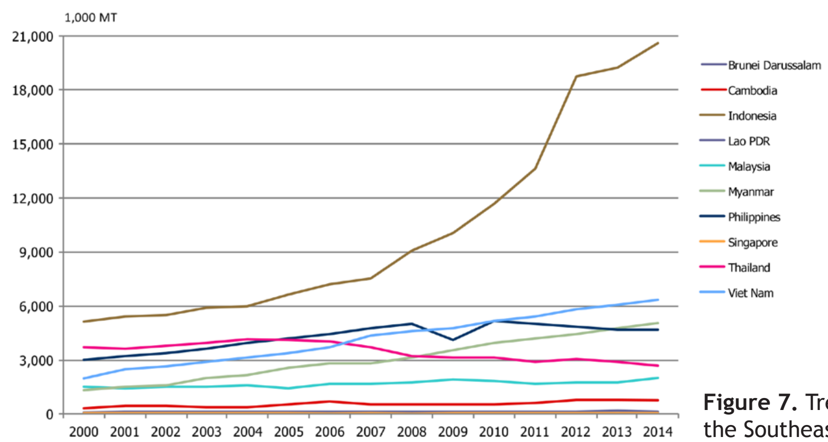


Figure 7. Trends of fisheries production of the Southeast Asian countries by quantity

[1] *Personal communication with the Bureau of Fisheries and Aquatic Resources (BFAR), Philippines*

Table 5. Production trends of the fisheries sub-sectors of Southeast Asia: 2000 to 2014 by quantity (million metric tons)

Year	Marine Capture Fisheries		Inland Capture Fisheries		Aquaculture		Total
	Production (million MT)	Percentage (%)	Production (million MT)	Percentage (%)	Production (million MT)	Percentage (%)	Production (million MT)
2000	11.88	70	1.36	8	3.70	22	**16.94**
2001	12.25	68	1.59	8	4.32	24	**18.16**
2002	12.57	66	1.55	8	4.81	26	**18.93**
2003	13.22	65	1.67	8	5.47	27	**20.36**
2004	13.59	63	1.88	8	6.52	29	**21.99**
2005	13.77	59	2.07	8	7.70	33	**23.54**
2006	14.06	57	2.25	9	8.56	34	**24.87**
2007	14.57	56	2.52	8	9.76	36	**26.85**
2008	13.85	51	2.37	8	11.10	41	**27.32**
2009	14.00	49	2.35	8	11.70	43	**28.05**
2010	14.87	47	2.38	8	14.19	45	**31.44**
2011	15.10	45	2.64	8	15.75	47	**33.49**
2012	15.59	39	2.82	7	21.16	54	**39.57**
2013	16.32	41	2.95	7	20.96	52	**40.23**
2014	16.66	40	3.03	7	22.53	53	**42.22**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a) for data from 2000-2007; and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a) for data from 2008 to 2014*

9% (**Figure 8**). While the value of marine capture fisheries in 2014 was about US$ 1,300/metric ton, those of inland capture fisheries and aquaculture were about US$ 1,220/ metric ton and US$775/metric ton, respectively (**Table 4**).

The production trends of the fisheries sub-sectors of Southeast Asia from 2000 to 2014 signify declining contributions from marine capture fisheries, which contributed up to 70% in 2000 but constantly decreased to approximately 40% from 2012 and onwards (**Table 5**). Nevertheless, such reduction was compensated by the contribution from aquaculture which increased from 22% in 2000 to 53% in 2014. These trends indicated the increasing importance of aquaculture as a source of food fish to meet the increasing demand for fish and ensure food security in the region.

III. MARINE CAPTURE FISHERIES PRODUCTION OF SOUTHEAST ASIA

In 2014, the global marine capture fisheries production was reported to be 82.7 million metric tons, accounting for 42.25% of the total fisheries production (195.7 million metric tons) with Asia and America as the top contributors (**Table 6**). It should be noted however that the trend of the global marine capture fisheries production has slightly decreased from 2000 to 2014 at an average of 229 thousand metric tons annually. This is due to severe fluctuations in production of America and the declining production trend of Europe over the years (**Figure 9**). Specifically for the Southeast Asian region, its marine capture fisheries production of 16.6 million metric tons in 2014 contributed approximately 20.1% to the global marine capture fisheries production. **Figure 10** shows the increasing trend in marine capture fisheries production of the Southeast Asian countries from 11.9 million metric tons in 2000 to 16.7 million metric tons in 2014, with an average increase of 0.34 million metric tons or 2% annually. In terms of quantity, the total marine capture fisheries production of the Southeast Asian countries during 2000-2014 indicated that Indonesia contributed the highest production especially in 2014 when the country's production was 5.97 million metric tons accounting for approximately 35.8% of the region's total, followed by Viet Nam, Myanmar, and Philippines, with production of 2.71 million metric tons (16.3%), 2.70 million metric tons (16.2%), and 2.13 million metric tons (12.8%), respectively (**Table 7**). Thailand and Malaysia also contributed considerable amount from their production of 1.56 million metric tons (9.4%) and 1.46 million metric tons (8.8%), respectively.

As shown in **Table 7** and **Figure 10**, Indonesia has been the largest producer in the Southeast Asian region throughout the period from 2000 to 2014 in terms of quantity, which had been increasing from 3.80 million metric tons to 5.97 million metric tons at an average rate of 154.00 thousand metric tons annually. Similarly, the marine capture fisheries production of Myanmar had been steadily increasing from 0.95 million metric tons to 2.70 million metric tons with an average rate of 125 thousand metric tons annually. Cambodia's production, although not much, had tremendously increased from 36 thousand metric tons in 2000 to 120 thousand metric tons in 2014 with an average rate of 6 thousand metric tons or 16% annually. The marine capture fisheries production of

Table 6. Marine capture fisheries production of each continent from 2000 to 2014 by quantity (thousand metric tons)

Year	World Total* (million metric tons)	Continents					
		Africa*	Americas*	Asia*	Southeast Asia**	Europe*	Oceania*
2000	**85,959**	4,676	25,532	26,648	11,880	16,138	1,085
2001	**84,250**	5,051	22,950	26,999	12,247	15,938	1,115
2002	**83,688**	4,886	24,109	25,711	12,574	15,230	1,177
2003	**80,756**	5,114	20,730	25,908	13,219	14,540	1,275
2004	**85,344**	5,223	25,691	25,699	13,591	13,884	1,466
2005	**84,207**	5,155	24,890	25,331	13,771	13,742	1,502
2006	**81,476**	4,706	22,437	25,682	14,059	13,344	1,368
2007	**81,785**	4,702	22,111	26,238	14,571	13,300	1,377
2008	**81,132**	4,830	21,880	26,379	13,846	13,005	1,224
2009	**79,589**	4,972	21,012	26,211	14,002	13,254	1,210
2010	**78,910**	5,152	17,445	26,488	14,874	13,756	1,195
2011	**83,696**	5,049	22,441	26,665	15,095	13,271	1,175
2012	**80,836**	5,704	18,392	26,960	15,591	12,919	1,270
2013	**82,246**	5,546	18,817	27,134	16,322	13,387	1,210
2014	**82,756**	5,799	16,858	28,452	16,655	13,660	1,332

Note: *Asia does not include data of Southeast Asia*
* ***Source:*** *FAO Fisheries and Aquaculture Information and Statistics Service*
** ***Source:*** *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a) for data from 2000-2007; and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a) for data from 2008 to 2014*

Table 7. Marine capture fisheries production of the Southeast Asian countries in 2000-2014 by quantity (thousand metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR*	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	2.46	36.00	3,807.19	-	1,285.49	949.67	1,740.04	5.37	2,773.67	1,280.59	**11,888.48**
2001	1.93	42.00	3,979.48	-	1,239.28	1,039.46	1,818.73	3.44	2,634.17	1,488.16	**12,246.65**
2002	2.05	45.88	4,073.51	-	1,272.08	1,060.25	1,899.49	2.77	2,643.71	1,575.64	**12,575.38**
2003	1.99	55.61	4,385.10	-	1,289.26	1,139.34	2,038.49	2.09	2,658.22	1,649.48	**13,219.58**
2004	2.43	55.82	4,379.24	-	1,369.65	1,279.18	2,079.93	2.17	2,654.97	1,765.71	**13,589.10**
2005	2.71	60.00	4,464.50	-	1,299.60	1,388.67	2,129.22	1.92	2,625.57	1,799.50	**13,771.69**
2006	2.28	60.50	4,512.19	-	1,379.86	1,525.00	2,154.80	3.10	2,484.80	1,816.10	**13,938.63**
2007	2.55	54.90	4,734.28	-	1,381.43	1,485.74	2,327.20	3.52	2,079.35	1,987.40	**14,056.37**
2008	2.36	66.00	4,741.93	-	1,394.53	1,679.01	2,377.52	1.62	1,644.80	1,946.60	**13,854.37**
2009	1.96	75.00	4,779.41	-	1,391.09	1,787.51	2,398.84	2.12	1,496.16	2,068.30	**14,000.39**
2010	2.35	85.00	5,039.42	-	1,428.88	2,048.59	2,424.48	1.73	1,617.40	2,226.60	**14,874.45**
2011	2.16	114.70	5,328.64	-	1,373.11	2,169.82	2,171.77	1.62	1,633.65	2,300.00	**15,095.47**
2012	4.52	110.00	5,400.98	-	1,472.24	2,332.79	2,145.23	1.97	1,612.07	2,510.90	**15,590.70**
2013	2.83	110.00	5,767.02	-	1,492.90	2,483.87	2,187.37	1.65	1,630.05	2,647.00	**16,322.69**
2014	3.19	120.25	5,967.1	-	1,458.13	2,702.24	2,131.87	1.43	1,559.75	2,711.10	**16,655.06**

* *- means magnitude is zero or not applicable. Being a landlocked country, Lao PDR has no marine capture fisheries*
Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a) for data from 2000-2007; and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a) for data from 2008 to 2014*

Thailand showed declining trends, especially after 2005 (**Figure 10**), which could be mainly attributable to reduced overfishing in the country and environmental degradation in the Gulf of Thailand, as well as the cessation of fishing operations by Thai vessels in Indonesian waters since 2008 (FAO, 2014a).

Meanwhile, the corresponding values of the production from the region's marine capture fisheries during the same period are shown in **Table 8**. Although some countries were not able to provide the data, the total value of the region's marine capture fisheries production from 2000 to 2014 seems to have increased corresponding to the increasing trend of the quantity of production. By country, Indonesia also led the Southeast Asian countries accounting for about 37% of the total value in 2014, with Malaysia emerging as the second highest producing country contributing about 22%. Meanwhile, Myanmar

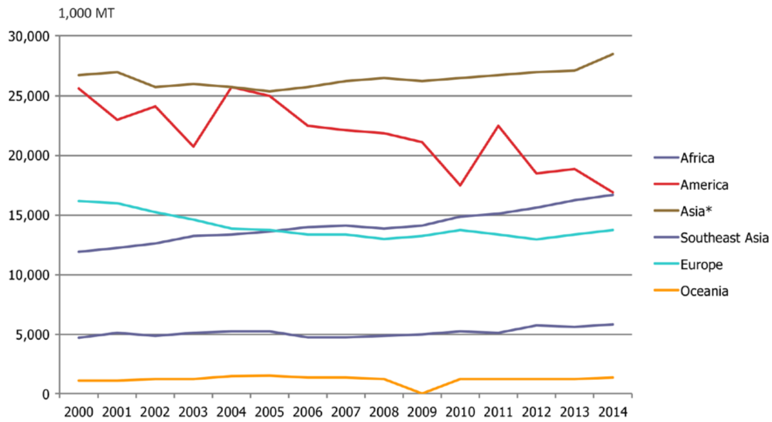


Figure 9. Trends in marine capture fisheries production of each continent by quantity (Asia does not include data of Southeast Asia)

Source: *FAO (2014a); and SEAFDEC (2005a; 2006; 2008a; 2008b; 2009a; 2010a; 2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a)*

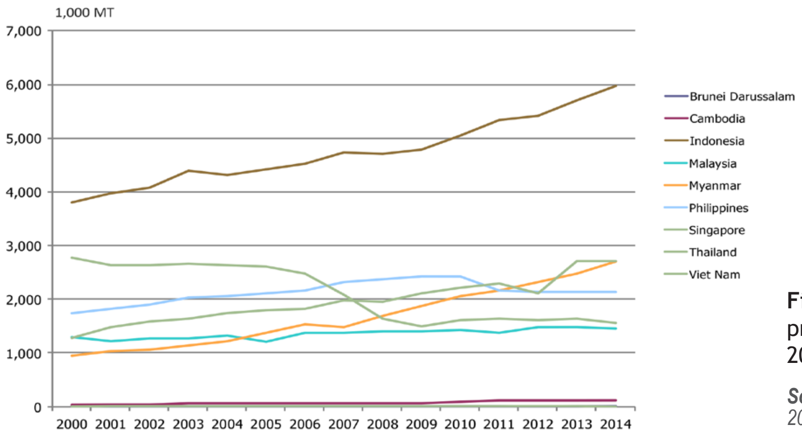


Figure 10. Trends in marine capture fisheries production of Southeast Asian countries in 2000-2014 by quantity

Source: *SEAFDEC (2005a; 2006; 2008a; 2008b; 2009a; 2010a; 2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a)*

Table 8. Marine capture fisheries production of the Southeast Asian countries in 2000-2014 by value (US$ million)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	…	…	1,810	-	1,158	…	1,445	11.0	1,230	…	**5,723**
2001	…	…	2,225	-	1,096	…	1,322	7.0	1,197	924	**6,771**
2002	…	…	2,896	-	1,107	…	1,444	6.0	1,346	875	**7,676**
2003	…	…	2,927	-	1,056	…	1,459	6.0	1,545	964	**7,958**
2004	…	…	3,164	-	1,103	…	1,597	6.0	1,535	…	**7,405**
2005	…	…	3,726	-	1,087	…	1,681	6.0	1,535	…	**7,405**
2006	…	…	4,106	-	1,343	…	1,997	12.0	1,629	…	**9,091**
2007	8	…	4,868	-	1,464	…	2,452	14.0	1,586	…	**10,421**
2008	7	…	4,957	-	1,667	1,585	2,811	8.6	1,276	…	**12,336**
2009	5	111	1,687	-	1,833	3,081	2,650	10.0	1,244	…	**10,417**
2010	7	…	6,558	-	2,015	3,400	2,525	11.0	1,383	…	**15,899**
2011	8	…	7,100	-	2,268	3,580	3,016	10.0	1,412	3,784	**21,179**
2012	8	…	4,863	-	2,583	3,849	2,890	12.0	1,449	4,384	**20,049**
2013	8	…	8,996	-	2,646	4,098	2,996	11.0	1,592	…	**20,349**
2014	9	…	8,014	-	4,768	4,459	2,787	9.0	1,589	…	**21,635**

* *- means magnitude is zero or not applicable. Being a landlocked country, Lao PDR has no marine capture fisheries. Being a landlocked country, Lao PDR has no marine capture fisheries*

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a) for data from 2000-2007; and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a) for data from 2008 to 2014*

which came third contributed about 21%, Philippines ranking fourth accounted for 13%, and Thailand at the fifth rank contributed about 7% (**Figure 11**).

With regards to species classification of the marine capture fisheries production of the Southeast Asian region, the countries reported a total of 203 species and/or species groups. These species include 163 finfishes, 18 crustaceans, 19 mollusks, and 3 aquatic invertebrates. **Table 9** shows the major groups of species from marine capture fisheries of the Southeast Asian countries with the corresponding production in quantity and value in 2014. Nevertheless,

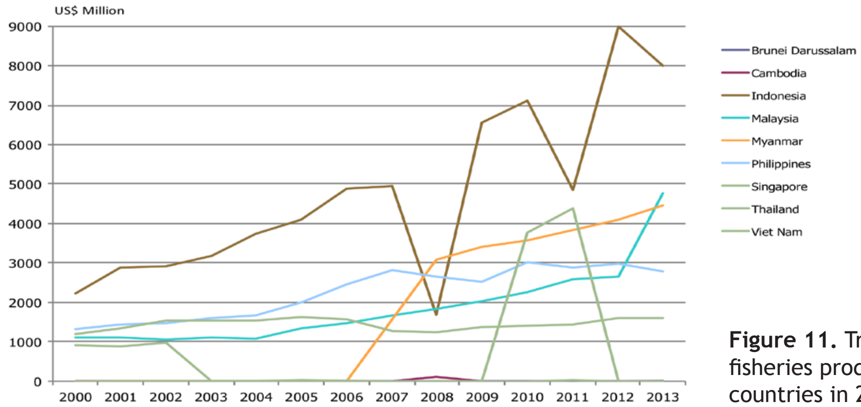


Figure 11. Trends of the value of marine capture fisheries production of the Southeast Asian countries in 2000-2014 (US$)

Table 9. Production of major groups of species of marine capture fisheries of the Southeast Asian countries in 2014 by quantity (metric tons) and value (US$ thousand)

Major groups of species	Production by quantity (metric tons)										Total value (US$ thousand)
	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total	
Shads, milkfish, barramundi, etc.	...	...	112,616	31,658	...	3,038	24	34	...	**147,370**	**290,117**
Flounders halibuts, soles, etc.	...	...	27,932	6,481	...	657	...	7,358	,,,	**42,428**	**66,826**
Red fishes, basses, congers, etc.	...	...	1,053,550	268,841	...	295,994	347	166,011	...	**1,784,743**	**2,982,826**
Jack, mullets, sauries, etc.	...	...	1,068,961	253,049	...	546,460	102	146,777	...	**2,015,349**	**2,842,025**
Herring, sardines, anchovies, etc.	...	...	509,342	71,135	...	433,712	48	218,981	...	**1,233,218**	**1,119,766**
Tunas	...	...	1,561,894	85,420	...	580,525	63	47,559	...	**2,275,461**	**3,711,934**
Mackerels	...	...	355,003	181,376	...	120,318	18	187,701	...	**844,416**	**1,421,856**
Sharks and rays	...	...	119,474	28,460	...	10,576	188	7,317	...	**166,015**	**238,544**
Misc. fishes	2,906	120,250	505,918	307,327	2,702,240	13,571	222	488,554	1,974,500	**6,115,488**	**6,089,826**
Crabs	...	...	86,701	13,489	...	28,525	120	32,967	...	**161,802**	**449,538**
Lobsters	...	...	10,086	819	...	213	5	1,156	...	**12,279**	**66,894**
Shrimps, prawns, etc.	...	...	164,559	39,682	...	33,765	...	47,258	...	**285,264**	**778,556**
Misc. crustaceans	187	...	99,444	67,939	...	...	225	...	...	**168,295**	**397,554**
Oysters	...	...	1,397	...	...	102	...	...	...	**1,499**	**312**
Mussels	...	...	4.024	...	...	23	...	...	...	**23**	**4,242**
Cockles, clams, etc.	...	...	50,219	8,268	...	610	...	15,576	...	**74,673**	**85,452**
Cuttlefish, squids, etc.	...	...	175,391	88,856	...	62,948	71	123,738	...	**451,004**	**1,019,987**
Mollusks	93	...	12,154	...	...	...	...	4,878	...	**17,125**	**6,769**
Invertebrates	...	...	47,974	5,326	...	835	...	63,881	...	**118,016**	**62,232**
Others	...	...	...	...	...	...	...	...	736,600	**736,600**	**...**
Total	**3,186**	**120,250**	**5,967,139**	**1,458,126**	**2,702,240**	**2,131,872**	**1,433**	**1,559,746**	**2,711,100**	**16,655,092**	**21,635,256**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

it should be noted that the large portion of the production from the region (36.7%) were recorded as "miscellaneous fishes" and "miscellaneous crustaceans," meaning that the catches were recorded without being classified into species or species groups. Besides miscellaneous fishes, the major species caught include tunas (13.7%); jack, mullets, sauries, etc. (12.1%); red fishes, basses, congers, etc. (10.7%); herrings, sardines, anchovies, etc. (7.4%).

In terms of production value, it should be noted that although the production volume of Indonesia has steadily increased during the period 2009-2014 (**Figure 10**), the corresponding value had been highly fluctuating particularly from 2007 onwards (**Figure 11**) due to the decreasing production values of several major species such as marine fishes *nei* by 52%, 14% for skipjack tuna (*Kutsuwonus pelamis*), 12% for scads *nei* (*Decapterus* spp.), and 5% for the narrow-barred Spanish mackerel (*Scomberomorus commerson*). However, several countries were not able to provide their respective data on production value to support the overall regional picture of the value of marine capture fisheries production, *i.e.* Cambodia, Lao PDR, and Viet Nam, although the latter was able to report for some years. In the case of Myanmar, the country started to report the value of its production from 2008 to the present, and the trend showed increasing value by US$ 479 million per year. Nevertheless, the general picture of the region seemed to indicate a highly fluctuating trend in production value over the years.

In terms of prices (values of the production per metric ton), the species with the highest price was lobster at US$ 5,450/metric ton, which was mainly produced by Indonesia and in smaller quantities by Thailand and Malaysia. This was followed by crabs at US$ 2,780/metric ton produced mainly by Indonesia and Thailand; shrimps, prawns, etc. at US$ 2,730/metric ton from Indonesia, Thailand, Malaysia, and Philippines; miscellaneous crustaceans at US$ 2,360/metric ton from Indonesia and Malaysia; cuttlefishes, squids, etc. at US$ 2,260/metric ton from Indonesia, Thailand, Malaysia, Philippines, and a small quantity from Singapore (**Table 9**).

3.1 Economically Important Marine Species

The economically important marine species that provided significant contributions to Southeast Asia's total fisheries production in 2014 include tunas, small pelagic fishes (*e.g.* scads, mackerel, anchovies, sardines), crustaceans and mollusks, demersal fishes, and seaweeds. These species are high in demand not only within the Southeast Asian region but also in other regions of the world, and thus dominate the fishery exports of the Southeast Asian countries.

3.1.1 Tunas

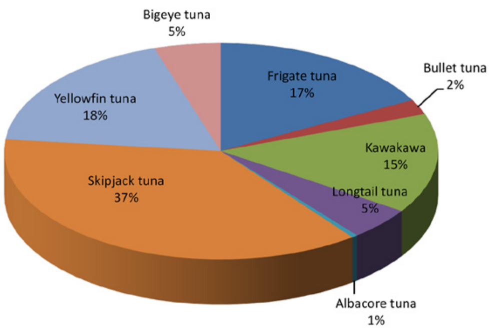
The tuna species that are caught in the exclusive economic zones (EEZs) of the Southeast Asian countries could be taxonomically classified under the family Scrombridae, and broadly categorized into two groups, *i.e.* oceanic tunas which include skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*), albacore tuna (*T. alalunga*), and bluefin tuna (*T. thymus*, *T. orientalis*, and *T. macoyii*); and neritic tunas including frigate tuna (*Auxis thazard*), bullet tuna (*A. rochei*), kawakawa (*Euthynnus affinis*), and longtail tuna (*T. tonggol*). Tunas are caught by commercial fishing gears, particularly trawl nets and purse seines as well as several other traditional fishing gears.

In 2014, only five countries could provide the statistics on tuna production by species, namely: Indonesia, Malaysia, Philippines, Singapore, and Thailand. Brunei Darussalam, Cambodia, Myanmar, and Viet Nam were unable to report their respective tuna production. **Table 10** shows the tuna production of Southeast Asia in 2014 accounting for approximately 4.7% or approximately 12.0% of the region's total marine capture fisheries production. The total production of oceanic tunas accounted for approximately 60.8% of the region's total tuna production. In 2014, Indonesia was the leading tuna producer in the Southeast Asian region contributing to the region's total tuna production by approximately 67.0%, followed by the Philippines contributing about 28.0%, Malaysia 3.0%, and Thailand 2.0%. In terms of species, skipjack tuna (*Katsuwonus pelamis*) contributed the highest production volume accounting for more than 37.0% of the region's total tuna production, followed by yellowfin tuna (*Thunnus albacares*) at 18.0%, and frigate tuna (*Auxis thazard*) at 17.0% (**Figure 12**).

Table 10. Tuna production of the Southeast Asian countries in 2014 by quantity (metric tons)

Species	Quantity (metric tons)					
	Indonesia	Malaysia	Philippines	Singapore	Thailand	Total
Neritic tunas	**513,607**	**56,702**	**169,609**	**no data**	**38,059**	**777,977**
Frigate tuna (*Auxis thazard*)	204,491	2,302	134,095	…	…	340,888
Bullet tuna (*Auxis rochei*)	45,005	…	…	…	…	45,005
Kawakawa (*Euthynnus affinis*)	208,522	29,535	35,514	…	22,179	295,750
Longtail tuna (*Thunnus tonggol*)	55,589	24,865	…	…	15,880	96,334
Oceanic tunas	**810,555**	**11,370**	**384,942**	**1**	**409**	**1,207,277**
Skipjack tuna (*Katsuwonus pelamis*)	496,682	4,689	233,853	1	…	735,225
Southern bluefin tuna (*Thunnus maccoyii*)	1,063	…	…	…	…	1,063
Yellowfin tuna (*Thunnus albacares*)	217,847	5,783	139,920	…	124	363,674
Albacore tuna (*Thunnus alalunga*)	8,750	47	…	…	14	8,811
Bigeye tuna (*Thunnus obesus*)	86,213	851	11,169	…	271	98,504
Total	**1,324,162**	**68,072**	**554,551**	**1**	**38,468**	**1,985,254**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*



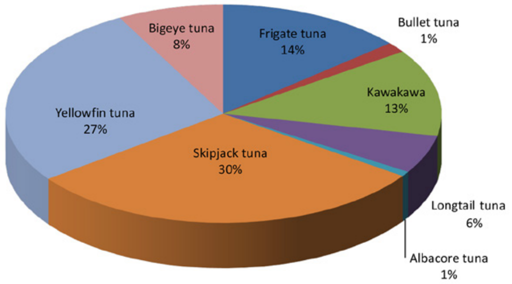


Figure 12. Percentage of tuna species production of Southeast Asia in 2014 by quantity *(above)* and value in US$ *(below)*

In terms of the value of production in 2014, tuna contributed approximately 7.0% to the region's total fisheries production or 14.0% of the region's total marine capture fisheries production. Skipjack tuna (*Katsuwonus pelamis*) also provided the highest production value at about 30.0% of the region's total tuna production, followed by yellowfin tuna (*Thunnus albacares*) contributing about 27.0%, and frigate tuna (*Auxis thazard*) about 14.0% (**Figure 12**). Data in **Table 11** suggest that albacore tuna (*Thunnus alalunga*) commanded the highest price among the tuna group at about US$ 2,555/metric ton, followed by bigeye tuna (*Thunnus obesus*) at US$ 2,465/metric ton, southern bluefin tuna (*Thunnus maccoyii*) at 2,355/metric ton, and yellowfin tuna (*Thunnus albacares*) at US$ 2,310/metric ton.

The region's tuna production in 2014 (**Table 11**) was derived mostly from FAO Major Fishing Areas 71 (Pacific, Western Central) and 57 (Indian Ocean, Western). Nevertheless, most of the production figures were actually based on the areas where tunas were landed and not fished. In 2014, the total value of tuna production from Fishing Area 71 was about US$ 2,803 million or 91% of the region's total tuna production value, with an average price of about US$ 1,690/metric ton, while the total value of the production from Fishing Area 57 of about US$ 277 million provided the remaining 9% at an average price of US$ 850/metric ton. For Fishing Area 71, the species that contributed the highest value to the total production value was skipjack tuna followed by yellowfin tuna, frigate tuna, and kawakawa; while for Fishing Area 57 the highest contributor was kawakawa followed by yellowfin tuna, frigate tuna, and longtail tuna.

3.1.2 Small Pelagic Fishes

The small pelagic fishes, which are also main contributors to the fisheries production of Southeast Asia, could be grouped as scads, mackerels, anchovies, and sardines. In 2014, production from small pelagic species contributed approximately 8.4% to the region's total fisheries production or 21.2% to the region's total marine capture fisheries production. **Table 12** shows the region's production of small pelagic species in 2014, indicating that scads and mackerels are among the most important, contributing about 93.0%. Indonesia was the main contributor at 1,690 thousand metric tons accounting for 48.0% of the region's total small pelagic production, followed by Philippines at 967 thousand metric tons (27.0%), Thailand at 454 thousand metric tons (13.0%), and Malaysia at 416 thousand metric tons (12.0%). Singapore reported that its total production of small pelagic species in 2014 was 112 metric tons.

Table 11. Tuna production of Southeast Asia in FAO Major Fishing Areas in 2014 by quantity (metric tons), and value (US$ thousand)

Species	Quantity (metric tons)			Value (US$ thousand)			Average value (US$/metric ton)
	Fishing Area 57	Fishing Area 71	Total	Fishing Area 57	Fishing Area 71	Total	
Neritic tuna	**166,994**	**610,983**	**777,977**	**143,690**	**901,508**	**1,045,198**	
Frigate tuna (*Auxis thazard*)	47,610	293,278	340,888	44,010	380,995	425,005	1,245
Auxis rochei (*Bullet tuna*)	27,934	17,071	45,055	13,243	34,053	47,296	1,050
Kawakawa (*Euthynnus affinis*)	57,653	238,097	295,750	49,771	348,395	398,166	1,345
Longtail tuna (*Thunnus tonggol*)	33,797	62,537	96,334	36,666	138,065	174,731	1,815
Oceanic tuna	**159,844**	**1,047,433**	**1,207,277**	**133,585**	**1,902,340**	**2,035,925**	
Skipjack tuna (*Katsuwonus pelamis*)	72,088	663,137	735,225	39,620	888,163	927,783	1,260
Southern bluefin tuna (*Thunnus maccoyii*)	1,063	…	1,063	2,502	…	2,502	2,355
Yellowfin tuna (*Thunnus albacares*)	45,246	318,428	363,674	44,178	796,272	840,450	2,310
Albacore tuna (*Thunnus alalunga*)	8,764	47	8,811	22,307	186	22,493	2,555
Bigeye tuna (*Thunnus obesus*)	32,683	65,821	98,504	24,978	217,719	242,697	2,465
Total	**326,838**	**1,658,416**	**1,985,304**	**277,275**	**2,803,848**	**3,081,123**	

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

Specifically in 2014, four species of scads that were reported in the fishery statistics of Southeast Asia accounted for approximately 37.0% of total small pelagic species production (**Figure 13**). Nonetheless, nearly 60.0% of scads had been reported as scads *nei* without being classified into species, followed by yellowstripe scad (*Selaroides leptolepis*) at approximately 16.5%, bigeye scad (*Selar crumenophthalmus*) at 15.5%, and hardtail scad (*Megalaspis cordyla*) at 8.0%. Indonesia was the lead producer of scads, contributing nearly 50.0% to the total scads production in the region, followed by Philippines at approximately 31.0% (**Table 12**).

Mackerels which contributed approximately 30% to the total small pelagic species production in 2014 (**Figure 13**) comprise six species, namely: narrow-barred Spanish mackerel (*Scoberomorus commerson*), seerfishes (*Scomberomorus* spp.), scomber mackerels *nei* (*Scomber* spp.), short mackerel (*Rastrelliger brachysoma*), Indian mackerel (*Rastrelliger kanagurta*), and other rastrelliger mackerels (*Rastrelliger* spp.). *Rastrelliger* spp. contributed nearly 77% to the region's total mackerel production, with Indonesia as the largest producer, which provided 52% to the region's total mackerel production (**Table 12**).

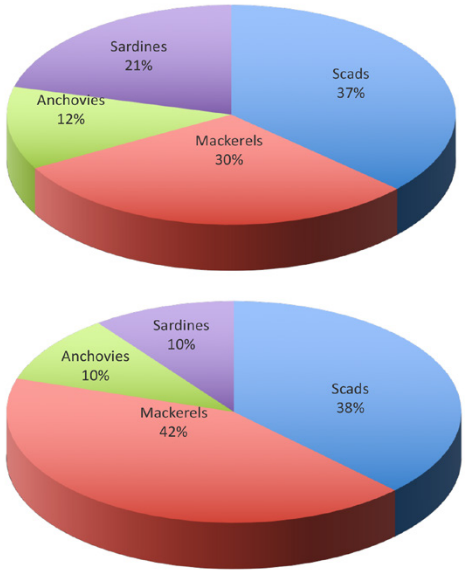


Figure 13. Percentage production of major groups of species of small pelagic fishes of Southeast Asia in 2014 by quantity *(above)* and value in US$ *(below)*

For sardines, the Philippines, Indonesia, and Thailand reported catching six species but their statistics report indicated only three species, namely: sardinellas *nei* (*Sardinella* spp.), spotted sardinella (*Amblygaster sirm*), and rainbow sardinella (*Dussumieria acuta*) as shown in **Table 12**. The production of sardines contributed about 21% to the total small pelagic production of the region

Table 12. Small pelagic fishes production of the Southeast Asian countries in 2014 by quantity (metric tons) and value (US$ thousand)

Major groups of species	Country					Quantity (metric tons)	Value (US$ thousand)	Average value (US$/ metric ton)
	Indonesia	Malaysia	Philippines	Singapore	Thailand			
Scads	**638,248**	**193,159**	**397,572**	**32**	**68,082**	**1,297,093**	**1,758,904**	**1,355**
Scads *nei* (*Decapterus* spp.)	376,276	102,644	265,806	32	33,044	777,802	994,339	
Bigeye scad (*Selar crumenophthalmus*)	16,650	47,630	116,382	…	20,537	201,199	363,638	
Yellowstripe scad (*Selaroides leptolepis*)	199,674	13,816	…	…	…	213,490	254,334	
Hardtail scad (*Megalaspis cordyla*)	45,648	29,069	15,384	…	14,501	104,602	146,593	
Mackerel	**556,228**	**197,985**	**137,232**	**80**	**171,285**	**1,063,810**	**1,988,106**	**1,870**
Narrow-barred Spanish mackerel (*Scomberomorus commerson*)	165,808	…	16,914	…	…	182,722	426,629	
Seerfishes *nei* (*Scomberomorus* spp.)	35,417	16,609	…	62	9,091	61,179	139,621	
Scomber mackerels *nei* (*Scomber* spp.)	1,271	…	1,403	…	…	2,674	1,349	
Short mackerel (*Rastrelliger brachysoma*)	269,411	…	39,602	…	…	309,013	416,108	
Indian mackerel (*Rastrelliger kanagurta*)	84,321	…	79,313	…	45,258	208,892	248,001	
Other rastrelliger mackerel (*Rastrelliger* spp.)	…	181,376	…	18	116,936	298,330	756,398	
Sardines	**296,281**	**…**	**361,120**	**…**	**80,648**	**738,049**	**477,964**	**650**
Sardinellas *nei* (*Sardinella* spp.)	220,565	…	354,423	…	80,648	655,636	284,118	
Spotted sardinella (*Amblygaster sirm*)	46,578	…	…	…	…	46,578	32,230	
Rainbow sardinella (*Dussumieria acuta*)	29,138	…	6,697	…	…	35,835	26,275	
Anchovies	**199,226**	**24,836**	**71,855**	**…**	**133,592**	**429,510**	**466,825**	**1,085**
Stolephorus anchovies (*Stolephorus* spp.)	199,226	24,837	71,855	…	…	295,918	408,600	
Anchovies *nei* (Engraulidae)	…	…	…	…	133,592	133,592	58,225	
Total	**1,689,983**	**415,981**	**967,779**	**112**	**453,607**	**3,527,462**	**4,691,799**	

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

(**Figure 13**), with sardinellas *nei* (*Sardinella* spp.) having the highest production that accounted for 89% of the total sardines production (**Table 12**).

Another important small pelagic species is anchovy with total production of 429,510 metric tons in 2014 (**Table 12**), contributing approximately 12% to the region's small pelagic production (**Figure 13**). Indonesia and Thailand were the main producers providing 46% and 31%, respectively, to the region's total anchovy production (**Table 12**).

In terms of value, mackerels ranked first accounting for about 42% of the total small pelagic species production, followed by scads at about 38% (**Figure 13**). The data shown in **Table 12** also suggest that mackerels commanded the highest price compared to the other small pelagic species at about US$ 1,870/metric ton, followed by scads at US$ 1,355/metric ton, anchovies at US$ 1,085/metric ton, and sardines at about US$ 650/metric ton.

3.1.3 Demersal Fishes

Demersal fishes generally live on or near the ocean floor or sea beds that usually consist of mud, sand or rock, and are bottom feeders which live in and feed from the sea bottom. The major species groups of demersal fishes found in the Southeast Asian waters include the flounders, halibuts, soles, lizardfish, sea catfishes, threadfin breams (*Nemipterus* spp. and *Polynemus* spp.), snappers (*Lutjanus* spp.), groupers *nei* (*Epinephelus* spp.), sillago whitings, croakers and drums, fusilier (*Caesio* spp.), pony fish (*Leiognathus* spp.), goatfishes, sweetlips, emperors, etc. Demersal fishes are usually caught by trawl nets, bottom gillnets, longlines, and handlines.

Based on the data of Southeast Asia in 2014, the total demersal fish production in terms of quantity was approximately 1,827,171 metric tons contributing about 11% to the total marine capture fisheries production of the region (**Table 13**). Indonesia, as the leading producer of demersal fish species, provided 1,081,482 metric tons or 59% of the region's total demersal fish production, followed by the Philippines with 296,651 metric tons contributing 16%, Malaysia with 275,322 metric tons or 15%, Thailand with 173,369 metric tons providing about 9%, while Singapore reported a few volumes. For Indonesia, the main demersal fish species were snappers contributing 12% to the country's total demersal fish production followed by threadfins *nei* at 11.8%, groupers at 10%, and catfishes at 9%.

In terms of value, threadfin breams (*Nemipterus* spp. and *Polynemus* spp.) had the highest value at approximately US$ 544 million. Second were the snappers at US$ 408 million with major species that comprise mangrove red snapper (*Lutjanus argentimaculatus*) and snappers *nei* (*Lutjanus* spp.). Groupers *nei* came in third with groupers *nei* (*Epinephelus* spp.), chocolate hind (*Cephalopholis boenak*), leopard coral grouper (*Plectropomus leopardus*), and humpback grouper (*Cromileptes altivelis*) as the major species, at US$ 393,624 million.

Table 13. Production of major groups of species of demersal fishes of Southeast Asian countries in 2014 by quantity (metric tons) and value (US$ thousand)

Major groups of species	Country					Quantity (metric tons)	Value (US$ thousand)	Average value (US$/metric ton)
	Indonesia	Malaysia	Philippines	Singapore	Thailand			
Flounders, halibuts, soles	27,932	6,481	657	…	7,358	42,428	66,826	3,795
Catfishes	102,111	25,465	4,292	45	2,883	134,796	219,681	1,630
Lizardfishes	22,283	40,057	4,313	…	34,876	101,529	168,984	1,665
Groupers *nei*	110,418	10,296	18,924	29	…	139,667	393,624	2,820
Sillago-whitings	1,605	1,993	11,896	2	3,177	18,673	14,272	765
Bigeyes *nei*	51,399	17,136	…	…	35,849	104,384	116,047	1,110
Snappers	130,301	19,979	18,497	86	5,179	174,042	408,054	2,345
Fusiliers	94,487	500	19,874	3	…	114,864	127,949	1,115
Threadfins *nei*	128,393	64,021	41,798	42	51,649	285,903	544,336	1,905
Pony fishes	87,905	8,957	50,613	15	…	147,490	139,516	945
Drums and croakers	77,928	39,205	…	34	19,402	136,569	215,683	1,580
Sweetlips *nei*	20,503	4,380	…	22	…	24,905	39,930	1,605
Emperor breams	41,578	2,199	11,996	…	…	55,773	53,075	950
Goatfishes *nei*	82,659	18,069	27,380	14	…	160,952	160,952	1,600
Spinefeet *nei*	38,740	2,609	26,427	28	…	67,804	115,128	1,698
Others	63,240	13,975	59,984	27	12,996	177,602	104,643	589
Total	**1,081,482**	**275,322**	**296,651**	**347**	**173,369**	**1,827,171**	**2,982,826**	

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

In the Southeast Asian region, the production of demersal fishes has gained significant economic importance due to the high price of major demersal fish species such as flounders, halibuts, and sole that commanded the highest average price at about US$ 3,795/metric ton, followed by groupers *nei* at US$ 2,820/metric ton, snappers at US$ 2,345/metric ton, and threadfins *nei* at US$ 1,905/metric ton (**Table 13**).

3.1.4 Crustaceans and Mollusks

Crustaceans and mollusks continue to serve as one of the most important contributors to the region's marine capture fisheries production. Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, and Thailand reported on their respective production of several species of crustaceans and mollusks. Although Cambodia, Myanmar, and Viet Nam had also been reported to be catching some species of crustaceans and mollusks, these countries were unable to provide the necessary data by species to the Fishery Statistical Bulletin of Southeast Asia 2014. At this point in time, it is therefore difficult to conclude the actual trend of the production of crustaceans and mollusks in the region. Nonetheless, based on the statistics currently available in 2014, the production of crustaceans and mollusks contributed about 6.0% to the region's total marine capture fisheries production. Indonesia was the largest producer contributing 473,524 metric tons accounting for 46.0% of the region's total crustaceans and mollusks production, followed by Malaysia at 21.0%, Thailand at 21.0%, and Philippines at 12.0% (**Table 14**).

Specifically for crustaceans, although this group contributed only about 3.8% to the total marine capture fisheries production by quantity, its contribution in terms of value was nearly 8.0% because these are high-value commodities that command high prices. The main crustacean species in the Southeast Asian region include the blue swimming crab (*Portunus pelagicus*), Indo-Pacific swamp crab (*Scylla serrata*), lobsters (*Panulirus* spp.), banana prawn (*Penaeus merguiensis*), giant tiger prawn (*Penaeus monodon*), Penaeus shrimps (*Penaeus* spp.), and penaeid shrimps (*Metapenaeus* spp.). Nonetheless, it should be noted that nearly 30.0% of crustaceans had been reported as marine crustaceans *nei* and not classified according to species. While penaeid shrimps (*Metapenaeus* spp.) contributed 19.0% in quantity, blue swimming crab (*Portunus pelagicus*) contributed 17.0%, and banana prawn (*Penaeus merguiensis*) contributed 16.0%. For mollusks, the important species were cuttlefishes (*Sepia* spp.), common squids (*Loligo* spp.), and octopuses (Octopodidae). Squids contributed 71% to the total mollusks production, followed by cuttlefishes at 17%.

In terms of average prices (**Table 14**), lobsters *nei* (*Panulirus* spp.) posted the highest at about S$ 5,450/metric ton followed by the giant tiger prawn (*Penaeus monodon*) at US$ 3,845/metric ton, banana prawn (*Penaeus mergiuensis*) at US$ 3,070/metric ton, common squids *nei* (*Loligo* spp.) at US$ 2,945/metric ton, blue swimming crab (*Portunus pelagicus*) at US$ 2,795/metric ton, and Indo-Pacific swamp crab (*Scylla serrata*) at US$ 2,685/metric ton.

Table 14. Production of major groups of species of crustaceans and mollusks of the Southeast Asian countries in 2014 by quantity (metric tons) and value (US$ thousand)

Major groups of species	Country						Quantity (metric tons)	Value (US$ thousand)	Average value (US$/ metric ton)
	Brunei Darussalam	Indonesia	Malaysia	Philippines	Singapore	Thailand			
Crustaceans	**187**	**361,290**	**121,929**	**62,503**	**350**	**81,381**	**627,640**	**1,692,542**	
Blue swimming crab	…	52,488	…	27,253	…	26,635	106,376	297,175	2,795
Indo-Pacific swamp crab	…	34,213	…	1,272	21	1,964	37,470	100,540	2,685
Lobsters *nei*	…	10,086	819	213	5	1,156	12,279	66,894	5,450
Banana prawn	…	89,606	…	…	…	9,506	99,112	304,518	3,070
Giant tiger prawn	…	34,784	…	645	…	1,545	36,974	142,515	3,845
Penaeid shrimps *nei*	…	…	…	9,530	…	20,209	29,739	51,965	1,745
Metapenaeus shrimps *nei*	…	40,169	39,682	23,590	…	15,998	119,439	279,558	2,340
Marine crustaceans *nei*	187	99,944	81,428	…	324	4,368	186,251	449,377	2,415
Mollusks	**93**	**112,234**	**88,856**	**61,252**	**71**	**128,616**	**391,122**	**1,026,756**	
Cuttlefishes *nei*	…	17,930	24,533	1,321	32	23,716	67,532	166,367	2,465
Squids *nei*	…	75,312	62,405	55,693	39	85,107	278,556	820,047	2,945
Octopuses *nei*	…	6,838	1,918	4,238		14,915	27,909	33,573	1,205
Marine mollusks *nei*	93	12,154	…	…	…	4,878	17,909	6,769	395
Total	**280**	**473,524**	**210,785**	**123,755**	**421**	**209,997**	**1,018,762**	**2,719,298**	

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

3.2 Fishing Vessels

According to SOFIA (FAO, 2016), the total number of fishing vessels in the world in 2014 was estimated at about 4.6 million (**Table 15**). Asia alone, excluding Southeast Asia had the highest number, consisting of 2.2 million vessels and accounted for 47.54%, followed by Southeast Asia (27.57%), Africa (14.75%), Latin America and the Caribbean (6.00%), Europe (2.07%), North America (1.89%), and Oceania (0.19%) (**Figure 14**).

Table 15. Number of fishing vessels (powered and non-powered) of each continent in 2014

	Number of fishing vessels (thousand)	Percentage (%)
World	**4,606.00**	
Africa	679.20	14.75
Asia*	2,189.50	47.54
Southeast Asia	1,270.00	27.57
Europe	95.50	2.07
Latin America and the Caribbean	276.20	6.00
North America	87.00	1.89
Oceania	8.60	0.19

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*
** Excludes data from Southeast Asia*

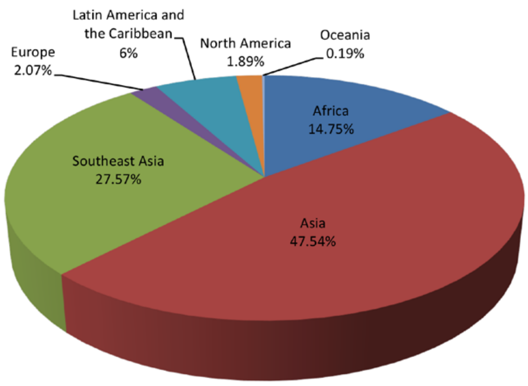


Figure 14. Percentage of fishing vessels (powered and non-powered) in each continent in 2014 (FAO, 2016a)

In Southeast Asia, the number of fishing vessels reported is based on the registered boats in the respective countries, although Cambodia was unable to report its number of registered fishing boats. Therefore, based on the available data in 2014 and the Regional Classification of Fishing Boats, Indonesia had the highest number of fishing boats at 651,966 comprising 477,782 powered and 174,184 non-powered boats, followed by the Philippines with 476,124 boats which include 469,807 municipal (less than 3 GT) and 6,317 commercial (more than 3 GT) fishing boats (Philippine Fisheries Profile 2014), and Malaysia with 57,972 boats comprising 54,940 powered and 3,032 non-powered boats (**Table 16**). The fourth highest number was reported by Viet Nam with 31,235 boats, followed by Myanmar with 28,958 boats of which 15,226 were powered 13,732 and were non-powered, Thailand with 23,556 boats, Singapore with 158 boats, and Brunei Darussalam with 38 boats.

The Regional Classification of Fishing Boats was developed to be able to compile the statistics on the fishing units considering the extent of existing fishing operations in Southeast Asia (SEAFDEC, 2008c). The data on fishing boats in the Southeast Asian countries indicated some increase in terms of numbers from 2000 to 2009, slightly decreased in 2010-2011, and slightly increased again since 2012 (**Table 17**). This merely reflected the improvements made by the countries in vessel registration and data collection on fishing vessels.

Table 16. Number of fishing vessels in Southeast Asia in 2014

Country	Powered boats		Non-powered boats	Total
	Out-board	In-board		
Brunei Darussalam	...	38	...	38
Indonesia	237,696	240,086	174,184	651,966
Malaysia	37,803	17,137	3,032	57,972
Myanmar	12,490	2,736	13,732	28,958
Philippines*	...	...	...	476,124
Singapore	146	12	...	158
Thailand	...	23,556	...	23,556
Viet Nam	...	...	...	31,235
Total	**288,135**	**283,565**	**190,948**	**1,270,016**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*
** Philippine Fisheries Profile 2014*

Table 17. Number of fishing vessels in the Southeast Asian countries from 2000 to 2014

Year	Brunei Darussalam	Cambodia	Indonesia	Malaysia*	Myanmar	Philippines**	Singapore	Thailand	Viet Nam	Total
2000	…	…	475,392	31,531	64,905	476,499	…	57,801	…	**1,106,128**
2001	…	…	514,291	31,780	42,271	476,499	…	57,801	…	**1,122,642**
2002	…	65,716	460,298	30,751	29,082	476,499	146	15,568	102,674	**1,180,734**
2003	…	65,151	528,720	35,458	32,120	476,499	145	15,983	102,069	**1,256,145**
2004	…	65,151	549,100	36,136	32,620	476,499	147	16,432	102,069	**1,278,154**
2005	…	…	566,597	36,136	61,857	476,499	146	57,801	…	**1,198,916**
2006		…	616,300	38,276	…	476,499	144	58,119	…	**1,189,338**
2007	3,128	…	604,937	39,221	…	476,178	144	58,119	…	**1,181,727**
2008	3,184		604,847	40,959	31,371	476,178	142	12,920	22,529	**1,192,130**
2009	2,750	108,145	596,230	48,745	30,248	476,178	133	16,891	24,990	**1,304,310**
2010	2,743	…	570,827	49,756	32,824	476,178	39	15,381	25,346	**1,173,094**
2011	2,607	…	581,845	53,002	30,848	476,178	39	17,203	28,424	**1,190,146**
2012	2,627	…	616,690	54,235	30,349	476,178	4	18,089	27,988	**1,226,160**
2013	46	…	603,318	57,095	27,638	476,178	155	16,548	30,132	**1,211,110**
2014	38	…	651,966	57,972	28,958	476,124	158	23,556	31,235	**1,270,007**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*
* *Updated figures provided by Fisheries Management Information Division, Department of Fisheries Malaysia*
** *Based on Philippine Fisheries Profile 2014*

3.3 Fishers and Fish Farmers

Fisheries and aquaculture play, directly or indirectly, an essential role in the livelihoods of millions of people around the world. The world's number of fishers by region suggested that since 2010 more than 75 million people were engaged in capture fisheries and aquaculture (**Table 18**). The classification of fishers and farmers was developed to compile statistics on the number of fishers by sub-sectors (marine capture fisheries, inland capture fisheries, and aquaculture) and their working status (SEAFDEC, 2008c). From 2000 to 2010, the trends in the number of fishers have varied by region, and the number of fishers during 2000-2012 had increased and then slightly decreased until recently. Generally, employment in fishing continues to decrease in countries with capital intensive economies. Factors that may account for this include policies to cut fleet overcapacity and less dependence on human work owing to technological developments and associated increased efficiencies (FAO, 2016a). Asia has the largest number of fishers in many decades. In 2014, 76% of the global population engaged in the fisheries and aquaculture sector came from Asia (excluding Southeast Asia) followed by Southeast Asia (11%), Africa (8%), and Latin America and the Caribbean (5%).

With regards to the number of fishers and fish farmers in the Southeast Asian region in 2014 (**Table 19**), Myanmar had the highest number at 3,781,550 followed by Indonesia at 2,667,440 and Philippines at 877,185. Thailand ranked fourth with 666,908 followed by Lao PDR with 594,500 and Malaysia with 169,937. Although small, Brunei Darussalam and Singapore were able to report their number of fishers and fish farmers, however, Cambodia and Viet Nam were not able to provide the same information. The number of fishers and farmers with corresponding working

Table 18. Number of fishers and fish farmers of each continent

	2000	2005	2010	2012	2013	2014
World	**59,476**	**66,502**	**76,177**	**77,133**	**75,599**	**75,385**
Africa	4,266	4,570	5,258	6,183	6,288	5,958
Asia*	49,560.1	56,497.7	57,971.5	60,935.8	59,922.5	57,583.1
Southeast Asia	2,296.9	2,058.3	9,288.5	6,279.2	5,837.5	8,178.9
Europe	882	764	764	750	382	479
Latin America and the Caribbean	1,988	2,146	2,433	2,520	2,783	2,800
North America	352	339	333	332	334	334
Oceania	131	127	129	133	52	52

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a); and The State of World Fisheries and Aquaculture 2016 (FAO, 2016a)*
* *Excludes data from Southeast Asia*

Table 19. Number of fishers and fish farmers in the fisheries sub-sectors of Southeast Asia in 2014 by working status

Country	Marine Capture Fisheries			Inland Capture Fisheries			Un-specified	Aquaculture		Total
	Full-time	Part-time	Occasional	Full-time	Part-time	Occasional		Full-time	Part-time	
Brunei Darussalam	433	...	...	...	...	...	...	95		528
Indonesia	1,192,350	689,740	304,810	217,930	161,480	101,130				2,667,440
Lao PDR	...	...	...	...	...	...	...	...	...	594,500
Malaysia	143,421							26,516		169,937
Myanmar	230,550,	252,000	917,000	488,000	301,000	...	796,500	224,123	...	3,781,550
Philippines	...	...	...	...	...	...	...	...	...	877,185
Singapore	36							508	162	706
Thailand	...	...	...	...	...	...	...	...	..3,781,55	666,908

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

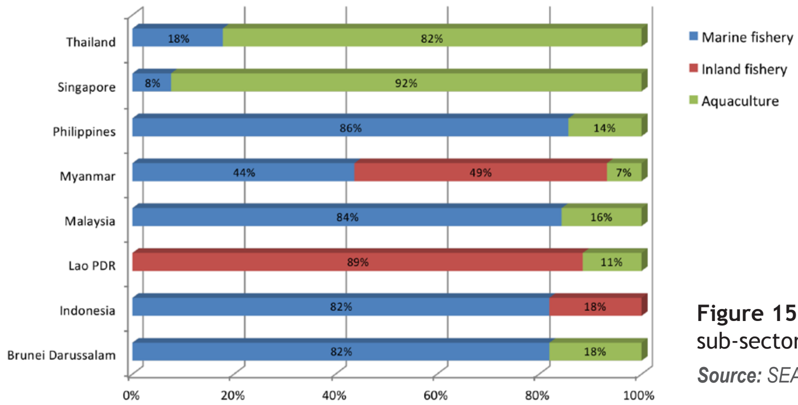


Figure 15. Percentage of fish workers in the fisheries sub-sectors of Southeast Asia in 2014

Source: *SEAFDEC (2016a)*

status is shown in **Figure 15**. There is however a need to exert efforts in improving data availability by encouraging the countries to enhance their data collection and reporting through census using questionnaires. This would enable the countries to compile the necessary information on fisheries including the number of fishers and fish farmers as well as the number of fishing vessels and gears.

IV. INLAND CAPTURE FISHERIES PRODUCTION OF SOUTHEAST ASIA

In Southeast Asia, the inland capture fisheries sector is important for its role in providing significant contribution to livelihood, food security, and local economy particularly for people in rural communities. The Mekong River Basin in Southeast Asia for example (**Figure 16**), recognized as one of the world's species-rich habitats, is a primary source of protein to a large number of people. In addition, the region being located in the tropical zone is also endowed with rivers, lakes, and reservoirs that serve as important habitats to numerous inland aquatic species. Despite its undeniable importance, information on production of inland capture fisheries are usually very scarce due to the nature of fishing activities that are mostly undertaken as small-scale operations, while large portion of the production is used for household consumption without being landed and not recorded at landing sites. Furthermore, activities in inland capture fisheries are highly seasonal, making data collection and analysis very much different from the other fisheries sub-sectors. According to the Mekong River Commission (MRC) Fisheries Programme, production from the region's inland capture fisheries depends primarily on annual flooding of the plains and wetlands around lakes, rivers, and along the Lower Mekong Basin.

Through the efforts made by many agencies to improve the compilation of information on inland capture fisheries

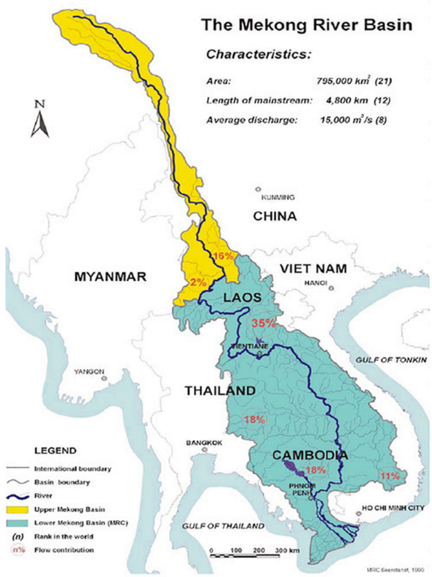


Figure 16. The Mekong River Basin *(**Source:** MRC)*

production in Southeast Asia, most of the countries were able to provide the necessary data including Brunei Darussalam and Singapore even if their respective production could be considered negligible. In most cases however, it is presumed that such data could be very much underestimated. Results of consumption surveys undertaken by the MRC in Cambodia, Lao PDR, Thailand, and Viet Nam also confirmed that the fisheries production of the Lower Mekong Basin is probably significantly higher than what had been officially reported. Nonetheless, data in **Table 20** and **Table 21** show the trends of inland capture fisheries production of the Southeast Asian countries, in terms of quantity and value, respectively. During 2000-2014, the region's production of inland capture fisheries has increased linearly by 6% per year and had a total of 3,028,233 metric tons in 2014 (**Figure 17**), accounting for approximately 15% of the region's total capture fisheries production or 7% of the region's total fisheries production. It should be noted that in the case of Myanmar, its inland capture fisheries production has significantly increased almost four times during the last decade (**Figure 17**).

In 2014, the inland capture fisheries production of Myanmar was highest accounting for 45.6% of the region's total capture fisheries production, followed by

Table 20. Inland capture fisheries production of the Southeast Asian countries from 2000 to 2014 by quantity (metric tons (MT))

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	0	245,600	318,334	*29,250	3,549	238,210	152,121	0	201,500	170,000	**1,358,564**
2001	0	360,000	310,240	*31,000	3,446	254,880	136,347	0	202,500	243,583	**1,541,996**
2002	0	360,300	304,989	*33,440	3,565	289,940	131,644	0	198,700	226,958	**1,549,536**
2003	0	308,750	308,693	*29,800	3,828	454,320	133,292	0	198,400	208,623	**1,645,706**
2004	0	250,000	330,880	*29,800	4,119	502,550	142,019	0	199,600	*206,600	**1,665,568**
2005	0	444,000	297,370	29,800	4,583	631,120	143,806	0	198,800	138,800	**1,888,279**
2006	0	559,642	293,921	29,800	4,164	718,000	161,394	0	214,000	152,325	**2,133,246**
2007	0	420,000	310,457	28,410	4,283	717,640	168,277	0	225,600	133,600	**2,008,267**
2008	0	430,600	497,740	29,200	4,353	818,740	181,678	0	228,600	144,800	**2,335,711**
2009	0	390,000	494,630	30,000	4,469	899,430	188,444	0	245,000	144,800	**2,397,773**
2010	0	405,000	344,972	30,900	4,545	1,002,430	185,406	0	209,800	194,200	**2,377,253**
2011	0	445,000	368,542	34,000	5,695	1,163,159	193,698	0	228,500	202,500	**2,641,094**
2012	0	528,000	393,552	34,105	5,042	1,246,460	195,804	0	222,500	194,500	**2,819,963**
2013	0	528,000	391,324	40,143	5,640	1,302,970	194,615	0	213,700	196,800	**2,873,192**
2014	0	505,005	446,509	60,237	5,611	1,381,030	211,941	0	209,800	208,100	**3,028,233**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*
** FAO Fisheries and Aquaculture Information and Statistic Service*

Table 21. Inland capture fisheries production of the Southeast Asian countries from 2000 to 2014 by value (US$ thousand)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	0	…	155,472	…	…	…	59,285	0	174,920	…	**389,677**
2001	0	…	189,590	…	…	…	57,022	0	157,072	…	**403,684**
2002	0	…	237,888	…	6,316	…	64,518	0	145,038	…	**453,861**
2003	0	…	257,779	…	6,316	…	66,029	0	170,236	…	**500,658**
2004	0	…	268,990	…	7,632	…	80,442	0	184,658	…	**541,901**
2005	0	…	323,827	…	8,446	…	84,077	0	194,859	…	**611,950**
2006	0	…	264,372	…	8,470	…	101,477	0	222,573	…	**596,877**
2007	0	…	368,247	215,708	9,855		125,464	0	266,740	…	**985,172**
2008	0	255,500	521,019	240,334	11,556	788,325	145,912	0	254,057	…	**2,215,437**
2009	0	334,845	616,640	93,168	11,014	1,349,145	164,252	0	273,290	…	**2,834,477**
2010	0	…	546,937	…	13,138	1,503,645	174,479	0	288,277	…	**2,526,476**
2011	0	…	635,754	…	17,978	1,744,738	185,799	0	330,193	…	**2,914,402**
2012	0	…	793,238	…	18,376	1,869,690	196,239	0	349,062	…	**3,226,605**
2013	0	…	741,813	194,730	20,129	1,954,455	206,569	0	356,767	…	**3,474,463**
2014	0	…	721,042	313,232	19,441	2,071,545	220,480	0	347,560	…	**3,693,300**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

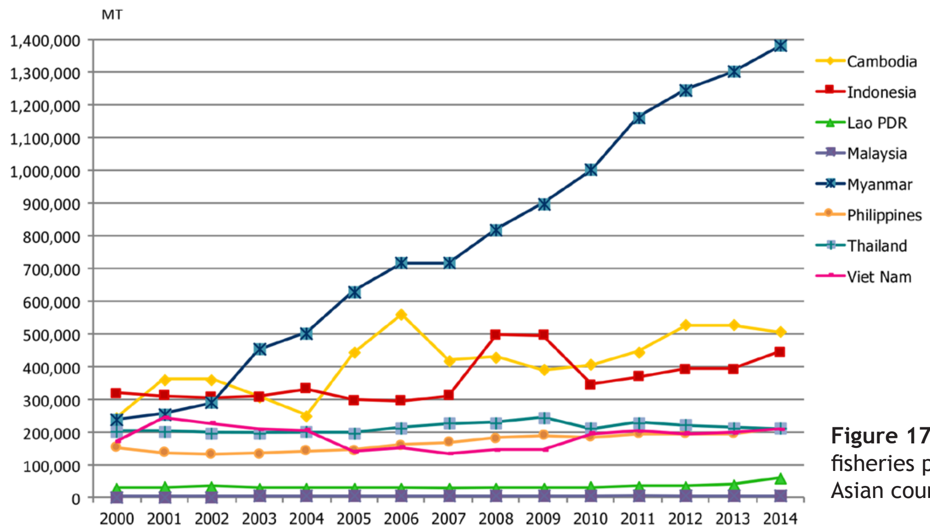


Figure 17. Trends of inland capture fisheries production of the Southeast Asian countries in 2000-2014 by quantity

Cambodia at about 16.7%, Indonesia at 15.0%, while Philippines, Thailand, and Viet Nam accounted for about 7.0% each (**Table 22**). For Lao PDR, although the reported production is not high compared with the other Southeast Asian countries, the importance of inland fishery is very significant considering that all capture fisheries production of the country is derived from inland capture fisheries.

One of the countries in the region with considerable proportion of inland capture fisheries production is Cambodia, its production in 2014 of which represented about 81% of its total capture fisheries production and almost 68% of the country's total fisheries production (**Table 22**). For Myanmar, its inland capture fisheries production represented about 34% of its total capture fisheries production and 27% of the country's total fisheries production (**Table 22**).

In terms of production of major groups of species (**Table 23**), only Indonesia, Malaysia, Philippines, and Thailand provided the figures at species levels and thus, only 22% of the total capture fisheries production could be reported. For Indonesia, its large portion of catch came from striped snakehead (*Channa striata*), followed by Nile tilapia (*Oreochromis niloticus*), Asian redtail catfish (*Mystus nemurus*), and snakeskin gourami (*Trichogaster pectoralis*).

For the Philippines, the large share of its production was derived from tilapia (*Oreochromis* spp.) and freshwater mollusks (Mollusca). For Thailand, production from Nile tilapia ranked first, followed by silver barb (*Barbonymus gonionotus*) and striped snakehead. Meanwhile, in terms of value, the region's production of Asian redtail catfish was the highest at about US$ 2,255/metric ton. This was followed by the striped snakehead at US$ 2,080/metric ton, climbing perch at US$ 1,665/metric ton, and Nile tilapia at US$ 1,535/metric ton (**Table 23**).

The other countries were not able to report their inland capture fisheries production at species level due to inadequacy of experts who are capable of identifying the

Table 22. Contribution of inland capture fisheries production to the respective Southeast Asian country's capture fisheries production and total fisheries production in 2014 by quantity (metric tons)

Country	Inland capture fisheries production (metric tons)	Capture fisheries production (metric tons)	Total fisheries production (metric tons)	Percentage of inland capture fisheries production in total capture fisheries production (%)	Percentage of inland capture fisheries production in total fisheries production (%)
Brunei Darussalam	0	3,186	3,947	-	-
Cambodia	505,005	625,255	745,310	80.77	67.76
Indonesia	446,509	6,413,648	20,600,772	6.96	2.17
Lao PDR	60,237	60,237	150,592	100.00	40.00
Malaysia	5,611	1,463,737	1,988,302	0.38	0.28
Myanmar	1,381,030	4,083,270	5,040,311	33.82	27.40
Philippines	211,941	2,343,813	4,681,418	9.04	4.53
Singapore	0	1,433	6,695	-	-
Thailand	209,800	1,769,546	2,667,309	11.86	7.87
Viet Nam	208,100	2,919,200	6,332,500	7.13	3.29
Total	**3,028,233**	**19,683,325**	**42,217,156**	**Ave: 15.38**	**Ave: 7.17**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

Table 23. Production of major groups of species of inland capture fisheries of the Southeast Asian countries in 2014 by quantity (metric tons) and value (US$/metric ton)

Major groups of species	Country								Total	Percentage in inland capture fisheries production (%)	Value (US$/ metric ton)
	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Thailand	Viet Nam			
Asian redtail catfish	...	27,157	...	...	...	...	...	...	**27,157**	0.90	2,255
Climbing perch	...	16,162	...	...	...	2,393	13,400	...	**31,955**	1.06	1,665
Cyprinids *nei*	...		...	...	...	32,236	...	...	**32,236**	1.06	975
Freshwater mollusks *nei*	...	997	...	...	...	59,428	...	...	**60,425**	2.00	150
Misc. fishes	505,005	96,987	60,237	5,611	1,381,030	...	101,400	208,100	**2,367,587**	78.18	1,120
Silver barb	...	11,903	...	...	...	...	26,200	...	**38,103**	1.26	1,335
Nile tilapia	...	28,637	...	...	...	...	28,100	...	**56,737**	1.87	1,535
Striped snakehead	...	39,030	...	...	...	11,199	14,700	...	**64,929**	2.14	2,080
Snakeskin gourami	...	23,643	...	...	...	6,431	3,900	...	**33,974**	1.12	1,020
Tilapia *nei*	...		...	...	...	54,180	...	...	**54,180**	1.79	1,265
Torpedo-shaped catfishes *nei*	...	19,039	...	...	...	6,211	9,500	...	**34,750**	1.15	1,490
Total	**505,005**	**263,555**	**60,237**	**5,611**	**1,381,030**	**172,078**	**197,200**	**208,100**	**2,802,033**	**92.53**	**1,320**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

fishes by species. Thus, Cambodia, Lao PDR, Myanmar, and Viet Nam could only provide their statistics classified into miscellaneous fishes. Taking into account the contribution of these countries' inland capture fisheries production to the region's total fisheries production which is considerably significant, there is a need to intensify capacity building to enable the countries to compile their data classified by major groups of species. The capacity building in the region could include strengthening the data compilation system and mechanism by means of conducting training courses on species identification, collection of accurate data through surveys, and data analysis. The impact of such effort could reflect the significance of inland fisheries in ensuring food security and enhancing the livelihoods of people in the region.

V. AQUACULTURE PRODUCTION OF SOUTHEAST ASIA

Increase in the world's human population from 6.1 billion in 2000 to 7.3 billion in 2014 led to the world's increasing demand for fish to sustain food security requirements. From 2000 to 2014, the aquaculture production at global level has continued to grow at an average rate of 7% annually or about 4.24 million metric tons/year (**Table 24**). Asia including that of Southeast Asia continued to be the leading aquaculture producer, and in 2014, accounting for about 92% of the world's total aquaculture production, out of which aquaculture production from the Southeast Asian countries contributed about 22% (**Figure 18**).

In the Southeast Asian region, while capture fisheries continued to show a declining trend particularly for marine capture fisheries from nearly 70% of the region's total fisheries production in 2000 to only 40% in 2014, aquaculture has steadily increased to compensate such decline. In addition to its contribution to food security, aquaculture also plays a vital role in enhancing people's livelihood and generating income by reforming the practice of using low-value fish as feed to produce higher value aquaculture products, thus, enhancing the economic growth of countries in the Southeast Asian region. Such reforms are necessary since using fish to produce fish could result in negative impacts on capture fisheries as the demand for fish-based ingredients for aquaculture feeds would increase.

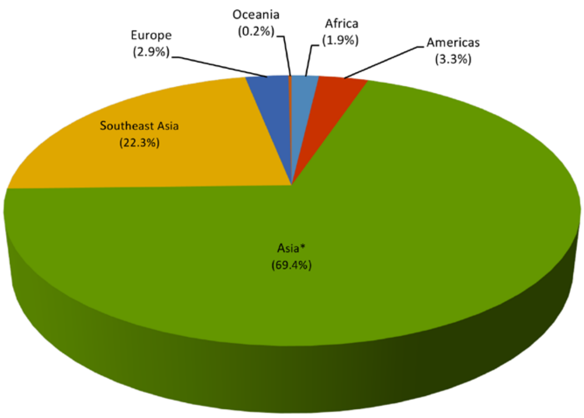


Figure 18. Percentage of continents' aquaculture production to world's total aquaculture production in 2014 by quantity

Table 24. Aquaculture production of each continent from 2000 to 2014 by quantity (metric tons)

Year	World Total* (million metric tons)	Continents					
		Africa*	Americas*	Asia*	Southeast Asia**	Europe*	Oceania*
2000	41,724,570	451,270	1,457,011	33,651,810	**3,969,068**	2,056,729	138,682
2001	44,324,713	489,275	1,765,476	35,591,301	**4,257,005**	2,092,655	129,001
2002	47,374,985	570,091	1,873,058	37,947,956	**4,806,000**	2,043,395	134,485
2003	50,271,308	624,608	1,975,940	39,936,929	**5,439,809**	2,161,537	132,485
2004	54,570,596	638,380	2,163,028	43,139,386	**6,308,557**	2,173,437	147,808
2005	57,820,603	727,390	2,192,363	45,089,956	**7,512,534**	2,135,194	163,166
2006	61,592,069	843,010	2,406,759	47,547,636	**8,426,187**	2,193,569	174,908
2007	64,798,959	916,790	2,386,409	49,853,487	**9,237,586**	2,367,132	176,006
2008	73,045,920	1,061,423	2,497,533	51,667,749	**11,063,934**	2,327,892	180,428
2009	73,045,920	1,103,338	2,554,484	54,306,390	**12,379,436**	2,518,895	183,377
2010	78,029,002	1,423,963	2,527,146	57,139,820	**14,186,737**	2,545,890	205,446
2011	82,649,339	1,537,737	2,789,598	59,696,054	**15,751,145**	2,661,427	213,378
2012	90,049,125	1,645,797	2,993,451	61,185,941	**21,156,490**	2,855,439	212,007
2013	97,162,044	1,738,014	3,071,887	68,175,004	**21,203,449**	2,767,782	205,908
2014	101,139,072	1,861,271	3,365,210	70,229,317	**22,533,831**	2,933,146	216,297

Note: *Asia does not include data of Southeast Asia*
* ***Source:*** *FAO Fisheries and Aquaculture Information and Statistics Service*
** ***Source:*** *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

From 2000 to 2014, the total production of aquaculture in the Southeast Asian region has continued to increase at an average rate of about 1,326 thousand metric tons/year or 14% per year, while its contribution to the region's total fisheries production had increased from 21% to 53% (**Table 25**). Moreover, the constant increase in aquaculture production of the region could be observed in 15 years, between 2000 and 2014 (**Figure 19** and **Table 25**).

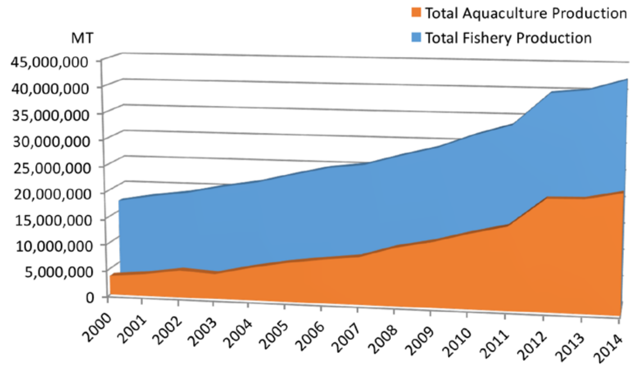


Figure 19. Contribution of the region's aquaculture production to the total fisheries production of Southeast Asia from 2000 to 2014

In terms of quantity, Indonesia emerged as the top aquaculture producer in 2014, contributing about 63% to the region's total aquaculture production, followed by Viet Nam about 15%, the Philippines about 10%, and Thailand about 4% (**Figure 20**).

In terms of value of the region's aquaculture production, the actual trend could not be established as some countries were not able to provide the data regularly (**Table 26**). Nevertheless, from the available data in 2014 in terms of average value per metric ton of aquaculture produce (**Table 25** and **Table 26**), Brunei Darussalam had the highest value at about US$ 11,675/metric ton, followed by Singapore

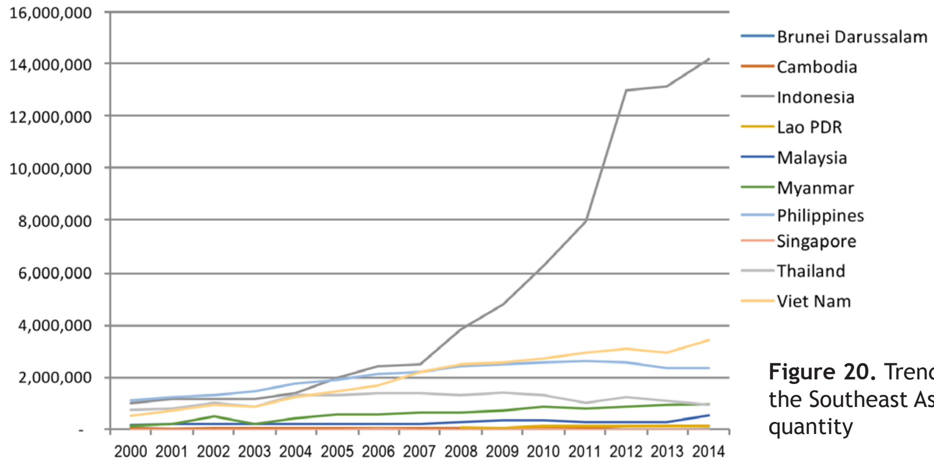


Figure 20. Trends of aquaculture production of the Southeast Asian countries in 2000-2014 by quantity

Table 25. Aquaculture production of the Southeast Asian countries from 2000 to 2014 by quantity (metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total (aquaculture production)	Total (fisheries production)
2000	113	14,430	994,965	…	151,771	121,950	1,100,902	4,613	738,083	510,555	**3,637,382**	**16,937,296**
2001	99	14,000	1,132,784	…	158,156	190,120	1,219,456	4,442	814,227	709,891	**4,243,175**	**17,621,843**
2002	158	22,003	1,180,961	…	166,217	497,564	1,338,393	5,012	1,021,226	956,059	**5,187,593**	**18,930,761**
2003	159	22,547	1,180,385	…	169,265	158,846	1,454,503	5,432	886,589	891,845	**4,769,571**	**20,274,399**
2004	708	37,675	1,354,501	…	171,267	437,970	1,717,027	5,406	1,301,497	1,198,617	**6,224,668**	**21,147,665**
2005	703	42,000	1,941,096	…	175,792	574,990	1,895,847	5,917	1,318,461	1,467,300	**7,422,106**	**22,987,784**
2006	700	41,390	2,377,474	…	168,574	574,990	2,092,275	8,572	1,353,021	1,687,727	**8,304,723**	**24,501,878**
2007	674	50,200	2,466,030	…	178,244	604,657	2,165,604	4,504	1,370,431	2,194,500	**9,034,844**	**25,302,872**
2008	390	39,720	3,855,200	64,300	243,124	653,855	2,407,698	3,518	1,330,800	2,468,320	**11,066,925**	**27,207,826**
2009	460	50,000	4,789,100	75,000	333,451	724,163	2,477,196	3,566	1,396,010	2,539,300	**12,379,246**	**28,917,096**
2010	421	60,000	6,277,923	82,100	373,151	850,959	2,545,765	3,501	1,286,117	2,706,800	**14,186,737**	**31,438,431**
2011	293	72,000	7,928,962	95,600	287,042	816,820	2,608,120	3,974	1,007,934	2,930,400	**15,751,145**	**33,488,051**
2012	556	90,000	12,969,364	101,895	283,559	838,426	2,524,641	3,577	1,233,772	3,110,700	**21,156,490**	**39,567,813**
2013	606	90,000	13,147,288	124,085	260,774	929,000	2,373,386	5,566	1,056,844	3,215,900	**21,203,449**	**40,229,315**
2014	761	120,055	14,187,124	90,355	524,565	957,041	2,337,605	5,262	897,763	3,413,300	**22,533,831**	**42,217,156**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

Table 26. Aquaculture production of the Southeast Asian countries from 2000 to 2014 by value (US$ thousand)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total Value
2000	…	…	1,083,046	…	255,348	…	728,296	9,946	2,457,007	…	**4,533,643**
2001	473	27,961	1,342,965	…	317,524	…	718,461	8,291	2,137,398	1,160,928	**5,714,001**
2002	715	26,598	1,562,287	…	284,437	…	686,398	6,847	1,559,294	1,340,095	**5,466,671**
2003	…	…	1,741,558	…	308,501	…	686,331	7,433	1,461,664	1,635,525	**5,841,013**
2004	3,093	42,165	1,966,996	…	309,750	…	799,826	8,524	1,714,509	2,356,981	**7,201,844**
2005	…	…	2,168,720	…	341,126	…	892,536	9,971	1,353,179	2,945,650	**7,711,182**
2006	…	…	2,341,501	…	351,975	…	1,085,011	9,477	1,990,005	…	**5,777,969**
2007	3,212	58,038	2,447,539	…	352,981	1,862,403	1,334,719	9,052	2,134,592	4,544,750	**12,747,286**
2008	392	61,790	4,222,498	91,141	452,880	782,566	1,718,634	9,262	2,065,301	4,617,700	**14,032,164**
2009	658	87,954	5,189,522	111,801	700,910	853,165	1,720,961	8,793	2,422,630	4,867,779	**15,964,173**
2010	4,950	…	6,980,897	…	793,085	917,706	1,835,308	14,864	2,830,930	…	**13,377,740**
2011	1,671	126,850	7,219,307	…	757,320	740,655	1,984,554	15,039	2,562,798	6,281,507	**19,689.700**
2012	4,730	…	7,635,708	…	833,156	1,348,346	2,152,328	12,686	3,313,323	6,383,000	**21,683,275**
2013	3,495	…	10,348,414	…	768,026	1,714,315	2,186,360	32,215	3,163,814	…	**18,216,639**
2014	8,884	…	9,503,444	108,426	1,197,902	1,857,360	2,135,384	42,756	2,555,166	…	**17,409,322**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

at US$ 8,125/metric ton suggesting that their aquaculture production, although minimal, is of high value. Thailand also had the highest average value from its aquaculture production in 2014 at about US$ 2,845/metric ton although it could be easily overtaken by Viet Nam if only the latter's value of its aquaculture production in 2014 was made available, noting that in 2012, the average value of the aquaculture production of Viet Nam was about US$2,050/metric ton. Based on the 2014 data, Malaysia came quite close to Thailand at US$ 2,285/metric ton followed by Myanmar at US$ 1,940/metric ton, Philippines at US$ 915/metric ton, and Indonesia at US$ 670/metric ton.

The aquaculture production of the Southeast Asian region could be classified into culture environments, namely: mariculture, brackishwater culture, and freshwater culture. In 2014, Indonesia is the top producer of aquaculture products from mariculture and brackishwater culture, followed by Philippines for mariculture, and Thailand and Philippines for brackishwater culture. As for freshwater culture, the top producer was Viet Nam followed by Indonesia (**Table 27**). In terms of quantity, mariculture contributed 53% to the region's total aquaculture production in 2014 while brackishwater culture contributed 14% and the remaining 33% from freshwater culture (**Figure 21**). In

Table 27. Production from aquaculture environments of the Southeast Asian countries in 2014 by quantity (metric tons) and value (US$ thousand)

Country	Quantity (metric tons)				Value (US$ thousand)	Average value (US$/metric ton)
	Mariculture	Brackishwater culture	Freshwater culture	Total		
Brunei Darussalam	162	592	7	761	8,884	11,675
Cambodia	7,416	…	112,639	120,055	…	…
Indonesia	9,029,843	2,446,031	2,711,250	14,187,124	9,503,444	670
Lao PDR	0	0	90,355	90,355	108,426	1,200
Malaysia	287,980	125,801	110,784	524,565	1,197,902	2,285
Myanmar	59,705	1,845	895,491	957,041	1,857,360	1,940
Philippines	1,820,533	254,692	262,380	2,337,605	2,135,384	915
Singapore	4,252	200	810	5,262	42,756	8,125
Thailand	202,732	279,907	415,124	897,763	2,555,166	2,845
Viet Nam	454,100	…	2,959,200	3,413,300	…	…
Total	**11,866,723**	**3,109,068**	**7,558,040**	**22,533,831**	**17,409,322**	**770**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

terms of value, notwithstanding the unavailability of data from some countries, freshwater culture contributed 43% followed by brackishwater culture at 40% and mariculture at 17%.

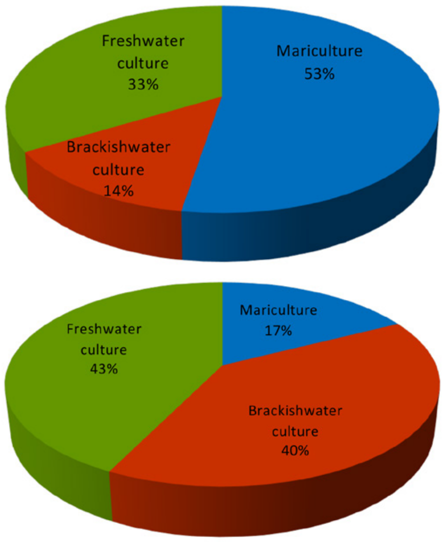


Figure 21. Contribution of the culture environments to the aquaculture production of Southeast Asia in 2014 by quantity *(above)* and value in US$ *(below)*

Data on aquaculture production of the Southeast Asian countries by species in 2014 indicated that Indonesia was the biggest producer derived largely from *Eucheuma* seaweeds *nei* (*Eucheuma* spp.) accounting for about 63% of the country's total aquaculture production, followed by *Gracilaria* seaweeds *nei* (*Gracilaria* spp.) accounting for 8%, Nile tilapia (*Oreochromis niloticus*) at 7%, torpedo-shaped catfishes (*Clarias* spp.) at 5%, and milkfish (*Chanos chanos*) at 4%. The second highest producer is Viet Nam, where 67% of its aquaculture production came from marine fishes *nei* (Osteichthyes) followed by Penaeid shrimps *nei* (*Penaeus* spp.) at 16% of the country's total aquaculture production. In the case of Philippines as the third highest aquaculture producer, its main aquaculture product is the elkhorn sea moss (*Kappaphycus alvarezii*) contributing 61% to the country's total aquaculture production followed by milkfish accounting for 17%, Nile tilapia at 7%, spiny eucheuma (*Eucheuma denticulatum*) at 5%. For Myanmar, its main production from aquaculture is roho labeo (*Labeo rohita*) which accounted for 61% of the country's total aquaculture production followed by catla (*Catla catla*) accounting for 7%, tilapias *nei* (*Tilapia* spp.) at 5%, giant tiger shrimp (*Penaeus monodon*), and mrigal carp (*Cirrhinus mrigala*) and silver barb (*Barbonymus gonionotus*) at 4% each. For Thailand, its main aquaculture product is the whiteleg shrimp (*Penaeus vannamei*) accounting for 29% of the country's total production from aquaculture followed by Nile tilapia (*Oreochromis niloticus*) at 21%, green mussel (*Perna viridis*) at 13%, hybrid catfishes (*C. gariepinus* x *C. macrophalus*) at 13%.

In terms of value of major aquaculture species, Brunei Darussalam had the highest average value at about US$ 11,675/metric ton (**Table 27**), especially for the orange-spotted grouper (*Epinephelus coioides*) which is the country's main aquaculture commodity valued at US$ 20,085/metric ton followed by the snappers *nei* (*Lutjanus* spp.) at about US$ 16,010/metric ton, giant seaperch (*Lates calcarifer*) at US$ 13,405/metric ton, blue shrimp (*Penaeus stylirostris*) at US$ 12,060/metric ton, and jacks, crevalles *nei* (*Caranx* spp.) at US$ 11,390/metric ton. Singapore had the second highest average value at US$ 8,125/metric ton (**Table 27**), with the mud spiny lobster (*Panulirus polyphagus*) commanding the highest price at US$ 67,025/metric ton followed by marble goby (*Oxyeleotris mamoratus*) at US$ 41,570/metric ton, humpback grouper (*Cromileptes macropomum*) at US$ 37,750/metric ton, penaeid shrimps *nei* (*Penaeus* spp.) at US$ 34,560/metric ton, Indo-Pacific swamp crab

(*Scylla serrata*) at US$ 28,290/metric ton, and groupers *nei* (*Epinephelus* spp.) at US$ 25,360/metric ton. For Thailand, its aquaculture production (**Table 27**) was at the third highest with an average value of about US$ 2,845/ metric ton. Specifically, the aquaculture species with the highest value were the giant river prawn (*Macrobrachium rosenbergii*) at US$ 7,650/metric ton followed by giant tiger prawn (*Penaeus monodon*) at US$ 7,065/metric ton, whiteleg shimp (*Penaeus merguiensis*) at US$ 5,675/ metric ton, and giant seaperch (*Lates calcarifer*) valued at US$ 3,785/metric ton.

5.1 Mariculture

Globally, mariculture production has grown from 21 million metric tons in 2000 to 47.45 million metric tons in 2014 (FAO, 2016). In 2014, Asia (including the Southeast Asia) was the highest producer of mariculture products at approximately 42.96 million metric tons or 90% of the global mariculture production, out of which the Southeast Asian countries contributed 30% to the global mariculture production. From 2000 to 2014, the region's total mariculture products increased in terms of quantity by about 759 thousand metric tons/year (**Table**

Table 28. Mariculture production of the Southeast Asian countries from 2000 to 2014 by quantity (metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	53	408	197,114	…	84,963	23,038	747,414	4,398	149,810	32,900	**1,240,098**
2001	30	394	221,010	…	87,468	68,854	827,670	3,700	246,602	319,071	**1,774,799**
2002	16	4,064	234,859	…	94,671	134,784	936,851	4,303	384,094	396,099	**2,189,741**
2003	18	8,324	249,242	…	92,936	25,709	1,039,081	4,786	361,400	443,135	**2,224,631**
2004	…	16,915	736,689	…	84,699	…	1,273,598	4,786	400,400	155,235	**2,672,322**
2005	37	16,400	890,074	…	80,239	804	1,419,727	5,280	364,061	213,800	**2,990,422**
2006	500	500	1,365,919	…	71,374	…	1,566,056	8,113	317,457	216,200	**3,546,119**
2007	…	16,630	1,509,062	…	72,922	…	1,626,206	4,159	309,497	208,500	**3,746,976**
2008	390	1,370	2,377,382	…	96,159	48,303	1,793,395	3,235	…	48,420	**4,368,654**
2009	72	4,925	2,537,100	…	111,524	50,464	1,860,462	3,286	316,927	172,003	**5,056,763**
2010	109	…	3,514,702	…	89,366	75,441	1,933,396	3,098	270,628	…	**5,886,740**
2011	121	2,620	4,605,825	…	60,975	3,158	1,992,953	3,448	135,481	318,300	**7,122,701**
2012	556	…	5,769,736	…	131,005	52,693	1,910,568	3,022	225,181	374,300	**8,467,061**
2013	134	4,633	8,372,817	…	41,941	4,775	1,727,165	4,159	237,817	368,800	**10,762,241**
2014	162	7,416	9,029,843	…	287,980	59,705	1,820,533	4,252	202,732	454,100	**11,866,723**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

Table 29. Mariculture production of the Southeast Asian countries from 2000 to 2014 by value (US$ thousand)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	…	…	134,182	…	47,895	…	75,410	5,952	40,692	…	**273,284**
2001	…	…	73,047	…	48,158	…	77,623	5,382	54,847	880,737	**1,109,600**
2002	…	…	122,985	…	51,579	…	86,379	4,079	57,207	1,024,056	**1,315,130**
2003	…	…	180,007	…	75,526	…	96,373	5,258	62,260	1,255,758	**1,619,311**
2004	…	4,585	167,787	…	60,263	…	171,539	7,147	97,215	622,600	**1,271,964**
2005	…	…	353,019	…	67,828	…	171,539	7,147	97,215	622,600	**1,271,964**
2006	…	…	220,568	…	108,470	…	216,342	7,381	1,457,754	189,500	**1,919,809**
2007	…	5,300	432,802	…	131,304	…	270,984	7,980	…	…	**929,804**
2008	392	3,890	983,185	…	159,407	…	500,275	8,082	…	1,493,750	**2,994,548**
2009	…	19,700	1,297,568	…	189,275	208,905	383,899	7,551	71,837	174,000	**2,224,666**
2010	…	…	1,437,044	…	34,369	193,568	934,081	13,204	110,379	…	**2,722,645**
2011	740	8,070	1,127,599	…	27,785	2,088	535,916	12,986	69,189	…	**1,784,373**
2012	4,716	…	1,349,055	…	500,888	213,465	649,976	10,028	201,477	…	**2,929,605**
2013	712	…	1,810,287	…	78,374	17,728	533,742	22,344	208,428	…	**2,671,615**
2014	1,710	…	1,668,006	…	234,956	260,538	665,468	28,724	181,171	…	**3,040,573**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

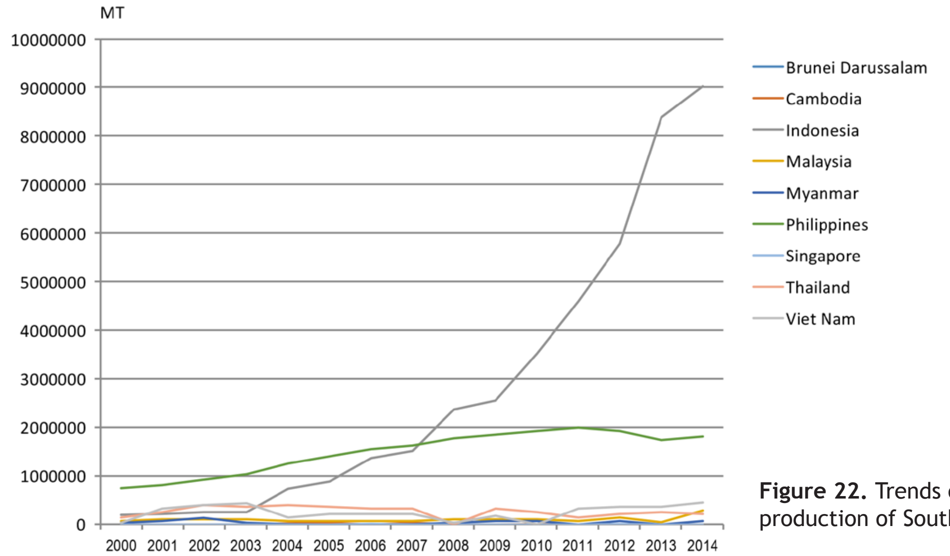


Figure 22. Trends of the quantity of mariculture production of Southeast Asian countries in 2000-2014

Table 30. Mariculture production of major groups of species of Southeast Asia from 2000 to 2014 by quantity (metric tons)

Year	Major group of species					
	Aquatic plants	Marine fishes	Marine mollusks	Shrimps	Others	Total
2000	910,635	21,971	291,122	…	16,370	1,240,098
2001	1,017,136	21,580	358,311	…	377,772	1,774,799
2002	1,147,212	29,037	495,371	…	518,121	2,189,741
2003	1,257,452	38,504	470,724	…	457,951	2,224,631
2004	1,987,178	42,216	642,727	75	126	2,672,322
2005	2,266,406	70,521	596,837	40,608	16,500	2,990,422
2006	2,883,247	69,314	551,143	40,630	1,785	3,546,119
2007	3,134,993	91,972	518,330	130	1,551	3,746,976
2008	3,534,124	245,967	588,563	…	…	4,368,654
2009	4,277,095	64,279	553,401	…	161,988	5,056,763
2010	5,198944	224,993	462,158	…	645	5,886,740
2011	5,840,426	449,323	291,382	…	1,750	6,582,881
2012	7,488,620	244,770	311,560	79,099	343,012	8,467,061
2013	9,879,417	292,890	334,836	127,050	186,379	10,820,572
2014	10,767,935	485,559	312,452	126,200	174,577	11,866,723

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

28 and **Figure 22**) and value by about US$ 198 million/year (**Table 29**). In 2014, Indonesia contributed the highest production quantity, accounting for 76% of the region's total mariculture production, followed by Philippines (15%), Viet Nam (4%), Malaysia (2%), and Thailand (2%). In terms of production value, Indonesia also led the countries with the value of its mariculture production contributing about 55% to the region's total, followed by the Philippines (22%), Myanmar (9%), Malaysia (8%), and Thailand (6%%), while the remaining countries contributed less than 1% to the region's total mariculture production value.

The mariculture production of Southeast Asia comes from major groups of species, namely: aquatic plants, marine fishes, marine mollusks, shrimps, and others. In terms of quantity, the aquatic plants contributed the largest production to the region's total mariculture production which had significantly increased during the period 2000-2014 at about 704,093 metric tons/year (**Table 30** and **Figure 23**).

The mariculture production of the Southeast Asian countries by major groups of species in 2014 is shown in **Table 31**, of which more than 50% could be reported at species level. The data indicated that Indonesia contributed the largest amount of aquatic plants particularly *Eucheuma* spp., followed by the Philippines which is *Kappaphucus alvarezii*. For marine mollusks group, Thailand provided the highest production of green mussels (*Perna viridis*) followed by blood cockles (*Anadara granosa*). Specifically in 2014, aquatic plants contributed 91% to the total

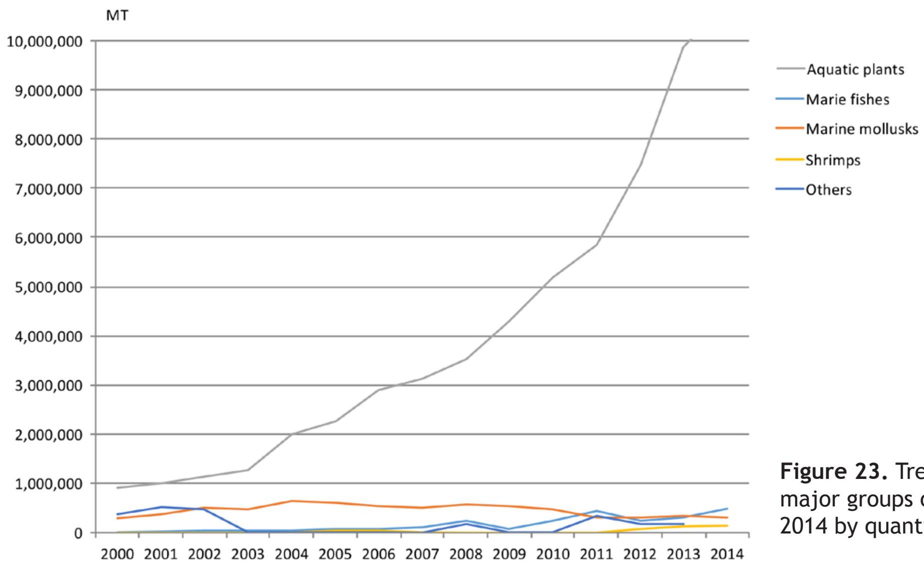


Figure 23. Trends of mariculture production of major groups of species of Southeast Asia in 2000-2014 by quantity

Table 31. Production of major groups of mariculture species of the Southeast Asian countries in 2014 by quantity (metric tons)

Major groups of species	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
Aquatic plants			**8,971,463**	**245,332**	**2,100**	**1,549,040**				**10,767,934**
Eucheuma denticulatum	…	…	…	…	…	113,127	…	….	…	113,127
Eucheuma spp.	…	…	8,971,463	…	…	…	…	…	…	8,971,463
Caulerpa spp.	…	…	…	…	…	1,199	…	…	…	1,199
Kappaphycus alvarezii	…	…	…	245,332	2,100	1,434,714	…	…	…	1,682,145
Marine mollusks			**44,596**	**42,649**		**41,127**	**511**	**183,569**		**312,452**
Marine mollusks *nei*	…	…	44,596	…	…	10	43	…	…	44,649
Perna viridis	…	…	…	1,415	…	18,762	467	117,014	…	137,658
Anadara granosa	…	…	…	40,454	…	…	…	53,716	…	94,170
Crassostrea spp.	…	…	…	780	…	22,355	1	12,839	…	35,975
Marine fishes	**163**	**…**	**87,001**	**…**	**…**	**230,162**	**3,648**	**19,163**	**146,100**	**413,135**
Marine crustaceans (shrimps)	…	…	…	…	42,000	…	…	…	84,200	126,200
Others	…	7,416	138	…	15,605	…	43	…	223,800	247,002
Total	**163**	**7,416**	**9,029,843**	**287,980**	**287,980**	**1,820,533**	**4,252**	**202,732**	**454,100**	**11,866,723**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

quantity of mariculture production in the Southeast Asian region (**Figure 24**).

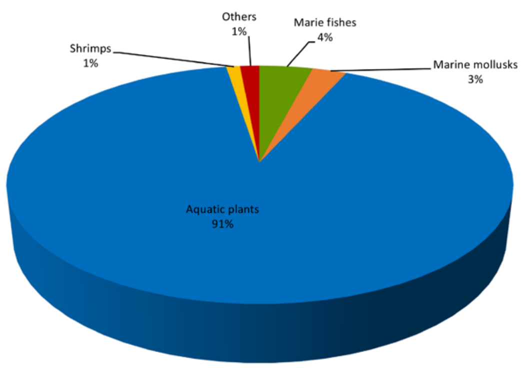


Figure 24. Percentage of production of major groups of mariculture species of Southeast Asia in 2014 by quantity

5.2 Brackishwater Aquaculture

The total brackishwater aquaculture production of the Southeast Asian region had increased from 1,115,635 metric tons in 2000 to 3,109,068 metric tons in 2014, accounting for an average increase of 142,388 metric tons/year (**Table 32** and **Figure 25**). During the past 15 years, Indonesia has been the region's top producer with an average increase in production of 144,000 metric tons/year, followed by Malaysia at 7,834 metric tons/year.

Similarly, the production value also increased at an average of US$ 235 million per year (**Table 33**). In terms of average value of the region's brackishwater aquaculture production in 2014, Singapore reported the highest average value of US$ 26,495/metric ton, followed by Brunei Darussalam

Table 32. Brackishwater aquaculture production of the Southeast Asian countries from 2000 to 2014 by quantity (metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	41	20	430,020	...	16,119	4,964	241,455	55	317,263	96,433	**1,106,370**
2001	31	143	510,744	...	27,232	5,473	268,120	40	287,928	...	**1,099,711**
2002	52	53	473,128	...	25,143	6,550	254,167	107	276,008	...	**1,035,208**
2003	52	90	501,977	...	26,382	18,421	254,744	30	341,878	...	**1,143,574**
2004	598	590	480,046	...	31,011	11,970	262,554	71	377,388	339,555	**1,503,783**
2005	537	100	643,975	...	33,547	250,407	277,230	35	414,926	287,200	**1,907,957**
2006	60	120	629,609	...	35,547	60,000	281,316	34	508,150	309,000	**1,823,836**
2007	611	...	629,797	...	35,258	48,303	294,495	...	535,834	500,500	**2,044,798**
2008	...	...	691,432	...	51,119	...	303,244	...	805,300	501,600	**2,352,695**
2009	354	75	1,080,700	...	69,296	2,926	308,440	...	558,444	554,397	**2,574,632**
2010	293	...	1,416,038	...	128,387	3,122	304,276	...	583,111	...	**2,435,227**
2011	159	...	1,531,456	...	103,758	51,965	336,159	...	533,653	...	**2,557,150**
2012	...	...	1,708,110	...	...	...	330,781	96	599,647	...	**2,638,634**
2013	456	91	2,362,480	...	85,941	1,969	369,591	389	329,035	...	**3,149,952**
2014	592	...	2,446,031	...	125,801	1,845	254,692	200	279,907	...	**3,109,068**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

Table 33. Brackishwater aquaculture production of the Southeast Asian countries from 2000 to 2014 by value (US$ thousand)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	...	...	731,798	...	125,236	...	534,739	430	2,206,325	...	**3,631,332**
2001	...	...	902,128	...	201,579	...	534,699	386	1,875,872	...	**3,547,229**
2002	...	...	1,118,924	...	167,105	...	485,225	969	1,248,738	...	**3.055,403**
2003	...	...	1,139,019	...	165,789	...	457,412	313	1,081,912	...	**2,904,025**
2004	2,695	767	1,529,358	...	173,158	...	490,853	593	1,175,007	1,146,005	**4,566,961**
2005	...	...	1,483,289	...	172,341	...	535,451	374	897,455	1,463,200	**4,616,652**
2006	...	...	1,736,275	...	162,295	...	611,344	625	...	...	**2,602,799**
2007	3,212	...	1,672,408	...	165,797	193,212	714,106	...	1,523,423	1,692,500	**6,038,269**
2008	...	375	1,840,902	...	209,481	641,278	831,073	...	1,602,685	467,450	**5,717,512**
2009	5,161	754	2,156,102	...	271,014	...	886,256	...	1,717,645	1,974,429	**7,160,596**
2010	4,800	...	3,409,438	...	506,555	...	481,441	...	2,066,328	...	**6,468,562**
2011	890	...	2,657,156	...	497,955	1,592	1,044,438	...	1,935,375	...	**6,137,406**
2012	...	...	2,643,864	...	...	...	1,040,218	717	2,363,096	...	**6,047,895**
2013	2,690	...	4,234,648	...	488,518	262,169	1,204,447	6,752	2,019,567	...	**8,281,791**
2014	7,130	...	3,526,200	...	737,340	1,600	1,040,667	5,299	1,610,425	...	**6,928,661**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

at US$ 12,045/metric ton, Malaysia at US$ 5,860/metric ton, Thailand at US$ 5,755/metric ton, Philippines at 4,085/metric ton, Indonesia at US$ 1,440/metric ton, and Myanmar at US$ 865/metric ton. It should be noted however that Cambodia and Viet Nam were not able to report the values of their respective brackishwater aquaculture productions in 2014 (**Table 33**).

In Southeast Asia, the major groups and species cultured in brackishwater include aquatic plants such as *Gracilaria* spp., crustaceans such as banana prawn (*Penaeus merguiensis*), giant tiger shrimp (*P. monodon*), whiteleg shrimp (*P. vannamei*), and other shrimps, as well as fishes such as milkfish (*Chanos chanos*) and marine fishes, and others. As shown in **Table 34**, aquatic plants provided the highest contribution to the total brackishwater aquaculture production in 2014 in terms of quantity at 36% followed by milkfish which contributed 24%, whiteleg shrimp at 23%, and giant tiger shrimp at 6%.

In terms of value, whiteleg shrimp contributed the highest value of about 64% followed by milkfish at 33%, and giant tiger shrimp at 28%. Although aquatic plants had the highest production volume (36%), its contribution in terms of value was only 2% (**Figure 26**).

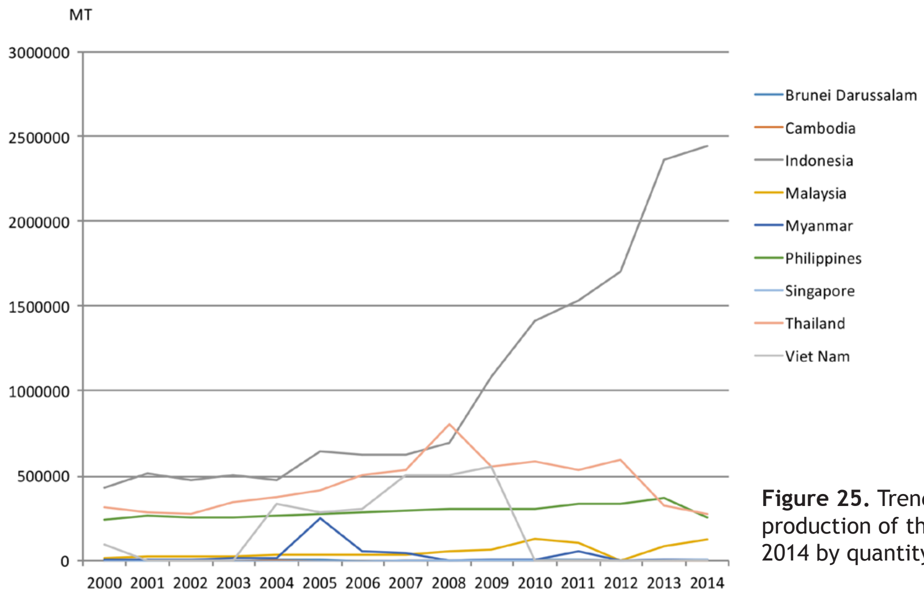


Figure 25. Trends of brackishwater culture production of the Southeast Asian countries in 2000-2014 by quantity

Table 34. Production of major groups of species of brackishwater aquaculture of Southeast Asia from 2000 to 2014 by quantity (metric tons)

Year	Major group of species								
	Aquatic plants (*Gracilaria* spp.)	Crustaceans				Fishes		Others	Total
		Banana prawn (*P. merguiensis*)	Tiger shrimp (*P. monodon*)	Whiteleg shrimp (*P. vannamei*)	Other shrimps	Marine mollusks	Milkfish (*Chanos chanos*)		
2000	…	…	511,867	…	118,392	408,827	67,120	164	**1,106,370**
2001	…	…	450,522	…	203,111	421,119	24,959	…	**1,099,711**
2002	…	…	439,532	…	69,396	425,892	100,388	…	**1,035,208**
2003	…	…	406,519	132,365	76,145	430,903	95,659	1,983	**1,143,574**
2004	…	320,429	478,865	…	143,165	448,910	111,743	671	**1,503,783**
2005	…		604,511	…	284,075	473,924	139,447	6,184	**1,907,957**
2006	33,321	399,816	427,467	…	837,503	439,706	64,790	21,049	**1,823,836**
2007	…	…	429,295	…	963,106	498,437	153,826	134	**2,044,798**
2008	…	78,087	522,326	745,948	224,545	…	174,413	607,376	**2,352,695**
2009	171,868	64,534	383,696	571,000	462,671	260,610	552,667	107,586	**2,574,632**
2010	517,605	87,905	243,174	767,653	31,650	683,990	81,521	21,729	**2,435,227**
2011	630,788	73,404	234,053	762,045	17,291	735,667	12,115	91,787	**2,557,150**
2012	776,177	64,258	188,870	825,169	1,419	756,842	25,899	…	**2,638,634**
2013	977,635	65,285	297,468	695,665	129,224	853,523	131,152	…	**3,149,952**
2014	1,106,065	74,838	197,571	699,776	12,997	738,605	142,756	136,460	**3,109,068**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

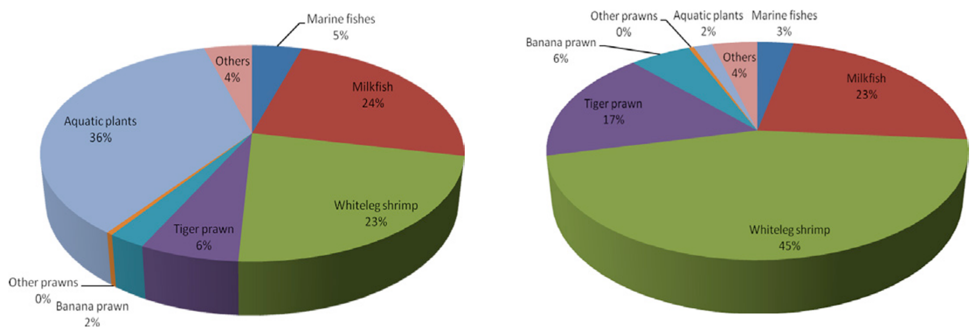


Figure 26. Production of major groups of species from brackishwater aquaculture of Southeast Asia in 2014 by quantity *(left)* and value in US$ *(right)*

Table 35. Production of major groups of species of brackishwater aquaculture of the Southeast Asian countries in 2014 by quantity (metric tons)

Major groups of species	Brunei Darussalam	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Total
Aquatic plants	…	1,105,529	…	…	536	…	…	**1,106,065**
Crustaceans								
Banana prawn	…	15,634	57,181	…	1,827	…	196	**74,838**
Tiger shrimp	…	129,231	4,205	…	47,843	…	16,292	**197,571**
Whiteleg shrimp	…	428,905	…	…	7,626	…	263,245	**699,776**
Other shrimps	591	11,031	…	…	1,151	50	174	**12,997**
Fishes								
Milkfish	…	577,464	…	…	161,141	…	…	**738,605**
Marine fishes	…	102,321	34,016	1,695	4,653	71	…	**142,756**
Others	1	75,916	30,399	150	29,915	79	…	**136,460**
Total	**592**	**2,446,031**	**125,801**	**1,845**	**254,692**	**200**	**279,907**	**3,109,068**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

In terms of the production quantity of brackishwater aquaculture in 2014 by Southeast Asian country and by major groups and species, Indonesia contributed the highest to the region's total production from its production of aquatic plants at 99.9%. This was followed by Indonesia and the Philippines from their milkfish (*Chanos chanos*) production, which accounted for about 78.0% and 22.0%, respectively. Moreover, from its production of the whiteleg shrimp, Indonesia is the largest producer providing about 61.0% to the region's total brackishwater aquaculture production (**Table 35**).

5.3 Freshwater Aquaculture

Inland fisheries and aquaculture play a significant role in providing food security for household consumption and improving livelihoods of rural populace in several countries of the Southeast Asian region. The Lower Mekong Basin (**Figure 16**) is likewise regarded as one of the most important environments for freshwater aquaculture in the region. According to MRC (2002), Cambodia, Lao PDR, Thailand, and Viet Nam, the countries that comprise the Lower Mekong Basin, had been engaged in aquaculture in the Lower Mekong Basin with diverse activities that encompass breeding, rearing and sale of fish fry and fingerlings, and growing of wild and cultured fingerlings in enclosed or semi-enclosed water bodies such as ponds, rice fields, and fish cages.

The development of freshwater aquaculture in the Lower Mekong Basin however, had not been evenly distributed as most aquaculture activities are taking place in the Mekong Delta of Viet Nam and Thailand. As a result, freshwater aquaculture productions of Cambodia and Lao PDR are very minimal. Moreover, the statistical data reported by the countries in the Lower Mekong Basin could have been underestimated resulting in low recognition of the importance of small-scale freshwater aquaculture, making it necessary for fisheries data collection to be efficiently carried out. Being widespread in the Lower Mekong Basin, freshwater aquaculture activities had gained some degree of growing importance as source of food and income for rural households.

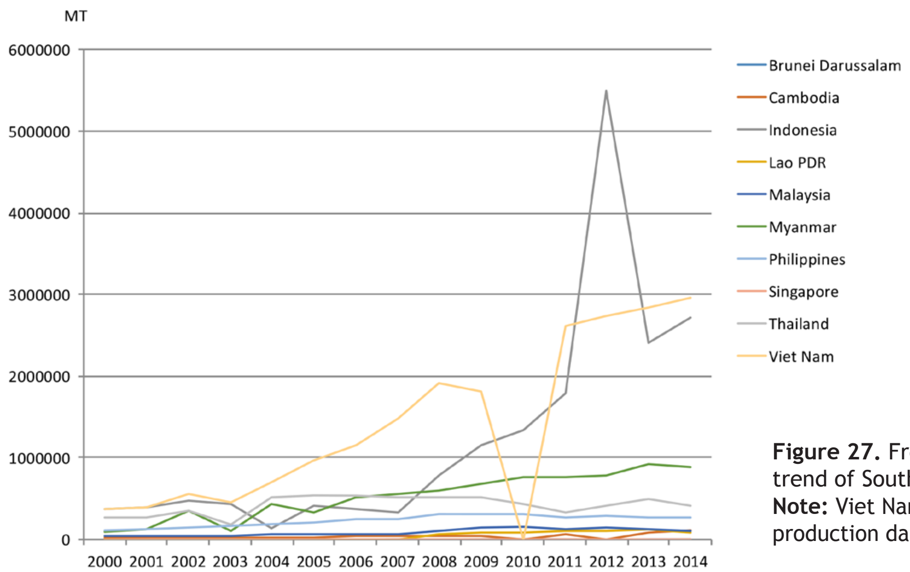


Figure 27. Freshwater aquaculture production trend of Southeast Asia in 2000-2014 by quantity
Note: Viet Nam was not able to provide its production data from freshwater aquaculture in 2010

In 2014, the total production from freshwater aquaculture in the region was reported to be 7,558,040 metric tons accounting for about 33% of the region's total aquaculture production as shown in **Figure 21**. Viet Nam had the highest production from freshwater culture at 2,959,200 metric tons, followed by Indonesia at 2,711,250 metric tons, and Myanmar at 895,491 metric tons (**Table 36**).

The trend of freshwater aquaculture production in the Southeast Asian countries from 2000 to 2014 as shown in **Figure 27** indicates a large increase of approximately 447,652 metric tons annually. In terms of value, production from freshwater aquaculture provided 43% to the region's total aquaculture production value (**Figure 21** and **Table 37**).

In 2014, Singapore posted the highest average value at US$ 10,780/metric ton followed by Malaysia at US$ 2,035/metric ton, Thailand at US$ 1,840/metric ton, Myanmar at US$ 1,780/metric ton, Philippines at US$ 1,635/metric ton, Indonesia at US$ 1,590/metric ton, Lao PDR at US$ 1,200/metric ton, and Brunei Darussalam at US$ 630/metric ton. Cambodia and Viet Nam were not able to report the values of their respective countries' freshwater aquaculture productions in 2014.

Table 36. Freshwater aquaculture production of the Southeast Asian countries from 2000 to 2014 by quantity (metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	19	14,002	367,831	…	50,689	93,948	112,033	160	271,010	381,222	**1,290,914**
2001	38	13,463	401,030	…	43,456	115,793	123,666	702	279,697	390,820	**1,368,663**
2002	90	17,886	472,974	…	46,403	356,230	147,375	602	361,124	559,960	**1,962,644**
2003	89	14,133	429,166	…	49,947	114,716	160,678	616	183,311	448,710	**1,401,366**
2004	110	20,170	137,766	…	55,557	426,000	180,875	549	523,709	703,827	**2,048,563**
2005	129	25,500	407,047	…	62,006	323,779	198,890	602	539,474	966,300	**2,523,727**
2006	140	40,770	381,946	…	61,653	514,990	244,903	425	527,414	1,162,527	**2,934,768**
2007	63	33,570	327,171	…	70,064	556,354	244,903	345	525,100	1,485,500	**3,243,070**
2008	…	38,350	786,386	64,300	95,846	605,552	311,059	283	525,500	1,918,300	**4,345,576**
2009	34	45,000	1,162,300	75,000	152,631	670,773	308,294	280	520,639	1,812,900	**4,747,851**
2010	19	…	1,347,183	82,100	155,398	772,396	308,093	403	432,378	…	**3,097,970**
2011	13	69,380	1,791,681	95,600	122,489	761,697	279,008	526	338,800	2,612,100	**6,071,294**
2012	...	…	5,491,518	101,895	152,554	785,733	283,292	459	408,944	2,736,400	**9,960,795**
2013	16	85,276	2,411,991	124,085	132,892	922,256	276,630	1,018	489,992	2,847,100	**7,291,256**
2014	7	112,639	2,711,250	90,355	110,784	895,491	262,380	810	415,124	2,959,200	**7,558,040**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a), and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

Table 37. Freshwater aquaculture production of the Southeast Asian countries from 2000 to 2014 by value (US$ thousand)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	…	…	217,067	…	80,263	…	118,147	3,564	209,990	…	**629,028**
2001	…	…	347,392	…	65,263	…	106,139	2,522	206,769	280,191	**1,008,429**
2002	…	…	440,725	…	62,368	…	114,794	1,799	253,349	316,039	**935,923**
2003	…	…	443,349	…	63,421	…	132,546	1,861	317,492	379,767	**1,338,492**
2004	398	36,813	269,851	…	67,105	…	162,960	1,744	479,587	1,055,741	**2,075,298**
2005	…	…	332,412	…	77,329	…	185,546	2,450	358,509	859,850	**1,822,566**
2006	…	…	384,658	…	79,781	…	257,325	1,471	532,252	…	**1,255,362**
2007	…	52,738	342,329	…	101,159	1,669,191	349,629	1,072	611,169	2,662,750	**5,779,567**
2008	…	57,525	1,398,411	91,141	139,556	141,288	387,286	1,180	462,616	2,656,500	**4,716,200**
2009	…	67,500	1,735,852	111,801	204,058	644,260	418,956	1,242	633,148	2,719,350	**6,583,413**
2010	150	…	2,134,415	…	252,161	724,138	419,786	1,660	654,223	…	**4,186,533**
2011	41	118,780	3,434,552	…	231,579	736,975	404,200	2,053	558,234	…	**5,486,414**
2012	14	…	3,642,789	…	332,268	1,134,881	462,132	1,941	748,750	…	**6,322,775**
2013	93	…	4,303,479	…	279,508	1,434,418	448,171	3,119	935,819	…	**7,404,607**
2014	44	…	4,309,238	108,426	225,606	1,595,222	429,249	8,733	763,570	…	**7,440,088**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a), and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

Table 38. Production of major groups of species from freshwater aquaculture of Southeast Asia from 2000 to 2014 by quantity (metric tons)

Year	Major group of species							
	Carps, barbells and other cyprinids	Catfishes	Freshwater crustaceans	Gouramis	Freshwater fishes *nei*	Tilapia and other cichilds	Others	Total
2000	342,185	235,689	19,949	…	125,393	244,664	323,034	**1,290,914**
2001	409,066	148,962	14,140	43,350	200,486	281,880	270,779	**1,368,663**
2002	447,496	171,717	16,696	49,661	122,278	367,489	787,307	**1,962,644**
2003	629,864	252,733	29,024	67,373	38,387	373,653	10,332	**1,401,366**
2004	551,173	278,865	37,648	…	96,465	380,584	703,828	**2,048,563**
2005	300,195	667,154	46,141	44,418	921,116	504,195	40,508	**2,523,563**
2006	495,534	756,841	32,294	44,971	1,006,699	530,852	67,577	**2,934,768**
2007	428,692	1,160,620	113,873	32,233	922,542	575,560	9,550	**3,243,070**
2008	680,758	1,674,598	37,378	37,883	620,456	615,705	678,698	**4,345,576**
2009	210,735	1,334,894	35,637	37,438	1,994,409	540,508	594,230	**4,747,851**
2010	1,080,784	520,891	30,458	92,854	414,999	957,984	…	**3,097,970**
2011	1,147,753	697,138	24,680	97,505	3,016,225	1,083,395	4,598	**6,071,294**
2012	4,597,741	908,048	428,323	124,198	2,569,582	1,226,926	105,977	**9,960,795**
2013	1,336,381	1,079,440	510,616	137,358	2,593,036	1,385,695	248,730	**7,291,256**
2014	1,341,130	1,211,575	567,299	160,093	2,587,773	1,537,799	152,372	**7,558,040**

Source: *Fishery Statistical Bulletin for the South China Sea Area 2000-2007 (SEAFDEC, 2005a; SEAFDEC, 2006; SEAFDEC, 2008a; SEAFDEC, 2008b; SEAFDEC, 2009a; SEAFDEC, 2010a); and Fishery Statistical Bulletin of Southeast Asia 2008-2014 (SEAFDEC, 2010b; SEAFDEC, 2011; SEAFDEC, 2012a; SEAFDEC, 2013; SEAFDEC, 2014; SEAFDEC, 2015a; SEAFDEC, 2016a)*

Table 39. Production of major groups of species from freshwater aquaculture of the Southeast Asian countries in 2014 by quantity (metric tons)

Major groups of species	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
Common carp	…	…	434,177	…	1,795	27,057	…	…	1,890	…	**464,919**
Catfishes, hybrid	…	…	…	…	…	…	…	…	113,832	…	**113,832**
Nile tilapia (*O. niloticus*)	3	…	947,113	…	…	…	164,814	58	189,947	…	**1,301,935**
Torpedo-shaped catfishes (*Clarias* spp.)	3	…	677,917	…	46,122	9,019	3,632	…	…	…	**736,693**
Roho labeo (*Labeo rohita*)	…	…	…	…	…	586,241	…	…	830	…	**587,071**
Giant river prawn	…	…	1,809	…	475	800	9	…	16,906	547,300	**567,299**
Pangas catfish	…	…	418,002	…	…	18,038	…	…	…	…	**436,040**
Tilapias *nei*	…	…	…	…	31,203	46,899	75,772	…	…	…	**153,874**
Giant gourami	…	…	118,776	…	…	…	126	2	3,212	…	**122,116**
Misc. freshwater fishes	1	112,639	113,456	90,355	31,189	207,437	18,027	750	88,507	2,411,900	**3,074,261**
Total	**7**	**112,639**	**2,711,250**	**90,355**	**110,784**	**895,491**	**262,380**	**820**	**415,125**	**2,959,200**	**7,558,040**

Source: *Fishery Statistical Bulletin of Southeast Asia 2014 (SEAFDEC, 2016a)*

In the Southeast Asian region, more than 30 major groups and species are being cultured in freshwater environment, about one-half of which are non-indigenous fish species such as tilapia, roho labeo, African catfish, giant freshwater prawn, and so on. Several countries however reported their production by major groups only such as freshwater fishes *nei* without providing the details at species level. Nonetheless, the report on the freshwater aquaculture production of major groups and species during the past 15 years indicated that tilapia and other cichlids group provided the largest production, followed by carps, barbells, and other cyprinids group, and catfishes group (**Table 38**).

Figure 28 shows that in 2014, misc. freshwater fishes *nei* accounted for 34% of the region's total production from freshwater aquaculture, followed by tilapia and other cichilds group accounting for 20%. It is also notable that the production of tilapia group in the region had increased by more than six times from 2000 to 2014 (**Table 38**). Carps, barbells and other cyprinids had the third highest production accounting for 18% of the region's freshwater

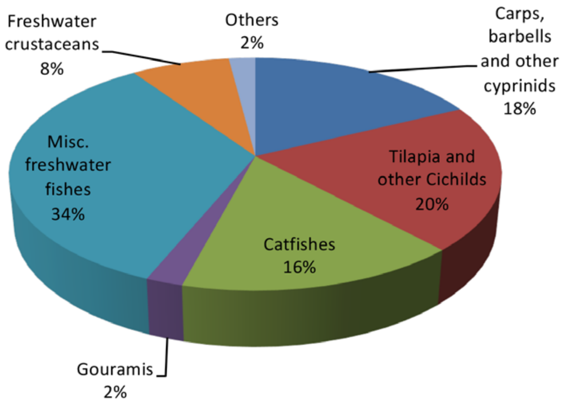


Figure 28. Percentage production of major groups of species in freshwater aquaculture production of Southeast Asia in 2014 by quantity

aquaculture production with roho labeo (*Labeo rohita*) having the highest production within the group (44%). The next group is catfishes accounting for 16%

In terms of quantity, the production of major groups and species from freshwater aquaculture of the Southeast Asian countries in 2014 indicated that Nile tilapia (*Oreochromis niloticus*) provided the highest production accounting for about 17.0% of the total production of the region with Indonesia producing 73.0% of the total production. Torpedo-shaped catfishes (*Clarias* spp.) came next providing 10.0%, produced mainly by Indonesia, Malaysia, Myanmar, Philippines, and Brunei Darussalam. Roho labeo (*Labeo rohita*) provided 8.0% with Myanmar contributing 99.8% to the total production (**Table 39**).

VI. FISH PROCESSING INDUSTRY

After harvesting, fish processing industries, processors, and wholesalers are the next link in the supply chain before wild caught and farmed fish and seafood continue on their journey to the consumers' plates. According to FAO (2014a), over 87% (146 million metric tons) of the global fish production in 2014 was used for human consumption. Of the portion not consumed by humans, 21 million metric tons was destined for non-food products, of which 76% (15.8 million metric tons) was processed into fishmeal and fish oil, with the remaining portion either

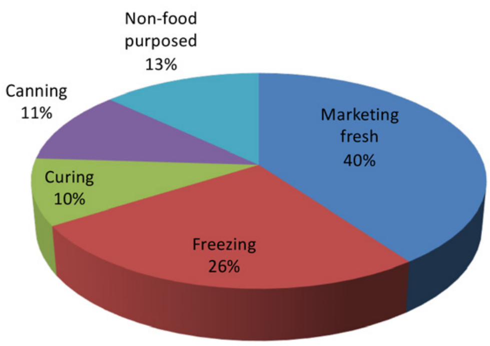


Figure 29. Percentage of disposition of the world fisheries production

sold live as aquarium fishes, used as bait or as live feed for aquaculture and other animal husbandry pursuits, or used for pharmaceutical applications. Of the fish destined for human consumption in 2014 (**Figure 29**), around 40% reached the market as live and fresh fish, 26% as frozen fish, and 11% and 10% as cured and canned or preserved products, respectively.

During the past few decades, the Southeast Asian region has played the major role of providing fish and seafood for the market in the world. As global trade in fish and seafood has increased, basic processing systems like filleting and de-heading had been more actively practiced in the region where labor is cheaper compared with that in other regions, just like much of the world's manufacturing processes. The fish processing industry has been identified as one of the most sustainable industrial sectors that contribute to countries' economies in the Southeast Asian region even if most of processed fish products are consumed domestically. Nevertheless, a good portion of the higher quality and higher value products is exported mainly to Japan, China, Hong Kong, US, EU, Australia, and Canada, among others. The main species processed are freshwater fishes as well as marine fishes that mostly come in the form of dried and frozen products. Fishes are also processed into salted-dried, smoked, frozen, canned, and steamed products to increase their shelf-life. In addition, most fishes are also used to produce the most significant traditional fish products of the region, *i.e.* fermented fish and fish sauce. As for the region's data on the disposition of the region's fisheries production, only three countries provided the relevant information, namely: Brunei Darussalam, Myanmar, and Singapore as shown in **Table 40**.

Table 40. Disposition of fisheries production of the Southeast Asian countries in 2014 by quantity (metric tons)

Disposition	Brunei Darussalam	Myanmar	Singapore	Total
Marketing fresh	...	1,292,359	6,696	**1,299,055**
Freezing	903	...	...	**903**
Curing	75	3,098,993	...	**3,099,068**
Canning	3	...	...	**3**
Non-food purposes	3,088	656,178	...	**659,266**
Total	**4,069**	**5,047,530**	**6,696**	**5,058,295**

Source: *FAO Fishery and Aquaculture Information and Statistics Service*

FAO (2014a) indicated that the utilization and processing of fish in Southeast Asia still need to be improved especially in the areas of marketing and transportation of live fish as well as on the aspects of innovations in refrigeration, ice-making, and packaging to ensure the products' integrity and allow expansion of fish distribution either in fresh, chilled or frozen forms. The report also indicated that several countries in the region still lack adequate infrastructures and services including hygienic landing centers, electricity, potable water, roads, ice, cold rooms, and refrigerated transport systems. Being associated with the region's tropical temperatures, the absence of these factors would usually lead to very high post-harvest losses and quality deterioration, with subsequent risks on the part of consumers' health.

In recent decades however, the complex patterns of globalization have transformed the fish processing sector, making it more heterogeneous and dynamic. While the fish food sector has been increasingly globalized with supermarket chains and large retailers emerging as important players in setting requirements for the products, processing has become more intensive, geographically concentrated, vertically integrated with producers to enhance the product mix, obtain better yields, and respond confidently to the evolving quality and safety requirements imposed by importing countries.

VII. FISH TRADE

In spite of the apparent stagnation of the world's total fish production during the last decade, international trade in fish and fishery products has continued to expand. In the midst of the long-term trend of stable capture fisheries production and steady growth of the global aquaculture sector that continued to prevail specifically in 2013, the world's consumption of fish also continued to grow, reaching almost 20 kg per capita. However, the value of global trade in fish and fishery products decreased significantly, contrary to the expected long-term trend. While the export volume of fish products reached 36.4 million metric tons in 2013 or 22.4% of world's total fisheries production, the total import accounted for about 35.2 million metric tons or 21.6% of the total fisheries production (**Table 41**). In the Southeast Asian region, the export of fish and fishery products in 2013 represented about 5,398,267 metric tons or 13.5% of the region's fisheries production, while import was 3,237,406 metric tons, posting a trade balance of 2,160,861 metric tons.

7.1 Global Trading of Fish and Fishery Products

The international trade in fish and fishery products in 2000-2013 did not expand faster than the previous years. The slower growth could have been caused by reduced world catches, higher interest rates on investments, and unfavorable economic conditions in key markets. As shown in **Table 42** and **Figure 30**, the world's export of fish and fishery products increased in terms of quantity by about 790,333 metric tons/year, and in terms of value by about US$ 6,405 million annually as indicated in **Table 43**.

Table 41. World fisheries trade of fish and fishery products of each continent in 2013 by quantity (metric tons). Southeast Asia is excluded from Asia data

	Total fisheries production	Trade of fish and fishery products		Trade balance (Export-import)
		Export	Import	
World	**162,646,576**	**36,410,597**	**35,202,954**	**1,207,643**
Africa	9,458,639	2,021,364	3,297,706	-1,276,342
Americas	21,981,502	7,186,282	4,633,127	2,553,155
Asia*	113,295,522	7,710,646	13,313,669	-2,365,617
Southeast Asia	40,040,915	5,398,267	3,237,406	2,160,861
Europe	16,435,139	13,440,925	13,513,167	-72,242
Oceania	1,393,499	653,113	445,285	207,828

Source: *FAO Fishery and Aquaculture Information and Statistics Service*
** Asia does not include data of Southeast Asia*

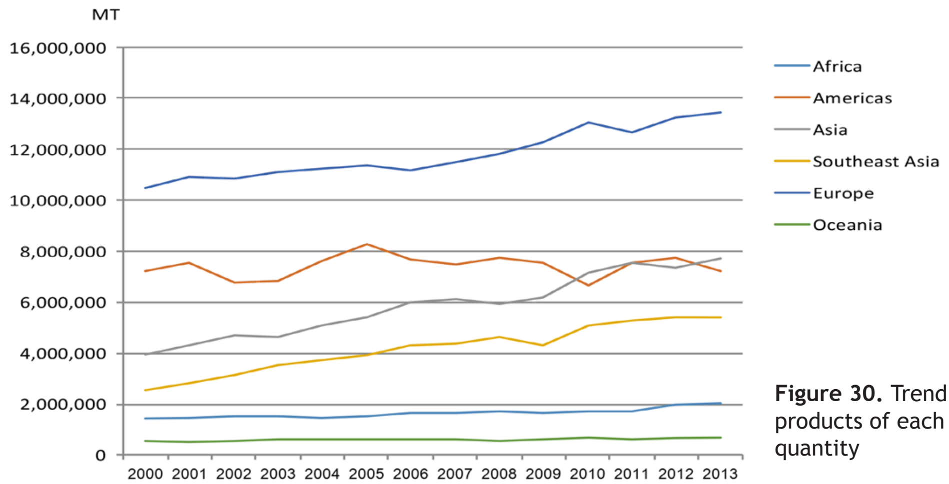


Figure 30. Trend of export of fish and fishery products of each continent from 2000 to 2013 by quantity

Table 42. Export of fish and fishery products of each continent from 2000 to 2013 by quantity (metric tons)

Year	World Total	Continents					
		Africa	Americas	Asia*	Southeast Asia	Europe	Oceania
2000	**26,136,271**	1,430,091	7,235,221	3,936,967	**2,539,163**	10,478,012	516,817
2001	**27,539,628**	1,464,989	7,566,236	4,315,238	**2,804,753**	10,882,619	505,884
2002	**27,523,730**	1,521,723	6,779,439	4,678,535	**3,144,459**	10,823,335	567,239
2003	**28,169,990**	1,532,714	6,809,435	4,644,624	**3,502,744**	11,096,611	583,862
2004	**29,784,741**	1,432,058	7,624,736	5,104,928	**3,751,037**	11,247,828	624,154
2005	**31,100,377**	1,524,564	8,273,622	5,377,442	**3,915,636**	11,375,252	633,861
2006	**31,406,006**	1,648,549	7,672,787	6,000,119	**4,321,512**	11,152,719	610,320
2007	**31,735,135**	1,627,755	7,469,906	6,144,044	**4,362,045**	11,518,041	613,344
2008	**32,314,837**	1,687,927	7,737,109	5,922,067	**4,606,164**	11,803,067	588,503
2009	**32,590,812**	1,674,224	7,573,871	6,198,749	**4,285,454**	12,279,281	579,233
2010	**34,337,688**	1,717,493	6,654,957	7,175,248	**5,089,710**	13,049,555	650,725
2011	**35,363,360**	1,740,950	7,561,803	7,544,526	**5,246,745**	12,634,866	634,470
2012	**36,335,779**	1,951,906	7,714,407	7,375,452	**5,389,839**	13,244,902	659,273
2013	**36,410,597**	2,021,364	7,186,282	7,710,646	**5,398,267**	13,440,925	653,113

Source: *FAO Fishery and Aquaculture Information and Statistics Service*
* *Southeast Asia data excluded from Asia data*

Table 43. Export of fish and fishery products of each continent from 2000 to 2013 by value (US$ thousand)

Year	World Total	Continents					
		Africa	Americas	Asia*	Southeast Asia	Europe	Oceania
2000	**55,835,627**	2,739,300	13,260,973	10,384,990	**8,811,103**	18,727,227	1,912,625
2001	**56,664,140**	2,879,692	13,799,946	10,355,114	**8,737,880**	19,083,132	1,808,376
2002	**58,758,186**	3,129,263	13,508,253	10,928,613	**8,723,050**	20,567,480	1,901,527
2003	**64,263,355**	3,452,866	14,796,346	11,591,057	**9,138,397**	23,343,683	1,941,006
2004	**72,083,379**	3,388,833	16,021,025	14,108,921	**10,076,565**	26,369,525	2,118,510
2005	**79,242,815**	3,838,723	17,791,996	15,420,204	**11,053,071**	28,961,231	2,187,590
2006	**86,671,876**	4,004,119	19,113,835	16,731,280	**12,510,156**	32,139,612	2,172,874
2007	**94,501,423**	4,582,178	19,765,897	18,000,239	**13,692,488**	36,157,954	2,302,667
2008	**103,082,420**	4,998,878	21,391,193	18,999,039	**16,136,715**	39,228,038	2,328,557
2009	**97,095,957**	4,808,051	19,298,621	19,290,169	**14,989,666**	36,491,325	2,218,125
2010	**111,423,636**	4,974,482	20,986,348	24,243,846	**17,436,472**	41,226,682	2,555,806
2011	**130,430,587**	5,177,642	25,477,480	30,064,733	**20,440,758**	46,482,527	2,817,447
2012	**130,379,186**	5,473,575	25,498,158	31,044,193	**20,969,230**	44,537,388	2,856,642
2013	**139,100,557**	5,801,536	27,098,573	33,412,151	**21,037,918**	48,912,139	2,838,240

Source: *FAO Fishery and Aquaculture Information and Statistics Service*
* *Southeast Asia data excluded from Asia data*

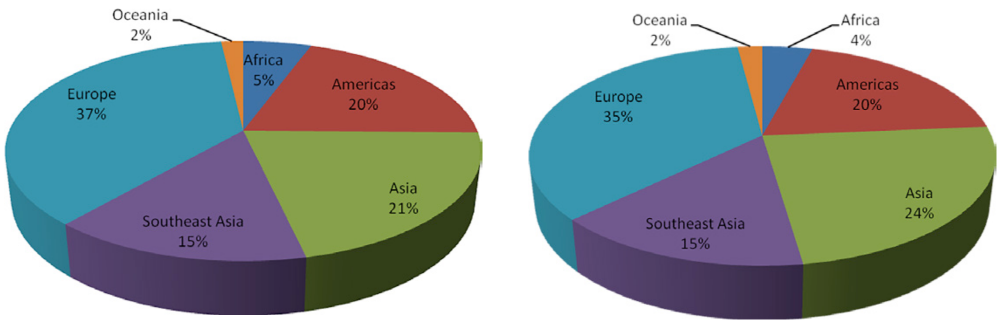


Figure 31. Percentage export of fish and fishery products from each continent in 2013 by quantity *(left)* and value *(right)*

Table 44. World's top ten exporters and importers of fish and fishery products in 2013 by value (US$ million)

Exporter	Export value (US$ million)	Importer	Import value (US$ million)
1. China	19,539	1. USA	18,975
2. Norway	10,368	2. Japan	15,318
3. Thailand	**7,057**	3. China	7,982
4. Viet Nam	**6,887**	4. France	6,507
5. USA	5,963	5. Spain	6,391
6. Chile	4,985	6. Italy	5,733
7. Denmark	4,664	7. Germany	5,414
8. India	4,602	8. UK	4,495
9. Canada	4,364	9. Sweden	4,486
10. Spain	3,947	10. China. Hong Kong	3,800

Source: *FAO Fishery and Aquaculture Information and Statistics Service*

Europe is the largest exporter of fish and fishery products during the past decade, and in 2013, Europe's export of fish and fishery products accounted for about 37% in terms of quantity and 35% in value of the world's total export of fish and fishery products (**Table 43** and **Figure 31**). Meanwhile, the Southeast Asian region's share of the export accounted for 15% of global export quantity and 15% of the world's export value. In the Asian continent, China is the largest exporter contributing about 14% to the global export value, while Norway provided about 7%. Among the Southeast Asian countries, Thailand exports fish products the value of which contributed 5% to the world's total while Viet Nam provided about 5% as well (**Table 44**).

Table 45. Import of fish and fishery products of each continent from 2000 to 2013 by quantity (metric tons)

Year	World Total	Continents					
		Africa	Americas	Asia*	Southeast Asia	Europe	Oceania
2000	**26,499,629**	1,582,539	3,282,251	8,212,939	**1,759,366**	11,315,052	347,482
2001	**27,956,060**	1,862,582	3,347,551	8,466,725	**1,895,859**	12,042,187	341,156
2002	**28,102,257**	1,734,558	3,351,954	8,869,107	**2,031,713**	11,766,050	348,875
2003	**28,589,655**	1,861,137	3,600,355	8,273,991	**2,024,873**	12,475,562	353,737
2004	**30,295,948**	2,285,897	3,817,751	9,284,761	**2,176,697**	12,345,191	385,651
2005	**31,946,828**	2,430,583	3,857,808	9,778,187	**2,595,730**	12,912,174	372,346
2006	**32,635,945**	3,085,191	4,038,905	9,405,792	**2,707,607**	13,009,907	388,543
2007	**33,159,128**	2,963,225	4,175,390	9,382,290	**2,649,850**	13,600,029	388,344
2008	**33,277,854**	2,967,164	4,205,517	9,462,675	**2,813,392**	13,430,748	398,358
2009	**33,740,748**	3,264,745	4,150,794	9,339,944	**2,994,016**	13,621,291	369,958
2010	**34,945,720**	3,463,550	4,456,480	9,895,994	**3,056,996**	13,682,311	390,389
2011	**35,923,083**	4,000,273	4,567,130	10,363,688	**3,169,355**	13,408,413	414,224
2012	**35,554,233**	3,400,597	4,556,080	10,354,080	**3,191,530**	13,592,762	459,184
2013	**35,202,954**	3,297,706	4,633,127	10,076,263	**3,237,406**	13,513,167	445,285

Source: *FAO Fishery and Aquaculture Information and Statistics Service*
** Southeast Asia data excluded from Asia data*

Table 46. Import of fish and fishery products of each continent from 2000 to 2013 by value (US$ thousand)

Year	World Total	Continents					
		Africa	Americas	Asia*	Southeast Asia	Europe	Oceania
2000	**61,001,766**	958,107	13,091,324	22,277,564	**1,948,460**	22,050,937	675,374
2001	**60,590,668**	1,262,848	12,885,821	20,278,458	**2,125,513**	23,357,848	680,180
2002	**63,081,526**	1,236,951	13,122,293	21,119,273	**2,281,302**	24,599,079	722,628
2003	**68,438,828**	1,464,073	14,298,726	20,318,727	**2,444,129**	29,086,421	826,752
2004	**76,776,293**	1,671,461	15,043,481	23,814,925	**2,960,543**	32,368,625	907,258
2005	**86,674,573**	2,008,112	16,189,004	24,784,946	**3,285,188**	36,353,884	1,053,439
2006	**92,142,015**	2,405,730	18,042,360	25,325,104	**3,496,203**	41,730,998	1,141,620
2007	**100,321,200**	2,887,792	19,137,495	25,782,122	**3,869,678**	47,315,532	1,328,581
2008	**109,580,946**	3,096,671	20,526,871	28,717,002	**4,828,956**	51,014,733	1,396,713
2009	**101,233,828**	3,392,088	19,163,657	26,816,566	**4,441,268**	46,105,292	1,314,957
2010	**112,707,347**	3,588,779	21,597,323	31,352,265	**5,005,693**	49,614,449	1,548,838
2011	**131,828,143**	5,399,732	24,683,420	37,167,905	**6,336,557**	56,365,747	1,874,782
2012	**130,737,326**	5,333,764	24,994,381	37,980,410	**6,883,034**	53,525,284	2,020,453
2013	**135,434,707**	5,267,308	27,068,221	36,270,825	**7,042,569**	57,734,068	2,051,716

Source: *FAO Fishery and Aquaculture Information and Statistics Service*
** Southeast Asia data excluded from Asia data*

On the other hand, the world's import of fish and fishery products during the past decade had increased in terms of quantity by about 669,487 metric tons/year (**Table 45**) and in value by US$ 5,726 million annually (**Table 46**). In 2013, Europe imported the largest quantity representing 38% of the world's total import quantity and 43% of the world's total import value. The second largest importer is Asia (excluding Southeast Asia) contributing about 29% and 27% in terms of quantity and value, respectively (**Figure 32**), with the United States of America as the largest importing country with its value accounting for 14% followed by Japan that accounted for about 11% of the world's total import (**Table 44**).

According to Jesse (1984), the general pattern of fish trade between developed and developing countries in the world seemed to have three main patterns, *i.e.* a) most trading is among developed countries; b) little trading occurs among the developing countries; and c) in trading between two groups, the general tendency is fish and fishery products from developing countries are bound for developed countries. Thus, developing countries not only become important importer of fish and fishery products but are also more important exporter-producer of fish and fishery products.

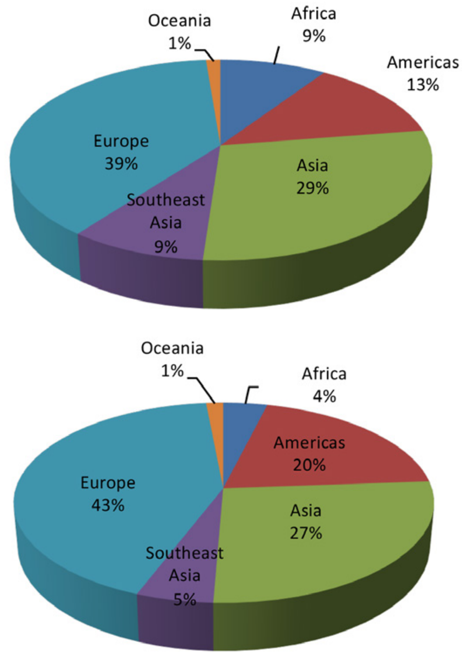


Figure 32. Percentage of import of fish and fishery products by each continent in 2013 by quantity *(above)* and value *(below)*

7.2 Southeast Asian Export-Import of Fish and Fishery Products

The growth of international trade in fish and fishery products of the Southeast Asian countries had become remarkable during the past decade (**Table 47** and **Figure 33**). While each country in the region gave high priority to export-oriented fisheries development, the region's exports increased rapidly with export growth that outpaced those of developed countries. From 2000 to 2013, the total quantity of exports from Southeast Asian countries has grown fast at about 219,931 metric tons/year.

Together with the quantity, the export value of the region's fish and fishery products also increased rapidly from 2000 to 2013 at about US$ 940,524 annually (**Table 48** and **Figure 34**).

In 2013, Singapore reported the highest average value of exported products at US$ 7,900/metric ton followed by Viet Nam at US$ 4,515/metric ton, Thailand at US$ 4,365/metric ton, Philippines at US$ 3,730/metric ton,

Table 47. Export of fish and fishery products of the Southeast Asian countries from 2000 to 2013 by quantity (metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	285	43,656	490,416	4	95,435	116,609	215,531	112,158	1,162,099	302,970	**2,539,163**
2001	149	38,424	457,913	30	126,229	144,623	171,361	102,137	1,250,204	513,683	**2,804,753**
2002	92	52,711	539,384	7	203,327	201,667	171,279	88,741	1,280,563	606,688	**3,144,459**
2003	144	56,876	830,383	24	160,262	212,999	188,789	87,811	1,440,364	525,092	**3,502,744**
2004	280	47,523	881,677	10	270,695	205,463	180,648	102,378	1,436,475	625,888	**3,751,037**
2005	452	53,266	825,076	0	275,006	278,675	131,789	109,564	1,570,762	671,046	**3,915,636**
2006	736	30,120	885,179	1	255,890	271,071	148,297	96,978	1,743,974	889,266	**4,321,512**
2007	568	24,100	814,303	0	303,461	259,054	159,406	86,493	1,823,612	891,048	**4,362,045**
2008	218	25,000	868,442	1	283,494	351,652	192,982	71,721	1,755,255	1,057,399	**4,606,164**
2009	229	30,000	839,803	2	257,413	324,710	183,801	66,030	1,732,874	850,592	**4,285,454**
2010	315	35,043	1,063,293	6	290,662	374,187	204,375	68,450	1,862,012	1,191,367	**5,089,710**
2011	420	30,000	1,122,149	9	295,022	373,898	231,711	57,218	1,762,955	1,373,363	**5,246,745**
2012	1,271	31,025	1,216,617	7	266,569	387,371	253,849	52,786	1,762,131	1,418,313	**5,389,839**
2013	1,498	32,000	1,228,475	9	246,024	376,848	317,973	47,906	1,618,684	1,528,850	**5,398,267**

Source: *FAO Fishery and Aquaculture Information and Statistics Service*

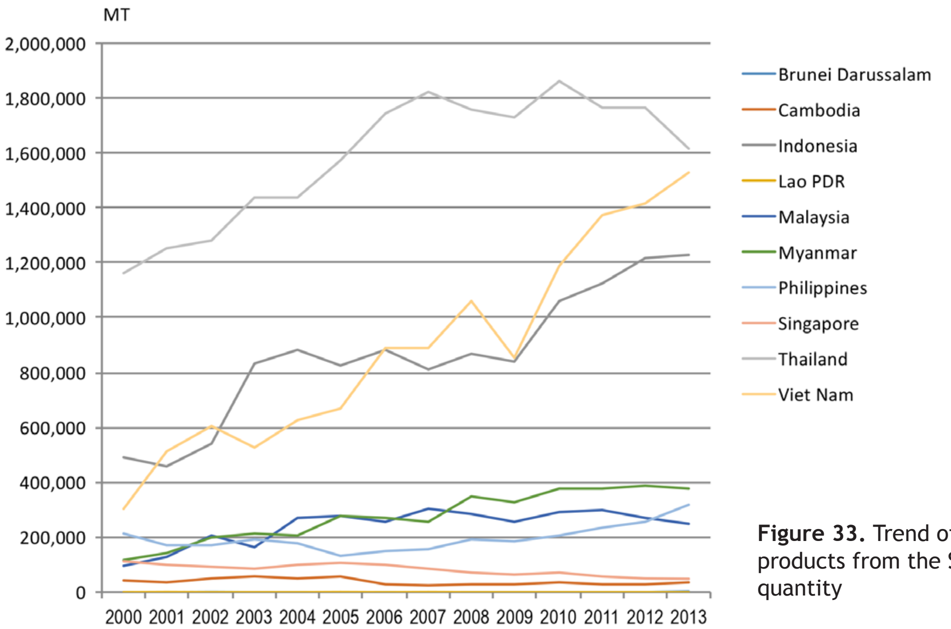


Figure 33. Trend of export of fish and fishery products from the Southeast Asian countries by quantity

Table 48. Export of fish and fishery products of the Southeast Asian countries from 2000 to 2013 by value (US$ thousand)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	296	34,469	1,610,291	29	200,469	183,707	455,984	457,105	4,384,437	1,484,316	**8,811,103**
2001	334	32,114	1,560,078	78	220,126	218,291	420,184	388,184	4,075,341	1,823,150	**8,737,880**
2002	459	36,284	1,516,537	27	381,983	251,534	453,030	325,267	3,713,299	2,044,630	**8,723,050**
2003	706	37,816	1,579,783	26	256,197	317,382	464,463	335,331	3,943,194	2,203,499	**9,138,397**
2004	119	42,400	1,736,184	12	573,238	318,514	454,384	422,195	4,079,407	2,450,112	**10,076,565**
2005	3,503	48,551	1,845,883	17	619,653	460,089	380,094	427,544	4,502,821	2,765,366	**11,053,071**
2006	5,305	26,835	2,019,803	3	624,015	362,951	419,552	396,388	5,275,349	3,379,955	**12,510,156**
2007	5,038	23,285	2,170,876	3	738,535	358,065	499,539	385,455	5,721,525	3,790,167	**13,692,488**
2008	2,398	24,679	2,600,968	6	770,273	560,568	672,813	398,016	6,547,742	4,559,252	**16,136,715**
2009	1,441	30,362	2,350,376	7	657,479	483,230	585,044	321,098	6,248,891	4,311,738	**14,989,666**
2010	1,533	40,011	2,718,018	12	827,565	495,454	680,905	384,244	7,166,020	5,122,710	**17,436,472**
2011	1,266	60,000	3,360,852	17	916,456	555,515	711,155	416,096	8,159,613	6,259,788	**20,440,758**
2012	2,435	61,020	3,752,132	33	846,169	654,129	850,344	366,907	8,144,920	6,291,141	**20,969,230**
2013	4,311	62,500	4,025,167	28	800,030	652,840	1,185,788	338,942	7,067,700	6,900,612	**21,037,918**

Source: *FAO Fishery and Aquaculture Information and Statistics Service*

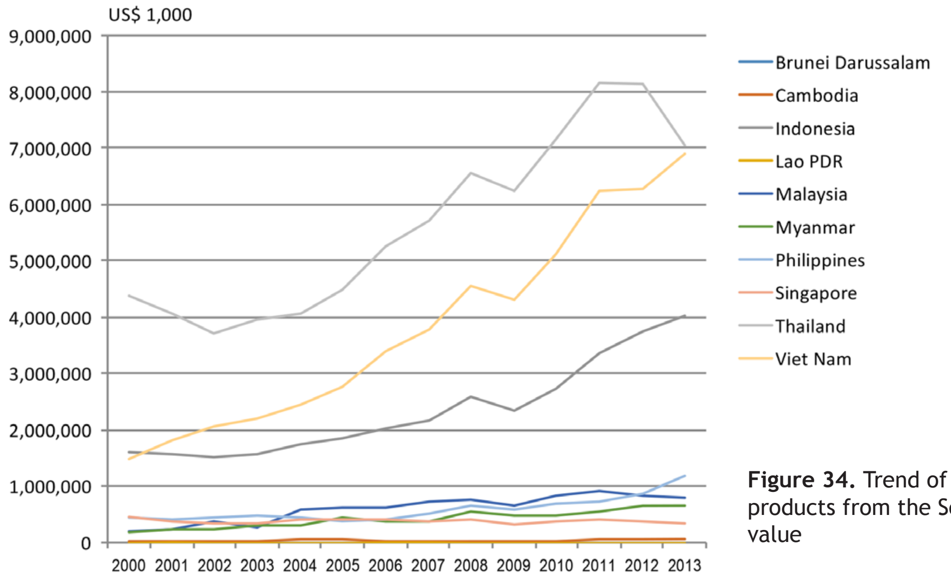


Figure 34. Trend of export of fish and fishery products from the Southeast Asian countries by value

Table 49. Trade of fish and fishery products of the Southeast Asian countries in 2013 by quantity (metric tons)

	Total fisheries production	Trade of fish and fishery products		Trade balance (Export-import)
		Export	Import	
Brunei Darussalam	3,431	1,498	13,956	-12,458
Cambodia	728,000	32,000	7,865	24,135
Indonesia	19,245,632	1,228,475	264,893	963,582
Lao PDR	164,228	9	5,995	-5,986
Malaysia	1,749,314	246,024	463,234	-217,210
Myanmar	4,715,840	376,848	9,528	367,320
Philippines	4,695,369	317,973	257,910	60,063
Singapore	7,210	47,906	206,906	-159,000
Thailand	2,900,591	1,618,684	1,667,847	-49,163
Viet Nam	5,831,300	1,528,850	339,272	1,189,578
Total	**40,040,915**	**5,398,267**	**3,237,406**	**2,160,861**

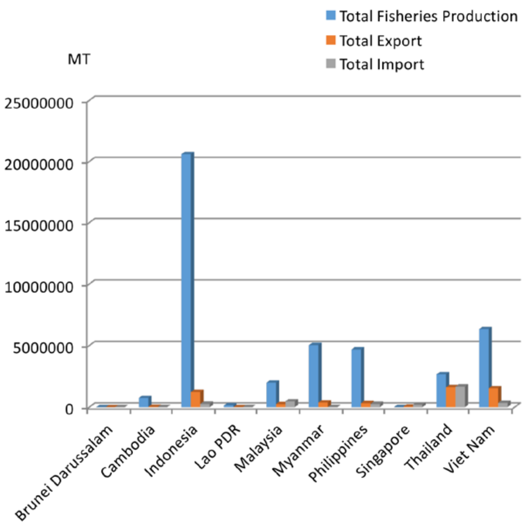


Figure 35. Trade of fish and fishery products in the Southeast Asian countries by quantity

Indonesia at US$ 3,275/metric ton, and Malaysia at US$ 3,250/metric ton. Meanwhile, Myanmar posted the lowest average value of exported products at US$ 1,730/metric ton (**Table 47** and **Table 48**).

In 2013, Thailand was the largest exporter of fish and fishery products representing about 56% of the country's total fisheries production by quantity. This was followed by Viet Nam, the quantity of which was about 26% of its total fisheries production (**Figure 35**).

As the largest exporting country, Thailand was also the largest importing country, posting a negative trade balance of 49,163 metric tons in 2013, followed by Malaysia with a negative trade balance of about 217,210 metric tons. Viet Nam posted a positive trade balance of 1,189,578 metric tons while Brunei Darussalam with the least fisheries production posted a negative trade balance at 12,458 metric tons and Singapore also with a high negative trade balance at 159,000 metric tons (**Table 49**).

Fish remained the most important exported fishery commodity accounting for 65% of the total export quantity of the region from 2000 to 2013, followed by crustaceans contributing 17% (**Table 50**, **Figure 36** and **Figure 37**). In the case of Thailand as the largest exporter in the region, its major export fishery products included canned seafood and shrimps followed by Viet Nam with frozen shrimps and processed pangas (*Pangasius* spp.).

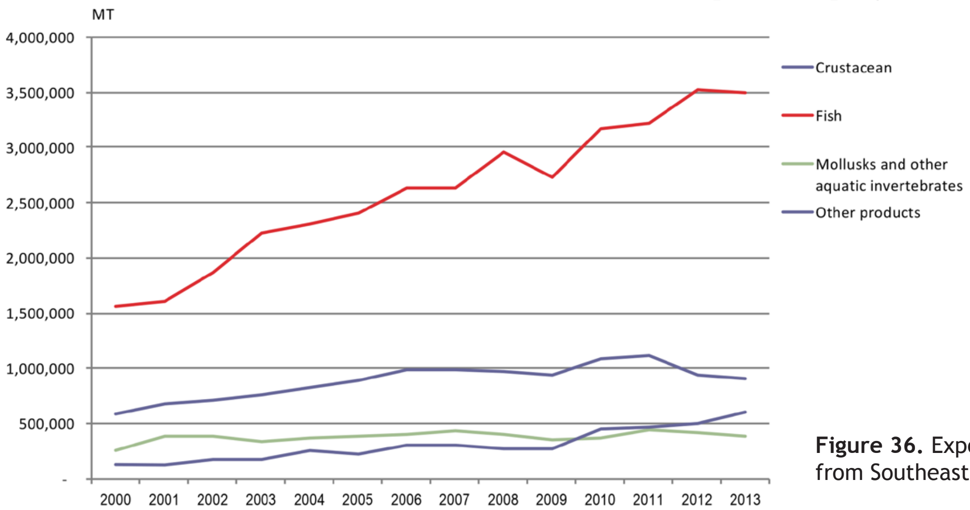


Figure 36. Export of fish and fishery products from Southeast Asia (2000 to 2013) by quantity

Table 50. Fish and fishery products exported by Southeast Asia from 2000 to 2013 by quantity (thousand metric tons)

Year	Major group of species								
	Fish								
	Fillets, frozen	Meat and fillets fresh or chilled	Meat, whether or not minced, frozen	Prepared or preserved (canned)	Dried, salted and smoked	Fresh or chilled, excluding fillets and meat	Frozen, excluding fillets and meat	Live	Total
2000	62.3	5.3	95.3	429.5	57.5	298.7	510.2	38.5	**1,497.3**
2001	87.9	7.7	128.9	567.5	74.8	302.9	395.4	40.3	**1,605.4**
2002	96.8	11.6	154.2	623.1	78.6	308.9	545.2	43.7	**1,862.1**
2003	106.8	14.7	151.1	730.8	88.7	309.4	786.4	42.7	**2,230.6**
2004	162.1	5.4	140.4	732.1	85.6	311.6	814.4	49.0	**2,300.6**
2005	211.4	7.4	181.5	826.8	125.0	297.4	705.1	48.2	**2,402.8**
2006	337.1	8.3	186.5	883.2	125.7	290.1	755.9	45.8	**2,632.6**
2007	296.0	31.4	198.1	894.8	127.5	314.3	734.6	37.2	**2,633.9**
2008	438.6	22.1	232.6	978.4	121.9	282.9	843.9	43.1	**2,963.5**
2009	301.7	24.0	199.2	998.2	122.9	253.9	780.8	44.9	**2,725.6**
2010	464.2	19.0	188.9	1,015.4	145.2	243.7	1,042.9	55.6	**3,174.9**
2011	516.3	18.5	189.9	1,066.4	138.3	224.6	1,018.9	52.6	**3,225.5**
2012	555.7	44.2	235.4	1,184.5	150.3	230.8	1,058.5	63.9	**3,523.3**
2013	638.1	28.4	169.8	1,207.7	143.4	231.3	995.9	84.9	**3,499.5**

(Cont'd)

Year	Major group of species									
	Crustaceans				Mollusks and Other Aquatic Invertebrates				Others	TOTAL
	Frozen	Not Frozen	Prepared or preserved (canned)	Total	Live, fresh or chilled	Other than live, fresh or chilled	Prepared or preserved	Total		
2000	417.3	43.1	127.6	**588.1**	17.4	213.0	27.6	**258.0**	129.8	**2,473.2**
2001	460.0	86.4	138.0	**684.4**	80.6	271.0	30.9	**382.5**	132.3	**2,804.6**
2002	489.9	80.4	141.0	**711.3**	71.4	289.1	33.6	**394.1**	177.2	**3,144.7**
2003	512.4	97.0	149.0	**758.4**	72.3	230.9	35.2	**338.4**	175.5	**3,502.9**
2004	565.7	84.1	171.3	**821.1**	52.9	268.9	54.0	**375.8**	253.7	**3,751.2**
2005	601.5	104.7	186.3	**892.4**	48.6	290.2	50.3	**389.1**	231.5	**3,915.8**
2006	661.5	89.3	241.3	**992.1**	22.8	320.4	54.8	**398.0**	298.8	**4,321.5**
2007	667.8	75.5	246.6	**989.9**	24.8	348.4	56.7	**429.9**	308.7	**4,362.4**
2008	639.1	70.4	263.2	**972.7**	31.8	320.2	53.3	**405.3**	264.6	**4,606.1**
2009	591.3	70.9	282.7	**944.9**	25.3	271.0	52.3	**348.6**	266.3	**4,285.4**
2010	702.1	65.7	316.9	**1,084.7**	20.2	311.4	44.9	**376.5**	453.7	**5,089.8**
2011	688.5	80.6	347.2	**1,116.3**	26.5	372.0	46.0	**444.5**	460.6	**5,246.9**
2012	558.5	86.1	302.2	**946.8**	24.1	338.2	52.6	**414.9**	504.9	**5,389.9**
2013	547.8	83.2	284.3	**925.3**	22.8	301.9	54.5	**379.2**	604.5	**5,408.5**

Source: *FAO Fishery and Aquaculture Information and Statistics Service*

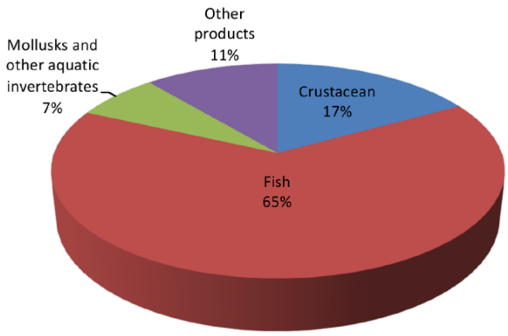


Figure 37. Percentage of major commodities exported by Southeast Asia in 2013

The quantity of fisheries import of the Southeast Asian region had been increasing from 2000 to 2013 at the rate of about 113,695 metric tons annually (**Figure 38**), posting a trade balance of about 2,160,861 metric tons in 2013 (**Table 49** and **Table 51**).

The value of the fishery products imported by the Southeast Asian countries increased by about US$ 391,855 annually from 2000 to 2013 (**Table 52** and **Figure 39**). In terms of average value of imported products, Brunei Darussalam had the highest value at US$ 3,675/metric ton

Table 51. Import of fish and fishery products by the Southeast Asian countries from 2000 to 2013 by volume (metric tons)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	6,642	3,174	171,349	2,510	322,923	415	248,407	182,377	813,789	7,960	**1,759,366**
2001	8,281	1,074	151,957	3,142	353,400	4,071	180,992	173,118	977,656	42,168	**1,895,859**
2002	6,483	1,267	110,035	2,725	464,172	464	217,069	177,869	1,006,347	45,282	**2,031,713**
2003	7,156	2,218	92,649	3,026	386,586	1,026	152,389	215,342	1,078,966	85,515	**2,024,873**
2004	9,094	3,071	126,826	3,943	325,116	1,648	134,375	227,405	1,240,567	104,652	**2,176,697**
2005	7,215	6,664	128,431	3,594	400,766	1,826	180,945	253,553	1,445,348	164,388	**2,595,730**
2006	7,694	3,731	165,195	3,028	440,135	1,354	170,834	244,644	1,470,636	200,356	**2,707,607**
2007	6,617	2,769	126,281	3,190	440,270	1,668	193,578	239,688	1,407,414	228,375	**2,649,850**
2008	6,505	2,167	198,980	3,884	386,051	2,400	200,331	225,704	1,533,690	253,680	**2,813,392**
2009	5,848	5,042	252,976	4,591	411,544	2,828	273,623	221,987	1,585,850	229,727	**2,994,016**
2010	7,181	4,265	300,157	5,561	424,032	4,840	195,037	220,791	1,586,764	308,368	**3,056,996**
2011	7,661	5,553	354,394	5,747	365,460	6,101	203,682	220,710	1,668,020	332,027	**3,169,355**
2012	9,926	7,169	269,422	5,731	417,029	7,122	268,477	213,305	1,662,765	330,584	**3,191,530**
2013	13,956	7,865	264,893	5,995	463,234	9,528	257,910	206,906	1,667,847	339,272	**3,237,406**

Source: *FAO Fishery and Aquaculture Information and Statistics Service*

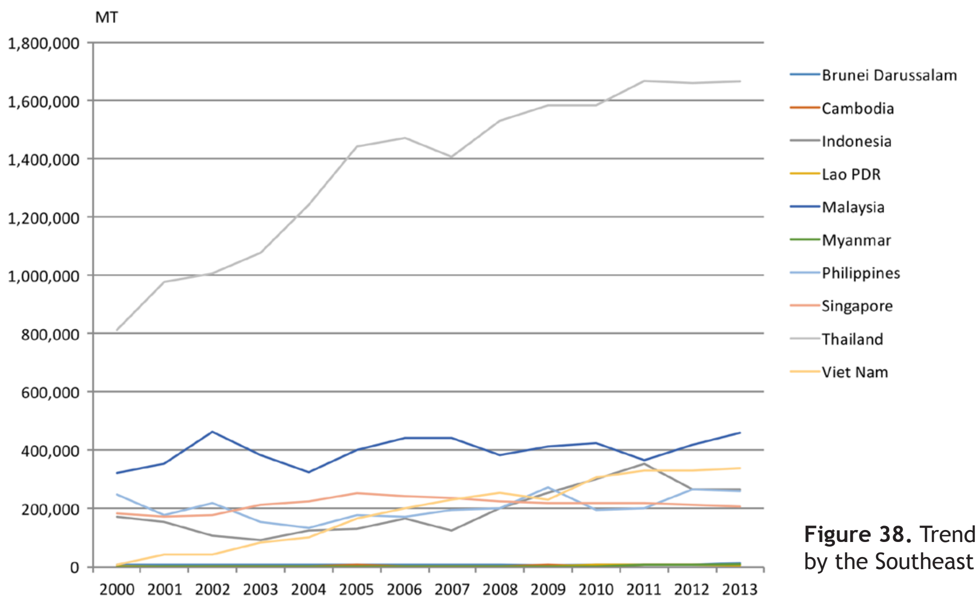


Figure 38. Trend of quantity of fisheries import by the Southeast Asia in 2000-2013

Table 52. Import of fish and fishery products by the Southeast Asian countries from 2000 to 2013 by value (US$ thousand)

Year	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Total
2000	15,239	2,724	101,644	2,069	307,340	742	111,596	544,165	826,699	36,242	**1,948,460**
2001	13,379	467	93,730	2,170	336,705	1,389	71,362	473,241	1,072,925	60,145	**2,125,513**
2002	13,136	586	79,095	1,727	400,345	642	92,524	497,176	1,079,930	116,141	**2,281,302**
2003	11,847	3,090	75,903	2,333	377,504	1,685	86,405	599,269	1,134,471	151,622	**2,444,129**
2004	15,527	3,225	143,669	3,331	538,112	2,789	73,892	706,016	1,255,346	218,636	**2,960,543**
2005	17,316	9,602	106,330	3,310	530,863	3,186	103,680	776,389	1,457,936	276,576	**3,285,188**
2006	25,823	4,206	142,742	3,084	580,337	2,568	103,126	757,944	1,573,958	302,425	**3,496,203**
2007	20,987	3,144	118,966	3,675	644,881	2,905	132,922	818,704	1,750,024	373,470	**3,869,678**
2008	20,054	2,443	202,029	4,409	594,255	5,204	176,815	914,863	2,447,759	461,125	**4,828,956**
2009	20,374	4,630	234,531	4,120	683,818	6,505	203,336	824,248	2,026,369	433,337	**4,441,268**
2010	27,517	4,008	325,091	4,449	790,291	11,217	148,552	968,787	2,195,932	529,849	**5,005,693**
2011	32,605	5,197	410,213	6,126	998,720	15,727	193,314	1,160,247	2,788,193	726,215	**6,336,557**
2012	42,728	6,867	357,841	6,952	1,071,037	18,378	263,038	1,072,760	3,205,504	837,929	**6,883,034**
2013	51,302	7,396	378,379	7,554	1,070,210	22,893	278,737	1,070,573	3,238,545	916,980	**7,042,569**

Source: *FAO Fishery and Aquaculture Information and Statistics Service* followed by Viet Nam at US$ 2,705/metric ton, Myanmar at US$ 2,405/metric ton, Malaysia at US$ 2,310/metric ton. As for Thailand which is the largest importer among the Southeast Asian countries, the value of its import was US$ 1,940/metric ton while Lao PDR's import was the lowest at about US$ 1,260/metric ton.

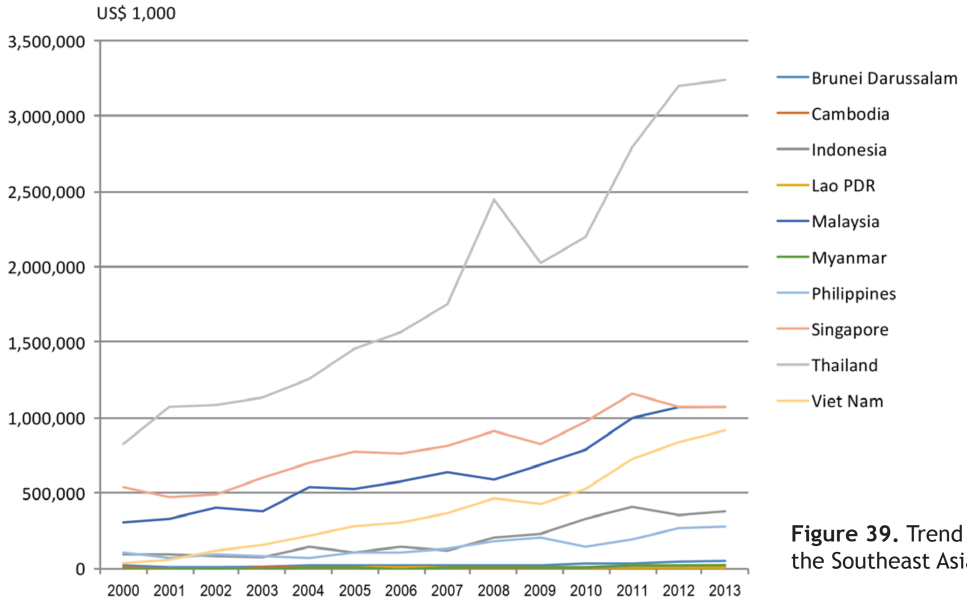


Figure 39. Trend of value of fisheries import by the Southeast Asian countries in 2000-2013 (US$)

PART II
Issues and Challenges in Sustainable Development of Fisheries of the Southeast Asian Region

1. MARINE FISHERY RESOURCES

The Southeast Asian region abounds with marine fishery resources which could include multi-species of fishes, crustaceans, mollusks, and invertebrates. Most of the economically important fishery resources of the Southeast Asian region that are generally exploited by pelagic fisheries include tunas, round scads, mackerels, anchovies, and sardines although some equally important species are also captured through demersal, high sea, and deep sea fisheries. The production trend of these species has been accessed from various available data such as the respective countries' national statistical data reports, SEAFDEC Fishery Statistical Bulletin for the South China Sea Area until 2007, SEAFDEC Fishery Statistical Bulletin of Southeast Asia from 2008 to 2014, reports from ASEAN-SEAFDEC programs on information collection of some small pelagic species in the South China Sea, and Information Collection of Highly Migratory Species in the Southeast Asian Region focusing on tuna, among others. Nevertheless, the production data shown in this report is based on the respective domestic fisheries in the jurisdiction of the countries in the Southeast Asian region.

1.1 Important Pelagic Fishery Resources

In Southeast Asia, small pelagic fishes such as tunas, round scads, mackerels, anchovies, and sardines are the most economically important fishery resources. Being highly migratory, these small pelagic fishes move across the Exclusive Economic Zones (EEZs) between neighboring countries depending on the oceanographic parameters and food availability. Impacts of climate change also influence the fluctuation of stock abundance as well as changes in migration routes of these species. Threats of overexploitation and decreasing recruitment due to degradation and destruction of aquatic habitats also exacerbate these serious problems. Since stocks of some pelagic species are being shared by many countries in the region, it is necessary that such transboundary stocks should be well managed to avoid overexploitation which could eventually lead to decline or even total collapse of the stocks. In the Southeast Asian region, recognition of shared stocks is fundamental for the promotion of fisheries management. However, insufficient information on stock identification and shared stocks of pelagic fishes hampers all efforts to promote sustainable management of the fisheries of these resources.

High variability in stock abundance coupled with the migratory behavior of pelagic fishes pose a great challenge in sustainable fisheries development and management. As human population and demand for fish and fish-based products continue to rise, there is a need to address these issues through the development of integrated management measures. This should be taken as a priority considering that the sustainability of the fishery resources would ensure food security in the Southeast Asian region, and one of the most dependable fisheries sub-sectors is capture fisheries, which has been playing a vital role in providing nutrition and food supply as well as improving the livelihoods of people in the region.

1.1.1 Tunas

Tunas (Family Scombridae), which include several species of oceanic and neritic tunas, are abundant throughout the Southeast Asian region. While oceanic tunas migrate over large areas, neritic tunas are commonly found within the EEZs and sub-regional seas of Southeast Asia. These tuna resources, which are of high economic importance to many Southeast Asian countries, not only generate export revenues for the countries but also provide important protein sources for people's domestic consumption. As the availability of oceanic tunas is seen to be declining, neritic tuna species are gaining more economic importance in the Southeast Asian region and have increasingly become the target for commercial and local fisheries especially that attractive prices are now being offered for these species by fish processing companies. However, there are still uncertainties about the distribution, migration, and utilization of tuna stocks in the waters of Southeast Asia, and without further clarification and dialogue, it would be difficult to develop appropriate tuna management plans at national and sub-regional levels.

While management efforts for the sustainable exploitation of oceanic tunas are guided by the recommendations from the Tuna Regional Fisheries Management Organizations, such as the Indian Ocean Tuna Commission (IOTC) and the West Central Pacific Fisheries Commission (WCPFC), for neritic tuna resources in the Southeast Asian region, it has become necessary that common approaches be promoted for the management of their utilization to ensure the sustainable use of available regional resources and maximize economic benefits for the region. Thus, the establishment of collaborative management plans for the region's neritic tuna fisheries was considered very crucial for the sustainability of these rich and important trans-boundary resources. Recognizing the urgency of such issue, the SEAFDEC Member Countries during the Forty-fifth Meeting of the SEAFDEC Council in April 2013 called for the development of a plan of action for regional cooperation on neritic tunas in the Southeast Asian region.

Subsequently, the SEAFDEC Council of Directors during the Forty-fifth SEAFDEC Council Meeting supported the proposal to strengthen regional and sub-regional cooperation to promote the conservation and management of sustainable neritic tuna fisheries in the Southeast Asian waters, which would require cooperation of the countries' tuna producers in showing and verifying the sustainability of targeted neritic tuna fisheries. In pursuing the planned activities of the abovementioned proposal, the SEAFDEC Secretariat reviewed the development of tuna capture fisheries in the Southeast Asian region. With financial support from the Governments of Japan and Sweden, and with the technical support from relevant SEAFDEC Member Countries, the SEAFDEC Secretariat came up with the preliminary status and trends of neritic tuna fisheries in the region. Meanwhile, consultations with the Member Countries were convened to come up with the way forward for the promotion of regional or sub-regional cooperation on sustainable utilization of neritic tuna resources in the Southeast Asian region.

1.1.1.1 Neritic Tuna Fisheries

In the Southeast Asian region, neritic tunas are mainly caught commercially using three fishing gears, namely: purse seines, ring nets, and driftnets (Siriraksophon, 2013). Three types of purse seine operations are adopted, such as purse seines using searching devices, purse seines associated with fish aggregating devices (FADs), and purse seines using luring light. In Thailand, as in many neighboring countries like Brunei Darussalam, Cambodia, Indonesia, Malaysia, and Myanmar, the purse seines that are currently used evolved from the Chinese purse seine (Yingyuad and Chanrachkij, 2010), which became widely used after 1957. A unique style of purse seine has since then been developed which is appropriate to the conditions of the waters of Thailand, where purse seine fisheries started in 1982 when the country's tuna canning industry began to expand. Initially, purse seines in Thailand were used to catch small pelagic fishes, but now this fishing gear is targeting small tunas.

The purse seine fisheries operation in Thailand is labor intensive with 30-40 crews working on vessels ranging in size from 25 m to 30 m. The length of Thai purse seine nets ranges from 800 m to 1,250 m, while the depth of the nets ranges from 70 m to 120 m, and mesh sizes that range from 2.5 m to 9.7 cm. Recently, modern purse seiners are equipped with radar, depth sounder, sonar transceiver, and satellite navigational instruments. Purse seine is one of the most efficient types of fishing gears for surrounding schools of fish, *e.g.* anchovies, sardines, scads, mackerel, bonito and tuna. Purse seine was developed from two different fishing gears and methods, *i.e.*, beach seine and lampara.

A ring net is also used to catch pelagic fishes including small tunas. It is a type of surrounding net which evolved from purse seine and a lampara net. The rings at the lower edge of the net allow a purse line to close it under the fish (pursing). With a central bunt (with smaller mesh) where the catch concentrates, the two wings are hauled together forming a spoon-shape as in a lampara net. Driftnets also play very important role in neritic tuna fisheries, especially in the early period of development of small pelagic fisheries in many Southeast Asian countries. Although driftnet operations are not as popular as purse seine fisheries nowadays, the drift gillnets are still important gear for some Southeast Asian countries especially in Viet Nam where 37% of its total annual neritic tuna catch of 72,650 metric tons is caught by drift gillnets (Thong, 2013).

1.1.1.2 Stock Assessment of Neritic Tunas

While assuming that stocks of neritic tunas in the Southeast Asian waters are found in two areas, *i.e.*, Pacific Ocean and Indian Ocean aligning with FAO Fishing Areas 57 and 71, respectively (**Figure 40**), SEAFDEC in cooperation with the Member Countries has carried out stock assessment of some neritic tunas in the waters of the region. Specifically, assessment of the longtail tuna (*Thunnus tonggol*) and kawakawa (*Euthynnus affinis*) stocks in the Pacific and Indian Oceans was conducted in 2016 using the Kobe Plot (Nishida *et al*., 2016), CPUE standardization, and the software package A Stock-Production Model Incorporating Covariates (ASPIC).

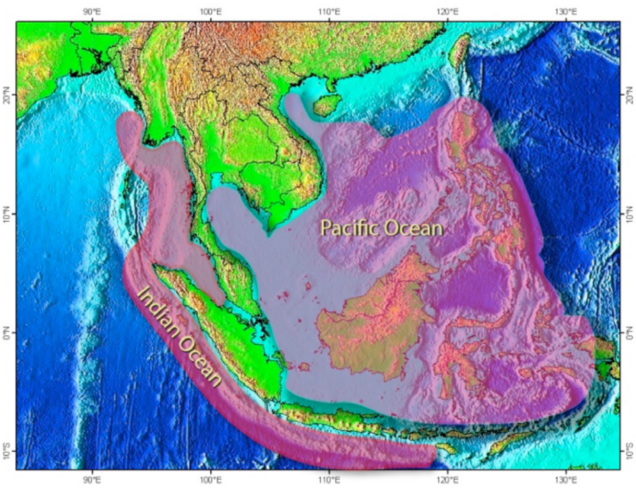


Figure 40. Pacific Ocean: FAO Fishing Area 57 (South China Sea) and Indian Ocean: FAO Fishing Area 71 (Andaman Sea-Southeast Asia) where stocks of neritic tunas are assumed to be found

Longtail Tuna

Based on the stock assessment using the Kobe Plot, the stock of longtail tuna in the Indian Ocean as of 2014 was in the red zone (unsafe) suggesting that the stock was already overfished but still fishing continues to take place. With TB/TBmsy=0.89 (TB: total biomass; TBmsy: total biomass maximum sustainable yield) and F/Fmsy=1.11 (F: fishing pressure; Fmsy: fishing pressure maximum sustainable yield), these estimates imply that TB is 11% lower than the MSY level and F is 11% lower than the MSY level (**Figure 41**). Catch was at its peak in 2011, but afterwards it decreased continually until 2014, although the stock had slightly recovered in 2014. However, the probability of uncertainties in the red, orange, and yellow zones (unsafe) of the 2014 point was very high at 78%. Therefore, catch and F should be decreased to their MSY levels, *i.e.* 37,000 metric tons and 0.51, respectively.

Meanwhile in the Pacific Ocean, the stock of longtail tuna in 2013 based on the Kobe Plot was in the green zone (safe), *i.e.* TB/TBmsy=2.22 and F/Fmsy=0.18, implying that TB is 122% higher than the MSY level and F is 92% lower than the MSY level (**Figure 42**). Catch was at its peak in 2008 and afterwards it sharply decreased in 2013 at 193,000 metric tons (the lowest level since 1980s). Nevertheless, the status of the stock is in the safe zone and the probability of uncertainties in the red, orange, and yellow zones (unsafe) around the 2013 point is 0%. Although both catch and F could be increased, these should be less than their MSY and Fmsy levels, *i.e.* at 200,000 metric tons and 1.07, respectively.

Kawakawa

As of 2014, the stock of kawakawa in the Indian Ocean was in the green zone (safe) with TB/TBmsy=1.28 and F/Fmsy=0.75 , *i.e.* TB is 29% higher than its MSY level and F is 26% lower than MSY level (**Figure 43**). Although kawakawa stock in the Indian Ocean is in the safe condition, fishing pressure and catch should not exceed the 2014 level because 53% of uncertainties around the 2014 point were in the red, orange and yellow zone (unsafe) while only 47% was in the green zone (safe).

In the Pacific Ocean, the stock of kawakawa was in the green zone (safe), *i.e.* TB/TBmsy=1.29 and F/Fmsy=0.74, implying that TB is 29% higher than the MSY level and F is 26% lower than the MSY level (**Figure 44**) due to significant catch decrease after 2002 (peak level) and the current catch level is low. In addition, the Kobe Plot shows that there is no probability that uncertainties in the 2013 estimates fall in the red, orange and yellow zone (unsafe). Although there are no problems in maintaining the current catch and F levels, these should be kept under their MSY levels at 185,000 metric tons and 0.43, respectively.

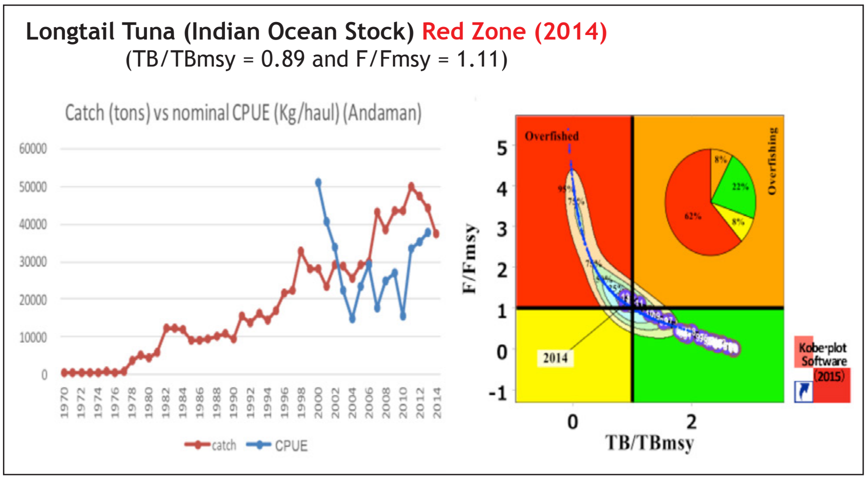


Figure 41. Stock assessment of longtail tuna in the Indian Ocean: Fishing Area 57 (Andaman Sea) in 2013 using the Kobe Plot

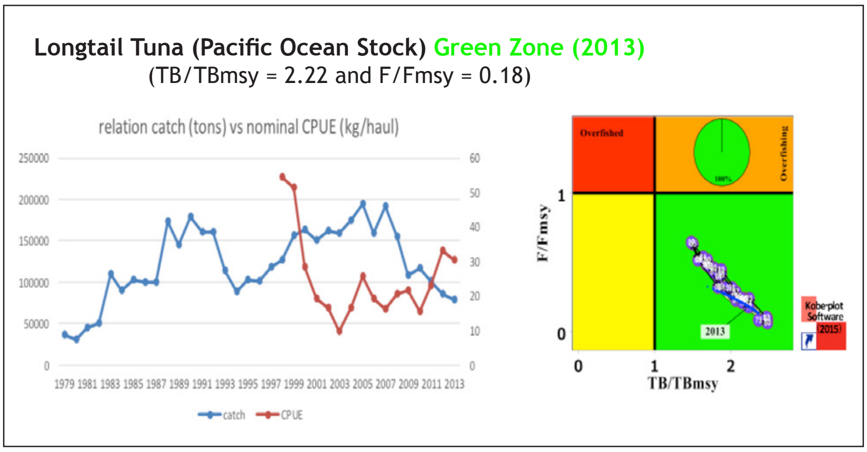


Figure 42. Stock assessment of longtail tuna in the Pacific Ocean: FAO Fishing Area 71 (South China Sea) in 2014 using the Kobe Plot

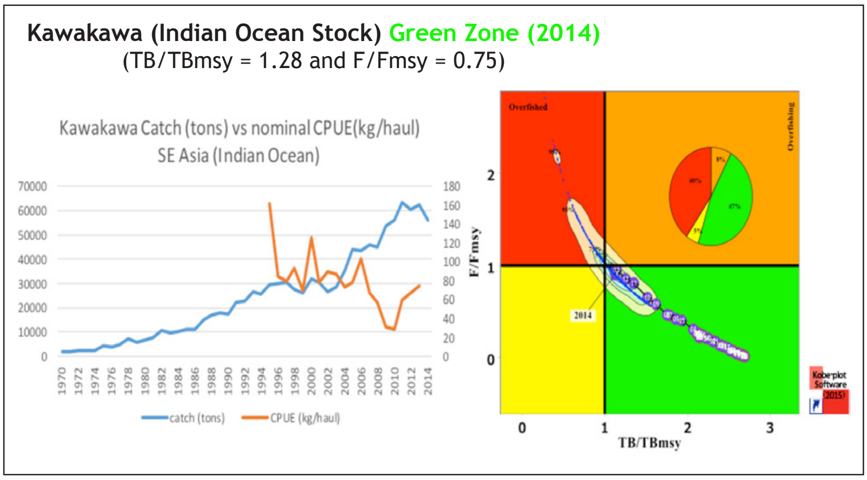


Figure 43. Stock assessment of kawakawa in the Indian Ocean: FAO Fishing Area 57 (Southeast Asia-Andaman Sea) in 2014 using Kobe Plot

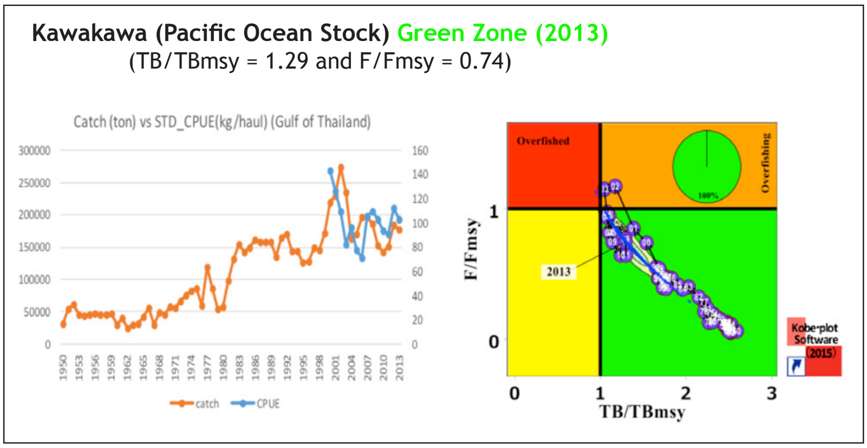


Figure 44. Stock assessment of kawakawa in the Pacific Ocean: FAO Fishing Area 71 (Gulf of Thailand) in 2013 using the Kobe Plot

The abovementioned stock assessment activities made use of catch data from FAO, IOTC, and the SEAFDEC Neritic Tuna Project, implying that almost all of the data are basically national statistics, thus there are wide ranges of uncertainties since stock structures are unknown. In addition, the CPUE data provided by the Department of Fisheries (DOF) of Thailand were also used considering that other plausible CPUE data were not available, thus there was no way of comparing the stock status with other concerned countries. Results of the stock assessment activities were therefore derived mainly from the CPUE series of DOF Thailand, which may not have covered a long historical data sufficient enough to carry out reliable stock assessments.

> *"Even though there are a number of caveats, some positive evidences emerged indicating that the results are likely realistic. First, the relationship between catch and CPUE in all four cases are negatively correlated, suggesting that the trends are likely realistic. Hence, results of stock assessments are likely credible. Second, results of stock assessments in the Indian Ocean stock are similar to those in the whole Indian Ocean based on the stock assessments conducted by IOTC" (IOTC, 2015).*

Issues and Challenges

During the series of regional technical consultations organized by SEAFDEC with the Member Countries, key issues that need to be addressed were identified for the promotion of the sustainable utilization of neritic tunas in the Southeast Asian region. These include: 1) insufficient data and information, 2) undetermined status of neritic tuna stocks, 3) open access scheme, 4) inadequate management of neritic tunas resources in some areas, 5) inadequate understanding of management and conservation measures, 6) negative impacts of climate change to changes in neritic tuna stocks, 7) negative impacts of fisheries to marine ecosystem, 8) illegal, unreported and unregulated (IUU) fishing, 9) inadequate infrastructures in fishing ports and landing sites, 10) post-harvest losses and product quality deterioration, 11) inaccessible intra-regional and international trade, 12) inadequate benefits for people involved in neritic tuna fisheries and industries, 13) working conditions and labor issues, 14) lack of sub-regional action plans for neritic tuna fisheries, 15) insufficient information on status and trends of neritic tunas at sub-regional level, and 16) limited support to intra-regional and international trade.

Regional Plan of Action for Neritic Tunas

In order to address the aforementioned issues, the Member Countries adopted the ***Regional Plan of Action on Sustainable Utilization of Neritic Tunas in the ASEAN Region (RPOA-Neritic Tunas)***. The features of the RPOA-Neritic Tunas (SEAFDEC, 2015) are summarized in **Box 1**.

Current Actions and Way Forwards

After the adoption of the **RPOA-Neritic Tunas**, SEAFDEC with support from the AMSs have implemented several action plans (**Box 2**). The Way Forward to promote and support the implementation of the RPOA-Neritic Tunas was also established as shown in **Box 3**.

Box 1. Main features of the Regional Plan of Action on Sustainable Utilization of Neritic Tunas in the ASEAN Region (RPOA-Neritic Tunas)

Objective	Issues	Action plan
Determining available data and information, improving data collection and develop-ing key indicators	1) Insufficient data and information	1) Improve data collection and analysis for neritic tunas
	2) Undetermined neritic tuna stocks status	2) Assess neritic tuna Stocks and develop resource key indicators
Improving sustainable fisheries management	3) Open access	3) Promote management of fishing capacity
	4) Inadequate management of neritic tuna resources in some areas	4) Promote sustainable utilization of neritic tuna resources
	5) Inadequate understanding of management and conservation measures	5) Enhance understanding of management and conservation measures of neritic tunas
	6) Negative impacts of climate change to changes in neritic tuna stocks	6) Mitigate the mpacts of limate change on neritic tuna stocks
Improving sustainable interaction between neritic tuna fisheries and marine ecosystem	7) Negative impacts of neritic tuna fisheries on marine ecosystem	7) Reduce negative impacts of neritic tuna fisheries on marine ecosystem
Improving compliance to rules and regulations and access to markets	8) Illegal, unreported and unregulated (IUU) fishing	8) Combat IUU fishing occurring in southeast asian region
	9) Inadequate infrastructures in fishing ports and landing sites	9) Improve infrastructures in fishing ports and landing Sites
	10) Post-harvest losses and product quality deterioration	10) Improve post-harvest techniques and product quality
	11) Intra-regional and international trade	11) Enhance intra-regional and international trade
Addressing social issues	12) Inadequate benefits for people involved in neritic tuna fisheries and industries	12) Improve the benefits for people involved in neritic tuna fisheries and industries
	13) Working conditions and labor is-sues	13) Improve working conditions of labor
Enhancing regional cooperation	14) Lack of sub-regional action plans for neritic tuna fisheries	14) Enhance and develop sub-regional action plans for neritic tuna fisheries
	15) Insufficient information on status and trends of neritic tunas at sub-regional level	15) Assessment of the status and trends of neritic tunas at sub-regional level
		16) Enhancing intra-regional and inter-national trade

Box 2. Regional Plan of Action on Sustainable Utilization of Neritic Tunas in the ASEAN Region

- Compilation and review of existing data and information on neritic tunas from all related national agencies to understand the status, trend, and biological parameters
- Review and strengthening of data collection systems on neritic tunas
- Capacity building for data enumerators, observers, port inspectors, scientists, or other key data informants on species identification and biological information
- Determination of the type of data required for stock assessment or key indicator analysis
- Utilization of the existing standard operating procedures (SOPs) for data collection to determine fisheries key indicators on status and trend of neritic tunas
- Encouraging the conduct of research on neritic tunas at national level (*e.g.* stock assessment, biological, genetics, tagging program, etc.)
- Capacity building on stock assessment (three training courses were conducted)
- Development of **Regional Plan of Action for Managing of Fishing Capacity, and promote Management of Fishing Capacity** (ongoing)

Box 2. Regional Plan of Action on Sustainable Utilization of Neritic Tunas in the ASEAN Region (Cont'd)

- Encouraging the involvement of ASEAN Member States in regional or sub-regional research on the impact, adaptation, and mitigation measures of climate change on fisheries particularly on neritic tunas (ongoing)
- Conduct of risk assessment on the effective management of neritic tunas based on the stock assessment of individual species (ongoing)
- Conduct of R&D on suitable fishing methods and practices for sustainable utilization of neritic tuna resources and promotion to ASEAN Member States
- Promotion of cooperation among ASEAN Member States and with other **RPOA-IUU** participating countries in combating IUU fishing under the **RPOA-IUU Framework** (ongoing)
- Development and promotion of the **ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chains in the ASEAN Region**
- Provision of technical support to promote proper handling and preservation of neritic tunas onboard and at ports (ongoing)
- Development and implementation of traceability system to monitor movement of neritic tuna fish and fishery products in the supply chain for export (*i.e.* origin of catch, transport, processing, storage, and distribution)
- Development of arrangements and partnerships between fisheries authorities or related agencies and fisheries industries regarding the implementation of labor standards in fisheries in accordance with national laws, the International Labour Organization (ILO) Work in Fishing Convention of 2007 (C188/Work in Fishing Convention, 2007) No. 188 and other related ILO Conventions (on-going)
- Review of the existing action plans in sub-regions such as Sulu-Sulawesi Seas, Gulf of Thailand, South China Sea, and Andaman Sea (ongoing)
- Establishment of cooperation on R&D to support sub-regional management of neritic tuna fisheries (ongoing)
- Establishment of the SEAFDEC scientific working group on neritic tunas for regional stock assessment and provision of scientific advice for policy considerations on neritic tuna management;
- Conduct of regular meetings of SEAFDEC scientific working group at sub-regional and regional levels (ongoing)
- Promotion of the development of **ASEAN Catch Documentation Systems and Schemes**
- Enhancement of the promotion of neritic tuna fish and fishery products from small-scale operators

Box 3. Way Forward to Promote the RPOA-Neritic Tunas

- Implementation of ASEAN Catch Documentation System and Scheme by ASEAN Member States for neritic tuna fish and fishery products at national level
- Development of joint trade promotions within and outside the region through the ASEAN Tuna Working Group
- Exchange of information among ASEAN Member States on legal framework, policies and management, and trade rules and regulations at sub-regional and regional levels on neritic tuna fisheries
- Recognition of security and safety issues for all types of fishing activities by implementing skills training programs
- Conduct of assessment of post-harvest losses of neritic tunas and describe the various ways of reducing post-harvest losses
- Strengthening surveillance activities and enforcement
- Prohibition of importation, landing, or transshipment at port of neritic tunas from vessels presumed to have carried out IUU fishing activities in the ASEAN region without prior clarification from vessel owners or concerned flag States
- Development of measures to refrain from conducting business transactions with owners and vessels presumed to have carried out IUU fishing activities
- Creation of platforms and fora to facilitate cooperation among scientists and managers
- Support the development of information, education, and communication (IEC) programs on sustainable use of resources
- Development of management measures to control fishing effort and capacity at national and sub-regional levels

1.1.2 Round Scads

Round scads (Family Carangidae) are the most common pelagic fishes in the Southeast Asian region, and the three species most common in the region are the Indian scad (*Decapterus russelli*), Japanese scad (*D. maruadsi*), and shortfin scad (*D. macrosoma)*. Most of these species are caught in their immature stage since mature fishes are rare in many areas as these are believed to migrate to deeper waters for spawning. The main fishing gear used to catch round scads is purse seine, where purse seine with luring light is common in Thailand, while purse seining around payao, a type of FAD, is commonly practiced in the Philippines. Round scads are also caught by trawl net and it has also been recorded that lift-net is used to catch round scads in the east coast of West Malaysia.

Stocks of round scads are known to be migrating in several fishing areas and thus, are shared with possible considerable uncertainty of their limits, specifically from the Gulf of Thailand to Sunda Shelf, Malacca Strait, Eastern South China Sea, and the Gulf of Tonkin (**Figure 45**). However, it is also possible that one or more stocks are not shared especially those found in the waters of Indonesia. Based on the results of collaborative studies in the South China Sea conducted by SEAFDEC/MFRDMD from 2002 to 2006, *D. macrosoma* is widely distributed in the coastal areas of the South China Sea (**Figure 46**) from the Gulf of Tonkin, Gulf of Thailand and west coast of Borneo, and in Palawan and west coast of Luzon in the Philippines (SEAFDEC, 2012b).

Results of studies conducted by SEAFDEC indicated that the exploitation rate of *D. macrosoma* in the South China Sea varies from 0.42 to 0.90 depending on the specific fishing grounds (**Figure 46**). Specifically, the exploitation rate *D. maruadsi*, varied from 0.26 to 0.90 while the exploitation rate of both *D. macrosoma* and *D. maruadsi* is high, especially in the Gulf of Tonkin and in the southern part of the east coast of Viet Nam where the exploitation rate could be higher than 0.8 (SEAFDEC, 2012b).

Figure 45. Maps showing Gulf of Thailand, Sunda Shelf, Malacca Strait, Gulf of Tonkin *(left)*, and Gulf of Tonkin, Gulf of Thailand, West Coast of Borneo, Palawan, West Coast of Luzon in the Philippines *(right)*

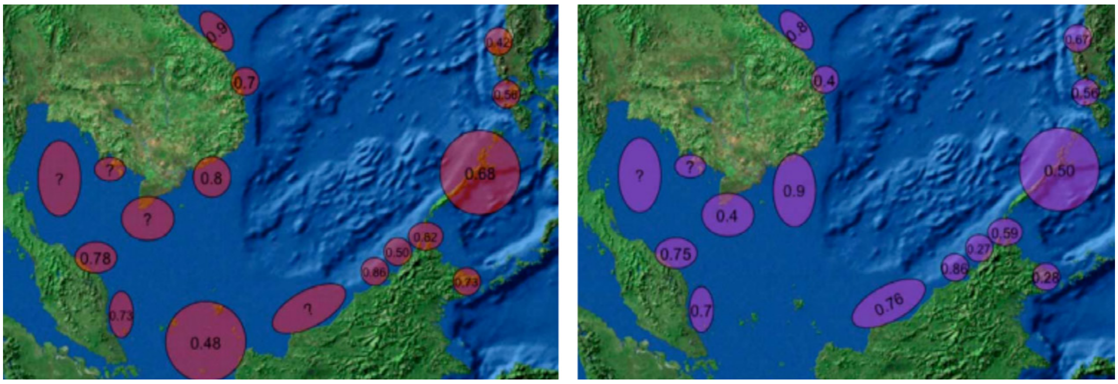


Figure 46. Exploitation rates of *Decapterus macrosoma (left)* and *D. maruadsi (right)* in the South China Sea in 2002-2005 based on studies conducted by SEAFDEC *(**Source:** SEAFDEC (2012b))*

Trends of the total catch of round scads (in metric tons) were compared between the South China Sea and Andaman Sea during 2000-2013. Results showed that the total catch from the former was greater than that of the latter (**Figure 47**), in spite of the decrease in total catch from the South China Sea starting 2003 that fluctuated between 2003 and 2010, but the total catch increased again from 2011. On the other hand, the trends of total catch from the Andaman Sea appeared to be stable and consistent.

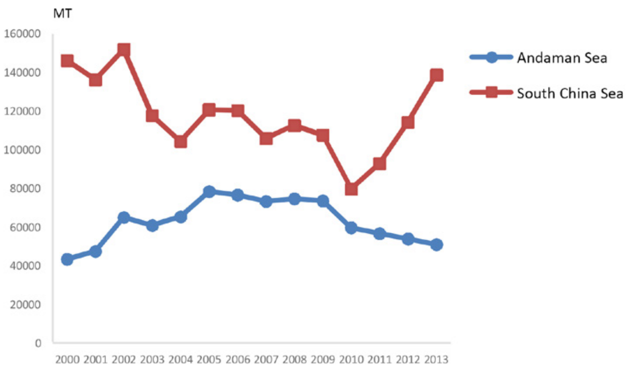


Figure 47. Trends of total catch of round scads from the South China Sea and Andaman Sea (2000-2013)

***Source:** SEAFDEC (2002-2013); SEAFDEC/MFRDMD (2000); SEAFDEC/MFRDMD (2015a); and Department of Fisheries Malaysia (2000-2014)*

The total catch of round scads based on the national statistics provided by four Southeast Asian countries, namely: Indonesia, Malaysia, Philippines, and Thailand, from 2000 to 2013 is shown in **Figure 48**. As the region's major producers of round scads, Indonesia and Philippines indicated total catch ranging from 300,000 metric tons in 2003 to about 420,000 metric tons in 2013, respectively. In the case of Thailand and Malaysia, the total catch ranged from 10,000 metric tons to 70,000 metric tons in 2000-2013. While the catch of Thailand fluctuated with a minimum recorded in 2004 at 30,000 metric tons and maximum in 2012-2013 at 70,000 metric tons, that of

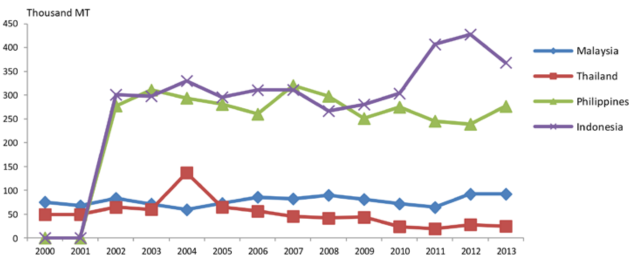


Figure 48. Total catch of round scads of some Southeast Asian countries in 2000-2013 by quantity

***Source:** SEAFDEC (2002-2013); SEAFDEC/MFRDMD (2000); and Department of Fisheries Malaysia (2000-2014)*

Malaysia had been consistent at about 10,000-20,000 metric tons during the same period.

In terms of value, round scads caught from the South China Sea seemed to command higher prices than those caught from the Andaman Sea (**Table 53**). The highest value of total scads production was recorded in the Philippines in 2013 at US$ 396,602 while the lowest value was recorded in the West Coast of Peninsular Malaysia in 2000 at US$ 5,117.

1.1.3 Mackerels

Mackerels (Family Scombridae) are also among the most economically important small pelagic fishes in the Southeast Asian region contributing about 38% to the small pelagic fisheries production or 11% to the total capture fisheries production in 2010 as shown in **Table 54**.

Mackerels are more predominantly caught in the Andaman Sea than in the South China Sea. As shown in **Figure 49**, higher catch was recorded in the Andaman Sea compared to that of the South China Sea. Although the catch from the Andaman Sea and South China Sea increased in 2010,

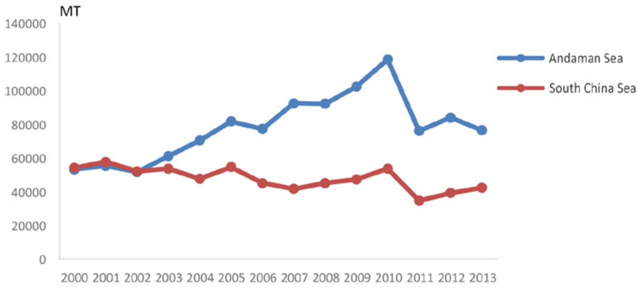


Figure 49. Production of mackerels from the South China Sea and Andaman Sea in 2000-2013

Source: *SEAFDEC (2002-2013); SEAFDEC/MFRDMD (2000); SEAFDEC/MFRDMD (2015a); and Department of Fisheries Malaysia (2000-2014)*

Table 53. Value of total production of round scads from different fishing grounds of the Southeast Asian countries from 2000 to 2014 (US$ thousands)

Year	Indonesia[1]		Malaysia[2]		Philippines[1] (SCS)	Thailand[1]	
	Natuna Sea (SCS)	Malacca Strait (AS)	West Coast (AS)	East Coast+SS+LB (SCS)		Gulf of Thailand (SCS)	Indian Ocean (AS)
2000	…	…	5,117	79,086	…	67,857[3]	24,559[3]
2001	…	…	5,881	71,583	…	…	…
2002	109,925	27,481	15,474	74,827	…	31,152	14,211
2003	108,094	27,023	22,287	56,811	…	36,206	15,889
2004	115,094	28,773	23,477	43,814	…	42,537	19,764
2005	132,878	33,219	26,331	54,619	…	42,506	19,749
2006	145,106	36,277	33,311	60,666	…	45,163	20,984
2007	153,949	38,487	34,467	55,492	…	26,859	13,780
2008	165,073	37,483	38,975	61,804	315,179	22,224	…
2009	29,321	5,239	33,444	77,125	262,969	22,532	…
2010	238,363	37,482	38,442	63,112	306,314	…	25,517
2011	323,502	…	30,211	77,307	317,185	24,801	…
2012	213,536	13,018	22,801	79,988	343,895	29,761	…
2013	314,315	28,967	23,442	84,334	396,602	…	29,027
2014	…	…	29,796	72,848	…	…	…

SCS: *South China Sea;* ***AS****: Andaman Sea;* ***SS****: Sabah-Sarawak;* ***LB****: Labuan; … = not available*
Source*: [1]SEAFDEC (2002-2013); [2]Department of Fisheries Malaysia (2000-2014); and [3]SEAFDEC/MFRDMD (2000)*

Table 54. Percentage of mackerels in small pelagic fisheries production and total capture fisheries production of the Southeast Asian countries in 2010

	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam	Average
% of mackerels catch in total capture fisheries production	17	…	13	19	…	19	2	4	…	11
% of mackerels catch in total small pelagic production	75	…	53	71	…	74	41	17	…	38

… = data not available
Source: *Tagging program for economically important small pelagic species in the South China Sea and the Andaman Sea, Regional Project Terminal Report (Mazalina and Katoh, 2014)*

Table 55. Production of mackerels from different fishing grounds of the Southeast Asian countries in 2010 by quantity (metric tons: MT)

Fishing grounds	Country	Total capture fisheries production (MT)	Production of small pelagic fishes (MT)	Production of mackerels (MT)
South China Sea	Brunei Darussalam	2,304	536	230
	Cambodia	85,000	NA	NA
	Indonesia (Natuna Sea)	3,757,030	771,023	218,625
	Malaysia (ECPM+SS+LB)	695,495	144,750	32,031
	Philippines	2,279,732	569,649	149,100
	Singapore	1,731	98	N/A
	Thailand	36,277	33,311	60,666
	(Gulf of Thailand)	990,607	213,140	13,759
	Viet Nam	2,226,600	NA	NA
	Total	**10,038,499**	**1,717,196**	**413,745**
Andaman Sea	Indonesia (Indian Ocean)	1,276,883	241,488	75,284
	Malaysia (WCPM)	733,383	213,766	154,194
	Myanmar	2,048,590	51,543	26,490
	Thailand (Indian Ocean)	628,346	120,225	17,011
	Total	**4,687,202**	**102,476**	**272,979**

ECPM: *East Coast Peninsular Malaysia*; ***WCPM:*** *West Coast Peninsular Malaysia*; ***SS:*** *Sabah-Sarawak*; ***LB:*** *Labuan*; *... = data not available*
Source: *Tagging Program for Economically Important Small Pelagic Fishes in the South China Sea and the Andaman Sea: Regional Project Terminal Report (Mazalina and Katoh, 2014)*

it decreased in 2011, which could be influenced by the trends of catch of Indonesia and Philippines as the main producers of mackerels (**Table 55**).

As mentioned earlier, Indonesia and Philippines are the major contributors to the region's total mackerel production, followed by Malaysia and Thailand (**Table 55**). The Fisheries Statistical Bulletin of Southeast Asia 2012 (SEAFDEC, 2014) reported that the highest catch of mackerels was recorded in Indonesia and Philippines at 3,757,030 metric tons and 2,279,732 metric tons,

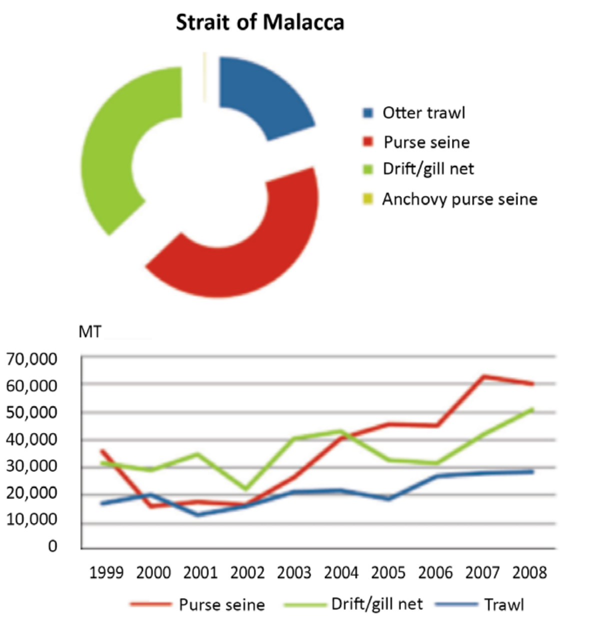


Figure 50. Composition *(above)* and trends *(below)* of mackerel catch by main gear types in the Strait of Malacca (Andaman Sea) in 2007 by quantity

respectively. Meanwhile, the lowest catch of mackerels was recorded in Brunei Darussalam with 230 metric tons.

Mackerels are caught by various types of fishing gears in the Southeast Asian waters and the three major types are purse seines, trawls, and driftnets. Purse seines and trawls are used more offshore than driftnets. In the Andaman Sea, mackerels are caught mostly by purse seines (43%) followed by drift/gill nets (37%) and trawls (20%); with landing trends that are constantly increasing (**Figure 50**). Purse seiners in Andaman Sea generally use FADs and luring lights, catching more Indian mackerels (*Rastrelliger kanagurta*) than short mackerels (*R. brachysoma*).

Meanwhile, in the South China Sea, mackerels are caught by purse seines accounting for about 45% of the total catch in 2008, followed by drift/gill nets at 31%, trawls at 18%, and others at 6% (**Figure 51**). The landings show declining trends indicating that the mackerel stocks in the South China Sea are already overexploited. For species composition of purse seine catch , Indian mackerels made up about 25% of the total catch while short mackerels account for only 2% .

The study conducted by Bidin and Kassim (2007) estimated that the average exploitation rates (E) for *R. kanagurta* is at 0.69 from 2002 to 2006 in four countries bordering the South China Sea. This higher E value was also recorded for *R. brachysoma* in a study done in Malaysia and Philippines with average exploitation rate of 0.66. It could be concluded that the mackerel resources in the South China Sea during the study period are already overexploited.

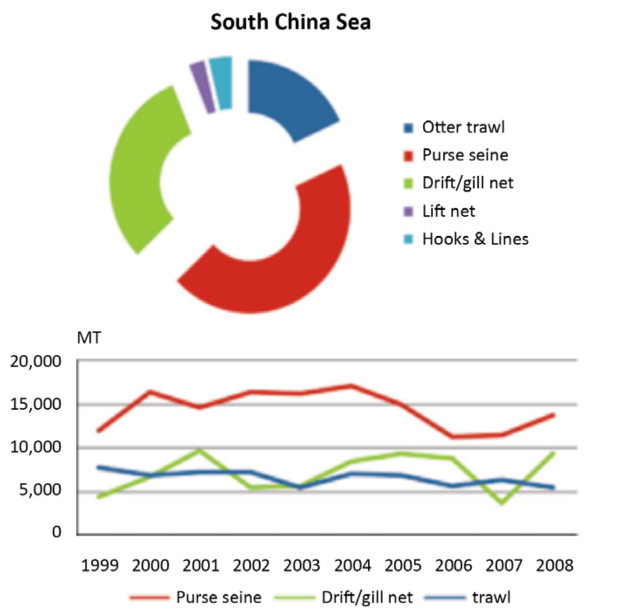


Figure 51. Percentage of production of major types of fishing gears used for catching mackerels in the South China Sea in 2008 *(above)*, and trends of production of major types of fishing gears used for catching mackerels in the South China Sea in 1999-2008 *(below)* by quantity

1.1.4 Anchovies

Anchovies (Family Engraulidae), like other small pelagic fishes, are widely distributed in the Southeast Asian region. Anchovies are found in the neritic zone or shallow coastal waters. Anchovies mainly feed on planktonic crustaceans. Their breeding period is throughout the year with peaks during the first part of northeast monsoon from October to January in Manila Bay, and from February to April and July to December in the Gulf of Thailand (SEAFDEC, 2012b). Shorthead anchovy (*Encrasicholina heteroloba*) and Indian anchovy (*Stolephorus indicus*) are the two dominant species found in the Southeast Asian region. In this region, anchovies are caught mainly by purse seine operating during day time, while purse seine using luring lights, bamboo stake traps, luring light lift-nets, set bag nets, stationary traps, push nets, and trawl nets are operated during night time. Fishing grounds are located in the South China Sea and Andaman Sea, and stocks of anchovies are believed to be transboundary in the Southeast Asian

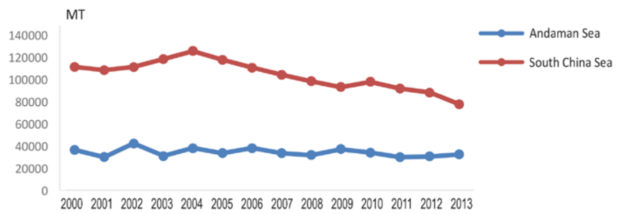


Figure 52. Total catch of anchovies from the South China Sea and Andaman Sea by quantity from 2000-2013

Source: *SEAFDEC (2002-2013); SEAFDEC/MFRDMD (2000); SEAFDEC/ MFRDMD (2015a); and Department of Fisheries Malaysia (2000-2014)*

waters; however, information on its status as shared stocks is limited.

In comparing the production trends of anchovies from 2000 to 2013 between the two fishing grounds, it was found that the South China Sea had higher production compared to the Andaman Sea (**Figure 52**). While the production trend in the South China Sea was gradually decreasing, the production trend in Andaman Sea seemed to be stable and consistent. Indonesia, Malaysia, Philippines, Singapore, and Thailand are the countries that catch anchovies in the South China Sea. On the other hand, the countries fishing for anchovies in the Andaman Sea are Indonesia, Malaysia, Myanmar, and Thailand.

The trends of the production values were also compared between the two fishing grounds. While the trend of the production values from the South China Sea fluctuated but gradually increased, in the Andaman Sea, the values appeared to be stable and consistent (**Figure 53**). The highest production value was observed in the South China Sea in 2011 at US$ 474,253 and the lowest production value recorded in 2003 in the Andaman Sea was estimated at US$ 16,307.

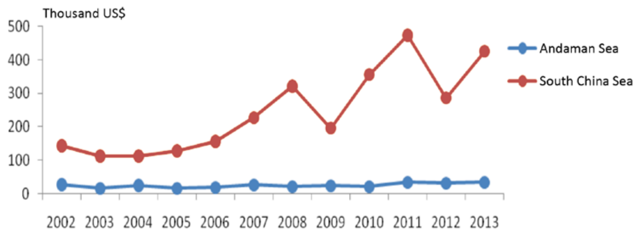


Figure 53. Value of the production of anchovies in the South China Sea and Andaman Sea from 2002 to 2013 (US$)
Note: South China Sea (SCS) countries: Thailand, Malaysia, Indonesia, Philippines and Singapore
Andaman Sea (AS) countries: Thailand, Malaysia and Indonesia

Source: *SEAFDEC (2002-2013)*

The annual production of anchovies in the Southeast Asian region is compiled based on available information contributed by six member countries, namely: Indonesia, Malaysia, Myanmar, Philippines, Singapore, and Thailand. Since 2002, Indonesia dominated the highest landings, followed by Thailand, Philippines, and Malaysia (**Table 56**). Meanwhile, Singapore and Myanmar recorded the lowest production of anchovies. The highest production (207,450 metric tons) was observed in Indonesia in 2009 while the lowest production (17 metric tons) was recorded in Singapore in 2005.

In Cambodia, the fishing grounds for anchovies are concentrated around Koh Sdach in Koh Kong, Tomnop Rolok in Preah Sihanouk and Kampong Bay in Kampot (**Figure 54**).

Table 56. Production of anchovies from different fishing grounds of the Southeast Asian countries from 2000 to 2014 by quantity (metric tons)

Year	Indonesia		Malaysia		Myanmar: SCS	Philippines: SCS	Singapore: SCS	Thailand	
	Natuna Sea (SCS)	Malacca Strait (AS)	West Coast (AS)	East Coast+SS+LB (SCS)				Gulf of Thailand (SCS)	Indian Ocean (AS)
2000	…	…	11,184	11,332	…	…	…	107,706	25,990[1]
2001	…	…	7,934	9,789	…	…	…	…	…
2002	101,372	67,581	14,997	8,677	…	74,095	54	123,841	27,890
2003	96,685	64,456	10,357	9,963	…	71,101	25	132,550	21,110
2004	92,887	61,924	14,652	8,798	…	71,498	24	139,326	23,911
2005	91,156	60,770	10,000	6,887	…	68,947	17	135,140	24,545
2006	99,014	66,010	10,441	8,799	4,505	70,568	36	125,919	31,865
2007	105,313	70,209	10,129	13,847	1,978	76,041	32	118,886	26,701
2008	118,670	81,005	9,167	9,136	5,024	73,235	…	119,964	24,110
2009	140,200	67,250	6,530	11,813	6,188	81,842	…	120,186	23,870
2010	122,379	53,347	7,082	9,331	6,973	80,183	…	107,944	29,216
2011	127,384	77,327	4,952	11,573	7,873	75,867	…	114,157	30,220
2012	122,674	80,546	5,272	12,186	5,031	71,165	…	111,563	31,563
2013	108,108	82,986	4,762	14,062	4,205	68,425	…	102,465	31,480
2014	…	…	5,687	17,409	2,156	…	…	…	…

***SCS:** South China Sea; **AS**: Andaman Sea; **SS**: Sabah-Sarawak; **LB**: Labuan; … = not available*
***Source:** SEAFDEC (2002-2013); SEAFDEC/MFRDMD (2000); SEAFDEC/MFRDMD (2015a); and Department of Fisheries Malaysia (2000-2014)*

Figure 54. Fishing grounds of anchovies and tunas in Cambodia

***Source**: SEAFDEC/TD (2016)*

In the Gulf of Thailand (**Figure 56**), the fishing grounds of anchovies are identified in four areas, namely: Southern Gulf of Thailand (SGOT), Middle Gulf of Thailand (MGOT), Northern Gulf of Thailand (NGOT), and Eastern Gulf of Thailand (EGOT). SGOT comprises the Provinces of Narathiwat, Pattani, Songkla and Nakhon Si Thammarat; MGOT the Provinces of Surat Thani, Chumphon and Prachuap Khiri Khan; NGOT the Provinces of Petchaburi, Samut Songkhram, Samut Sakhon, Samut Prakan and Chonburi; and EGOT the Provinces of Rayong, Trat and Chanthaburi.

Figure 55. Fishing grounds of anchovies in Malaysia

***Source:** SEAFDEC/TD (2016)*

In Malaysia, anchovies are caught in the shallow coastal waters of Tanjung Dawai in Kedah and Tukun Motor Bakar in Kelantan, and in the vicinity of the archipelago such as Pulau Pangkor in Perak, Langkawi in Kedah, and Perhentian in Terengganu-Kelantan border (**Figure 55**). In the East Coast of Peninsular Malaysia (ECPM) in the South China Sea, the landing sites are in Kelantan and in Sabah. High landings of anchovies were recorded during February-April in the West Coast of Peninsular Malaysia (WCPM). Whereas, in the ECPM, particularly in Kelantan, two phases of high landings were recorded, *i.e.* beginning of April to June, and from September to October. Overall, Kedah in the WCPM in the Andaman Sea is the major contributor which accounted for 40% of total landings (Faisal, 2015).

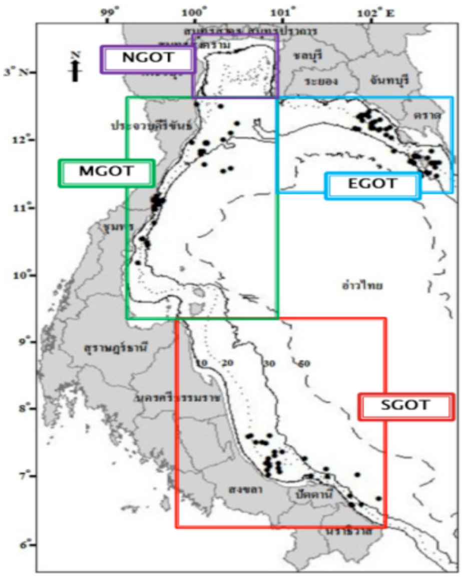


Figure 56. Fishing grounds of anchovies in the Gulf of Thailand

Source: *Khemakorn* et al. *(2016)*

Different types of fishing gears are used for catching anchovies in the various fishing grounds in the Gulf of Thailand (**Figure 57**). For small cast nets, the fishing grounds are confined in areas 5 to 10 nautical miles from the shoreline with water depth between 10 to 30 m, especially in Ko Kut in Trat Province, Leam Sing in Chantaburi Province, and Bang Saphan and Nathip in Prachaup Kirikhan.

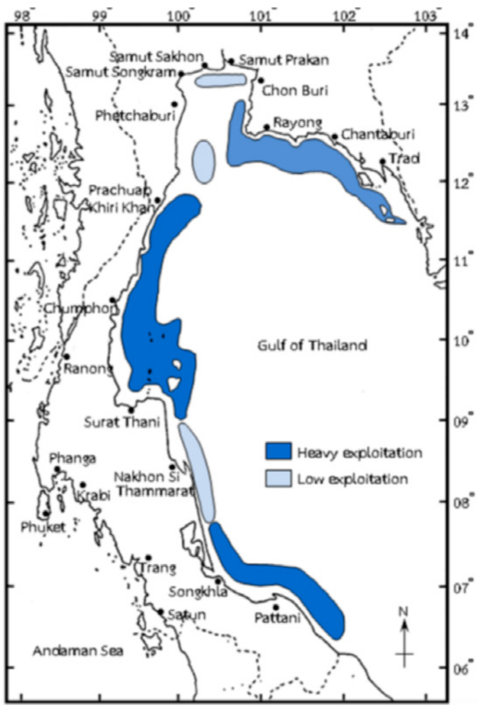


Figure 57. Distribution and level of exploitation of anchovies in the Gulf of Thailand

Source: *SEAFDEC/TD (2016)*

For medium cast nets, the fishing grounds are located between 5 to 10 nautical miles from the shoreline and in deeper waters at 10-50 m located between Rayong and Trat Provinces and between Prachaup Kirikhan to Narathiwat Provinces. Meanwhile, the daytime purse seines are used in areas farther out of the sea between 5 to 25 nautical miles from the shoreline and concentrated between Rayong and Chonburi and Prachaup to Nakorn Srithammarat. For purse seine with luring lights, the fishing grounds are located in deep water areas and confined in Ko Kut in Trat Province and Prachuap Kirikhan Province.

In Viet Nam, anchovies are very important fishery resource, where the total biomass recorded in 2013 was about 140,000 metric tons. Shorthead anchovy (*Encrasicholina heteroloba*) contributed 60% to the total production. Most of anchovies are caught from Phu Quoc and Tho Chu islands in Kien Giang (**Figure 58**) using purse seines and pelagic pair trawls. For pelagic pair trawl, anchovies comprised an estimated 58% of the trash fish caught where 33% of anchovies' composition comprised the shorthead anchovies. Trash fish represent 57% of the total catch by pelagic pair trawl (Bat and Cuong, 2016).

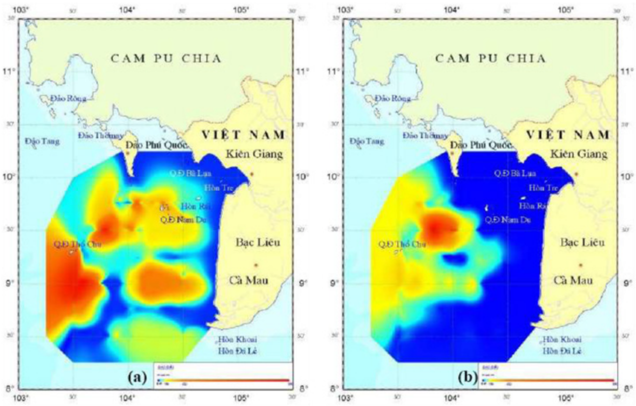


Figure 58. Distribution of anchovies in Viet Nam during (a) southwest and (b) northeast monsoons

Source: *Bat and Cuong (2016)*

Every Southeast Asian country has its distinctive post-harvest utilization methods for anchovies. In Thailand, anchovies are used for the production of fish sauce (39%), dried and other products for export (59%), and processed as fish paste and fish meals (about 2%). Fresh anchovy is sold according to size of vessels (Nasuchon, 2005). The price of the catch from vessels less than 12 m in length is about Thai Baht (THB) 70/kg for dry products (THB 1.00 = US$ 0.029 (as of June 2017)). Meanwhile, the price of catch from vessels 12-16 m in length is THB 50-60/kg and the catch is mainly used to produce fish meal and fish sauce. The difference in prices is determined by the different species of anchovies caught (Wanchana, 2016).

In Kelantan, Malaysia the average price for fresh anchovy is about Malaysian Ringgit (RM) 1.50/kg (RM 1.00 = US$ 0.23 (as of June 2017)). Meanwhile, less quality fresh anchovies are processed into fish sauce, locally called "budu". The most abundant anchovy species landed in Genting, Tumpat is *Encrasicholina punctifer*, locally called "bilis tembaga hitam". Dried products of this species are sold for RM 12/kg (Faisal, 2015). In Viet Nam, anchovies are sold at local markets and processed into commercial products such as fish sauce, dried and fish milk (Bat and Cuong, 2016).

Anchovy fishery in the Southeast Asian region especially in the South China Sea is very active. In order to assess the current status of anchovy resources, it is necessary that more surveys be conducted not only in the South China Sea but also in the Andaman Sea. The results could provide accurate and comprehensive information necessary for the management of the current stocks of anchovies. Considering the possibility that these resources are shared among neighboring countries in the South China Sea and Andaman Sea, regional management measures should be established and such effort needs serious consideration by all countries concerned.

1.1.5 Sardines

Sardines (Family Clupeidae) are important small pelagic fishes utilized for several fishery products such as canned, dried, smoked, boiled, and fermented (fish sauces), and are also marketed fresh by many countries such as Malaysia, Indonesia, and Philippines. Sardines are normally found in the coastal and offshore areas at water depths ranging from 30 to 70 m, feeding on phytoplankton and zooplankton. There are three common species of sardines found in the Southeast Asian region, namely: *Sardinella gibbosa*, *S. frimbriata*, and *S. albella*. Catching of sardines in the Gulf of Thailand depends on seasonal spawning with the peaks predicted in March-April and July-August. Purse seine is the main fishing gear used to catch sardines.

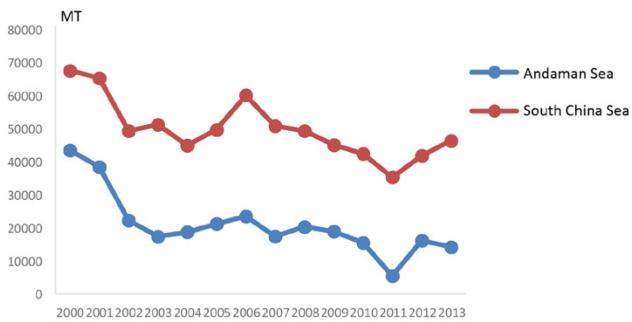


Figure 59. Production trends of sardines in the South China Sea (SCS) and Andaman Sea (AS) in 2000-2013 by quantity

Source: *SEAFDEC (2005a; 2006; 2008a; 2008b; 2009a; 2010a; 2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a)*

The available statistical data on catch of sardines in Southeast Asia from 2000 to 2013 suggested that the trend of sardines catch from the South China Sea was about three times more than that of the Andaman Sea (**Figure 59**). Nonetheless, the total catches from these two fishing grounds seemed to be declining from 2000 until 2013 with some recoveries in 2006 and 2012.

The total production of the main sardine producing countries in the region seemed to have fluctuated during the period 2000-2013, with the total catch varying from 15,000 metric tons to 46,000 metric tons, with peaks noted in Malaysia in 2000 and Thailand in 2006 (**Figure 60**). The total catch of sardines was stable at about 40,000 metric tons in Thailand, while for Malaysia although the catch also fluctuated, this seemed to follow slight increasing trends in 2000 but decreased in 2011. Philippines showed increasing trend from more than 250,000 metric tons in 2000 to 313,000 metric tons in 2007. Likewise, the catch of Indonesia also increased from more than 280,000 metric tons in 2000 to 380,000 metric tons in 2007.

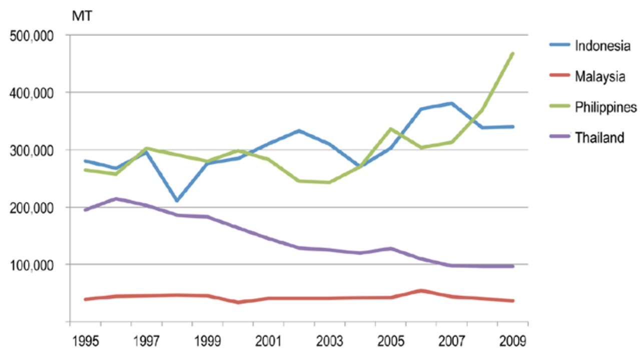


Figure 60. Production trends of sardines from main producing countries of Southeast Asia in 1995-2009 by quantity

Source: *SEAFDEC (2012b)*

1.2 Important Demersal Fishery Resources

The most economically important demersal fishes distributed from the coastal areas to the continental shelf slopes in the Southeast Asian region include the threadfin breams (Family Nemipteridae), lizardfishes (Family Synodontidae), bigeye snappers (Family Priacanthidae), croakers (Family Sciaenidae), and goatfishes (Family Mullidae), as well as other pelagic fishes including barracuda (Family Sphyraenidae). Considered as by-catch, these fishes are now being targeted and used as raw materials in the production of surimi not only in the region but also in the world, because of their properties and characteristics appropriate for processing into export-quality surimi.

1.2.1 Raw Materials for Surimi

Surimi is an intermediate product made from minced fish meat that has been washed, refined, and mixed with cryo-protectants. It has become one of the most dynamic commodities in the Asian seafood industry because of innovations in production and utilization. Japan is known as the world's leading surimi producer, and its frozen surimi provided the impetus for expanding the industry and surimi markets based on the vast resources of Alaska pollock (*Gadus chalcogrammus*) since 1950. In Southeast Asia, surimi prduction started to pick up in the late 1960s, by making use of the aforementioned fisheries by-catch. Caught from the EEZs of the five main producing Southeast Asian countries, namely: Indonesia, Malaysia, Philippines, Singapore, and Thailand, these demersal fishers' production trend indicated to be considerably increasing from 1980 to 2014 (**Figure 61**).

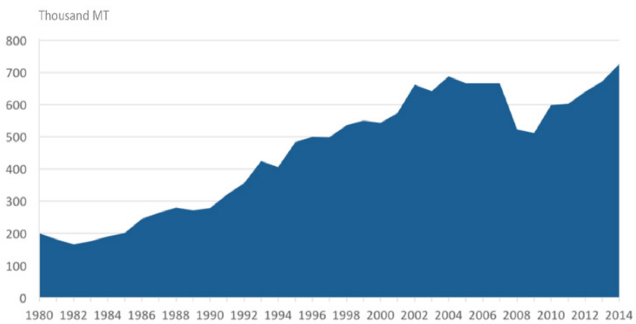


Figure 61. Production trend of raw materials for surimi production from Southeast Asian waters by quantity

While the production quantity of demersal fishes used as raw materials for surimi production had drastically increased from 165,700 metric tons in 1982 to 687,300 metric tons in 2004, it slightly decreased from 2005 to 2007. In 2008 and 2009, the quantity had reduced to 511,400 metric tons but production increased to 726,000 metric tons in 2010 until 2014. In 2014, the threadfin bream (*Nemipterus* spp.) belonging to Family Nemipteridae and goatfish (*Upeneus* spp.) of Family Mullidae were the dominant fishes caught representing 28% and 24%, respectively, of the total capture fisheries production of Southeast Asia. These were followed by croakers (*Johnius* spp., *Pennahia* spp.) of Family Sciaenidae, big-eye snappers (*Priacanthus* spp.), lizardfishes (*Saurida* spp.) of Family Synodontidae and Mullidae (**Figure 62**).

The appreciation of the Japanese yen and the exclusion of Japan from the US and Russia Alaska pollock resources led to a shift from the pollock of the US and Russia, especially in the high sea region of the Bering Sea, the raw materials for surimi shifted to the New Zealand's hoki or Southern blue whiting (*Macruronus novaezelandiae*) which had become one of the most promising alternative sources of

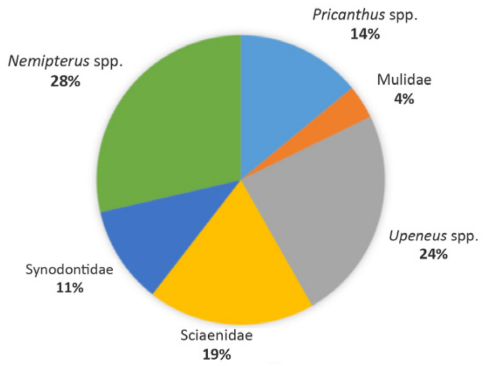


Figure 62. Contribution of the economically important demersal fishes used as raw materials for surimi to the capture fisheries production of Southeast Asia in 2014

raw materials because of its abundance and high quality. However, when New Zealand reduced its hoki catch allocation in 1989, independent fishing support to the surimi industry changed to targeting the Canadian Pacific hake (*Merluccius productus*), Chilean jack mackerel (*Trachurus murphyi*), and various Argentine demersal fish species. This also led to the decline of the surimi production of Japan from its peak in 1984 at 418,000 metric tons down to 310,000 metric tons in 1989 and to 132,000 metric tons in 1994.

The production trend of the raw materials for surimi production from the five major producing Southeast Asian countries (**Figure 63**) indicated that the quantity of catch in Thailand dropped drastically from 350,000 metric tons in 2004 to 128,000 metric tons in 2008. While that of Indonesia had increased from 157,000 metric tons to 196,000 metric tons in the same period, it experienced a decrease in 2009 then a significant increase to 350,000 metric tons in 2010 until 2014. For Malaysia, its production had slightly increased from 53,200 metric tons in 1991 to 162,000 metric tons in 2014. For the Philippines, the production was stable within 50,000 and 80,000 metric tons from 1982-2014. Although there is no surimi industry in the Philippines, most of the fishes

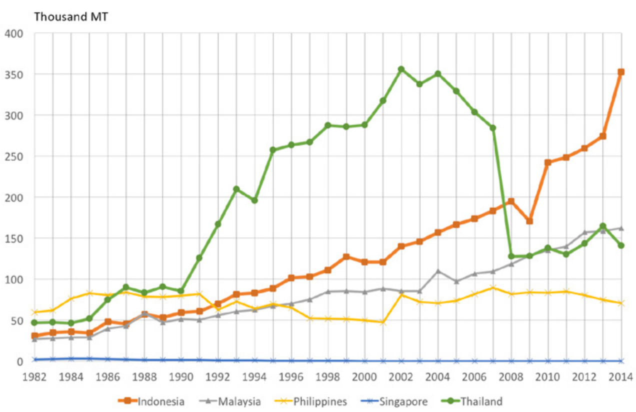


Figure 63. Production trend of surimi raw materials of the major producing Southeast Asian countries in 1982-2014 by quantity

that could be used as surimi raw materials and produced by the country are utilized for local consumption. The production of Singapore of the raw materials for surimi, although minimal, was stable.

There are many reasons that led to the drastic changes in the supply of raw materials for surimi production from the five countries. For Thailand, the change in the fisheries policy of Indonesia that disallowed the extension of licenses of fishing vessels from foreign countries had made it difficult for Thai trawlers to continue their joint ventures with Indonesia (The Nation, 2008). In the late 1970s, the fishes used as raw materials for surimi production, especially the threadfin breams and bigeye snappers were abundant in the waters of Thailand, *i.e.* in the Gulf of Thailand and Andaman Sea. The Department of Fisheries of Thailand reported in 1963 that fishing effort for threadfin breams yielded 276 kg/hour. However, it reduced to only 80 kg/hour in 1988 and only 20 kg/hour in 2000. Considering the rapid growth of the surimi industry in Thailand as well as the depletion of the country's demersal fishery resources, raw materials had to be sourced mostly from neighboring countries such as Myanmar, Indonesia, and Malaysia. Later, the new fisheries policy of Myanmar also impacted the limited operations of Thai trawlers in the country's waters after 2010.

1.2.1.1 Surimi Production

While the surimi production of Japan had been decreasing from 310,000 metric tons in 1989 to 132,000 metric tons in 1994, that of the other four major surimi-producing

Table 57. Number of processing plants for surimi production in Indonesia as of 2015

Company	City	Type of pro-cessing	Products	Capacity (metric tons/year)
JAVA Seafood, PT.	Kab[1]. Indramayu	Surimi	Frozen surimi	
PT. Devindo Nusantara	Kota Jakarta Utara	Freezing	Frozen fish (tuna, marlin, mahi Frozen surimi Frozen fish (small pelagic, demersal and freshwater)	1,200
PT. Blue Sea Industry	Kota Pekalongan	Freezing	Frozen surimi	21,000
Holi Mina Jaya	Kab. Rembang	Freezing	Frozen demersal fish Frozen pelagic fish Frozen shrimp Frozen cephalopods Frozen surimi	30,000
PT. Indoseafood	Kab. Rembang	Freezing	Frozen surimi	1,500
Laut Jaya Abadi	Kab. Kendal		Frozen surimi	
PT. Maya Food Indus-tries	Kota Pekalongan	Freezing Canning	Frozen surimi Canned sardines and mackerel	
PT. Nam Kyung Korea Indonesia (NKS)	Kab. Tegal	Freezing Drying	Frozen surimi Frozen fish Frozen sea cucumber Dried sea cucumber	7,500
PT. Phillips Seafood Indonesia	Kab. Pemalang	Canning	Pasteurized crab meat (in can)	1,500
PT. Sinar Bahari Agung	Kab. Kendal	Freezing	Frozen surimi	15,000
CV. Sinar Mutiara Abadi	Kab. Rembang		Surimi	6,000
PT. Andaman Delmar	Kab. Rembang		Frozen surimi	5,400
PT. Bintang Karya Laut	Kab. Rembang		Frozen surimi	1,200
PT. Alter Trade Indonesia	Kab. Sidoarjo	Freezing	Frozen surimi Frozen shrimp	1,500
PT. Istana Cipta Sembada	Kab. Banyuwangi	Freezing	Frozen value-added seafood	6,000
PT. Kelola Mina Laut Plant 1	Kab. Gresik	Freezing	Frozen cooked shrimp Frozen raw shrimp Frozen cephalopods Frozen pelagic fish Frozen value-added seafood	12,000
PT. Southern Marine Products	Kab. Probolinggo	Freezing	Frozen surimi Frozen pelagic fish	
PT. Starfood Internation-al	Kab. Lamongan	Freezing	Frozen surimi	15,000
PT. Tridaya Jaya Ma-nunggal	Kab. Pasuruan	Freezing	Frozen pelagic fish Frozen demersal fish Frozen surimi	2,400
PT. QL. Hasil Laut	Kab. Lamongan	Freezing	Frozen surimi	12,000
MITRA UTAMA, CV	Kota Surabaya	Canning	Fish nugget, fish meatball, fish sausage	

[1] *Kab is short for Kabupaten which means Regency*

countries, namely: Republic of Korea, Thailand, New Zealand, and the United States had increased from about 26,000 metric tons to 260,000 metric tons during the same period. The Korean surimi industry showed the greatest potential for independent growth among the Asian surimi producers with a production of 60,000 metric tons in 1989. During this period, the surimi industry in Thailand also showed considerable growth potential dependent on technical assistance from Japan. Such successes stimulated the development of the surimi industry in the Southeast Asian countries, especially in Indonesia, Malaysia, Myanmar, and Viet Nam.

As of 2005, there were eight processing plants for surimi production in Indonesia (Pangsorn *et al*., 2007) and in 2015, the number of processing plants increased to 21 with a production capacity of about 167,000 metric tons per year (**Table 57**).

The rapid growth of surimi industry in Southeast Asian countries as well as depletion of demersal fishery resources and emerging new fisheries policies, led to the reduction of raw materials that impacted on the supply required by the surimi producers. In order to address such concerns, SEAFDEC conducted a study on surimi industry and its raw materials in Southeast Asia during 2005-2008, and came up with recommended mitigation measures for the sustainable management of the region's demersal fishery resources (**Box 4**). These measures are meant to support the policy makers in promoting the proper management of demersal fishery resources particularly the raw materials for surimi production in the Southeast Asian region.

Box 4. Recommended measures to mitigate the conflicts between man and processing industries in exploiting the region's demersal fishery resources

1. Development of appropriate fisheries management systems
2. Strict enforcement of monitoring, control and surveillance (MCS)
3. Exploring the possibility of increasing the price for resource utilization, *e.g.* increasing price of surimi but striking a balance between price and resource management
4. Fishing operations to target only species for surimi production and avoiding the catch of juveniles of other commercially important species, *e.g.* promoting the use of juvenile and trash excluder devices (JTEDs)
5. Promotion of the continued use of trash fish or low-value fish for surimi production
6. Development of technology for using pelagic fishes in surimi production, *e.g.* horse mackerel
7. Reduction of post-harvest losses through good preservation and handling techniques onboard fishing vessels
8. Tapping of potential sources of raw materials outside the region for surimi production
9. Continued promotion of the use of trash fish mainly for surimi instead of promoting it for the production of fish meal for aquaculture and livestock
10. Maximizing the use of trash fish for human consumption in terms of fish meat or productin of traditional fish products
11. Continued development of technology for the utilization of freshwater fishes for surimi production

1.2.2 Live Reef Food Fish

Live reef fishes, the most valued commodities in fishery trade, have long been traded around Southeast Asia. Wild fishes which are captured from coral reef areas or reared in marine culture facilities entered this trade since the 1960s as luxury food items because of their superior taste and texture. A combination of gears targeting spawning aggregations and juveniles is used to catch the fish, while the use of destructive fishing methods is also carried out to harvest live food fish especially in coral reef areas. The first major report on the collection of live reef fish for food was written by Johannes and Riepen (1995) based on their research that involved extensive interviews with government officials, industry representatives, fishers, village leaders, university researchers, divers, dive tour operators, and NGOs. Personal visits to countries involved in the trade were also conducted. Barber and Pratt (1997) described the trading of marine ornamental and live reef food fishes, and emphasized that the use of cyanide is commonly practiced in catching these commodities throughout Southeast Asia and proposed to use possible environmentally-sound alternatives that are promoted by the Destructive Fishing Reform Initiative. Lau and Parry-Jones (1999) produced a detailed and comprehensive analysis of the Hong Kong live food fish market, the first quantitative research to be carried out using analyzed data from the Hong Kong Department of Census and Statistics (HK CSD).

1.2.2.1 Trading of live reef food fishes in Sulu-Sulawesi Sub-region

Reef fishes are particularly sought-after delicacy, and thus, the Chinese consumers have in recent years, turned to trading this commodity with countries well-endowed with coral reefs, such as the Philippines, Malaysia (notably Sabah), and Indonesia (Sulawesi Provinces). Hong Kong, the largest consumer of live reef food fish in Asia, has a largely urbanized population of 6.3 million and is a major center for live reef food fish trade in the region. As the demand has continuously increased in recent years, Hong Kong now imports live reef fish for food from many Southeast Asian countries as well as from Seychelles in the Indian Ocean.

Johannes and Riepen (1995) reported that the live reef food fish trade started in the late 1960s in Hong Kong. The most popular fish species traded at that time was the red grouper, *Epinephelus akaari*. Overexploitation of this species in Hong Kong and Chinese inshore waters forced fishers to move farther to Pratas Reef which is about 200 miles southeast of Hong Kong as well as to Spratlys and Paracel Islands in the South China Sea and Philippine waters. Trading of this species was so remunerative that by the mid-1980s premium live reef fish was being exported by air as well as by sea to Hong Kong. Started in the Philippines in 1975, the live reef fish trade has spread to Palau (1984), Indonesia (1985), Malaysia (1986), Papua New Guinea (1991), and in the 1990s to Maldives, Australia, Solomon Island and Marshall Islands, Kiribati (1996) and Seychelles, Fiji, Andaman and Nicobar Island in 1998, and the Maldives.

More than 21 countries could be exporting live reef fish to Hong Kong. Indonesia, Philippines, Malaysia, Thailand, Viet Nam, and Myanmar had become major Southeast Asian trade partners for Hong Kong and Australia, Marshall Islands, Pohnpei, Papua New Guinea, Palau, Yap, Solomon Islands, Kiribati, Tonga, Fiji from the Pacific Ocean. According to the 1999 research conducted by TRAFFIC East Asia and WWF Hong Kong, the total import of live reef fish into Hong Kong was estimated to be around 32,000 metric tons with wholesale value of US$ 500 million, based on 1997 import statistics (Lau and Parry-Jones, 1999).

Although Hong Kong appears to be the major importer of live reef fish for food, major expansion in the live reef fish trade also occurs in China, Taipei, Malaysia, and Singapore. According to Lau and Parry-Jones (1999), the common live reef fish imported into Hong Kong are the high-finned grouper (*Cromileptes altivelis*), humphead wrasse (*Cheilinus undulates*), giant grouper (*Epinephelus lanceolatus*), brown marbled grouper (*E. fuscoguttatus*), Sabah hybrid grouper (*E. polyphekadion*), orange spotted grouper (*E. coioides*), leopard coral grouper (*Plectropomus leopardus*), spotted coral grouper (*P. maculatus*), and squaretail leopard grouper (*P. areolatus*).

1.3 Challenges and Future Direction

Marine fisheries provide significant contribution to the region's total fisheries production, accounting for 40% by quantity and 50% by value. In assuring the sustainable utilization and management of marine fishery resources, it is necessary to have adequate data and information on the status of the concerned species. Large quantities of marine capture fisheries are derived from pelagic fishery resources, such as tunas, round scads, mackerels, anchovies, sardines, among others. Nevertheless, due to the migratory and transboundary nature of most pelagic fish species that are shared among many countries, and because these fishes move across the waters of the countries in the region, regional collaboration is necessary at appropriate levels, *e.g.* bilateral and sub-regional levels, to ensure the sustainable utilization of these fish species.

For tunas, the management of oceanic tunas is being undertaken under the purview of Regional Fisheries Management Organizations (RFMOs), particularly the IOTC for the Indian Oceans and the WCPFC for Western Central Pacific region. Neritic tunas which are not covered by WCPFC but are economically important for many countries in Western Pacific Ocean of the region should be properly managed. Therefore, in order to put in place the sustainable utilization of the neritic tunas, the SEAFDEC Council in 2015 endorsed the Regional Plan of Action for Conservation and Management of Neritic Tunas or RPOA-Neritic Tunas which was developed by the AMSs under the guidance of SEAFDEC. Based on the framework of the RPOA-Neritic Tunas, stock assessment has been undertaken by concerned countries for some neritic tuna species. However, data collection still needs further improvement for the long term management of the species, particularly for the management of fishing capacity and sustainable utilization of the species which should be carried out through close collaboration among the concerned countries. For other small pelagic fishery resources in the region, lack of historical data on landing of the catch and CPUE caused difficulties in understanding the status of the resources. Hence, improved data collection of the species is also required to serve as basis for the sustainable management of the fisheries.

Other important groups of marine fishery resources comprise the demersal species, of which several low-value species have been used as raw materials for the production of surimi – one of the very important fishery products of the region since the 1980s. Due to complexities in accessing the data on the status of the region's surimi industry, collaboration among the Member Countries is necessary in order to obtain more data and information from the major surimi-producing countries. Reef fishes are another important group of demersal fishery resources, which are very highly economical, especially in terms of value from trade either as live reef food fish (LRFF) or ornamental fish. Live Reef Food Fish Trade (LRFFT) involves the capture of reef fishes which are kept alive for sale and consumption mainly in Hong Kong and mainland China. Even though live fish have long been traded around Southeast Asia as a luxury food item, trading of fish captured from coral reefs has expanded rapidly in recent decades. As a consequence, LRFFT has become a major threat to the coral reef ecosystems and marine biodiversity, aside from the impacts from overfishing, capture of juvenile fishes for grow-out and spawning aggregations, use of destructive fishing practices such as cyanide and other destructive gears, IUU fishing; and undervaluation of the resources. To address the concern on the vulnerability of LRFF, the Southeast Asian region and the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) member countries adopted in 2013 the "***Resolution on Sustainable LRFFT***." However, due to the continued illegal trading of LRFF in large quantities, especially to major markets not within Southeast Asia, the first steps towards addressing this issue is to seek the cooperation of these concerned countries for them to provide the relevant information which could lead to better understanding of situation on LRFFT, and come up with the appropriate measures and incentives that could enhance the sustainable utilization of LRFF resources.

Deep sea and offshore aquatic species, *e.g.* deep sea shrimps, oceanic squids, are another group of fishery resources that have potentials for utilization, but knowledge on the status of these resources is still inadequate due to difficulties in undertaking resource surveys and data collection. Although many of these species could be considered underutilized at this stage, activities toward their exploration, identification of fishing grounds, and promoting the utilization of these resources should be undertaken with extreme caution, considering that without adequate knowledge on the resources and measures to ensure proper management for their sustainable utilization, such resources could be overharvested and degraded to the extent that their stocks could not recover anymore.

2. INLAND FISHERY RESOURCES

2.1 Status, Issues, and Concern

Inland capture fisheries play an important role in sustaining food security requirements, employment, and income generation for people living along the inland waters in the Southeast Asian region. Specifically, inland fisheries provide high quality protein, essential nutrients, and minerals that are often difficult to obtain from other sources of food. Inland fisheries also provide economic opportunity and a “safety net” that allows for continued food production when other sectors may fail (Bartley and Jorgensen, 2010).

In the Southeast Asian region, inland capture fisheries comprise a large number of small-scale fishers, who are mostly subsistent and engaged only in part-time fishing activities. Therefore, most of those engaged in these fishing activities are also having other occupations like farming or even livestock-raising, and as such, many of them could not be categorized solely as fishers. Most activities related to inland capture fisheries are highly seasonal, which could peak during flood receding periods or at the end of the rainy season, the period when fish growing in floodplains would usually move back to rivers and streams, enhancing the fish stocks but risking to be caught by readily-installed stationery fishing gears. Production of inland capture fisheries is also highly diversified, where most of the catch although large in number and quantity, could be small in size and with high species diversity. Furthermore, in rural areas, there are no designated fishing ports, especially for non-commercial activities. Thus, production from inland fishery resources is not only freely accessed at any time but could also be landed anywhere without any recording, and goes to various channels, with a large portion meant for household consumption (Pongsri, 2014).

Based on the Fishery Statistics Bulletin of Southeast Asia (SEAFDEC, 2005a; 2006; 2008a; 2008b; 2009a; 2010a; 2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a), the total production from inland capture fisheries in the region has continuously increased for more than double over the past 15 years, from 1.36 million metric tons in 2000 to 3.03 million metric tons in 2014 (**Table 5** and **Table 20**). The top inland capture fisheries producing country in Southeast Asia in 2014 was Myanmar accounting for 46% of the total production from inland capture fisheries of the region followed by Cambodia, Indonesia, Philippines, Thailand, and Viet Nam (**Figure 17**). Although fishery statistics data indicated an increasing production trend from inland capture fisheries, the sub-sector has been facing with several issues that threaten its sustainability. One of the main challenges is the rapid growth of human activities, which impacts the inland-water environment including fish habitats, fish migration, water quality, and the inland fishery resources as a consequence (FAO and MSU, 2016). The impacts of climate change also led to changes in water regimes and all activities involving the inland water resources.

2.1.1 Inland Fisheries for Food Security and Poverty Alleviation

Inland fisheries involve large numbers of not only small-scale fishers but also those people engaged in all the stages of the commodity chain of the sub-sector. Thus, inland fisheries operations could be one of the very important measures for reducing poverty especially in rural areas, *e.g.* in the lower Mekong River Basin, as well as in remote, rural areas of the Southeast Asian region. Especially for landlocked country like Lao PDR where all its capture fishery production is derived from inland areas, this sub-sector is very significant for sustaining livelihoods and providing the nutritional requirements of its people.

2.1.2 Data Collection on Inland Capture Fisheries

The unique characteristics of inland capture fisheries, *i.e.* comprising large numbers of small-scale and/or part-time fishers, high seasonality and complexity of fishing activities, diversity of species composition, lack of designated ports, and large portion of the production going directly to household consumption, make collection of data and information on fish production a laborious effort to pursue. As a result, most inland capture fisheries statistics are recognized as underestimated. In addition, reporting systems used by enumerators do not seem to cover all fishers and landing sites, as the distribution and consumption pattern of inland fishery products are external to the usual major commodity chains (Welcomme, 2011). Data collection is also hard to undertake considering that inland fisheries use various types of fishing gears, activities, and methods.

The insufficient data therefore does not provide enough information on the status and trend of inland fisheries, leading to little awareness and understanding of the public, stakeholders and policy makers on the importance of inland capture fisheries. This is one of the big challenges in the sustainability of inland capture fisheries. Thus, it is necessary that data collection systems and methods that are applicable to various conditions and background of inland capture fisheries in the region should be improved, which should also incorporate not only quantity but also species composition of the catch, so that the contribution of this sub-sector to the sustainability of fisheries in the region could be visualized.

2.1.3 Impacts of Water Barrier Construction on Inland Fisheries

Sustaining the production of inland capture fisheries requires that inland aquatic habitats and ecosystems should be maintained so that the biological and ecological requirements of aquatic species that inhabit inland waters could be fulfilled. Nevertheless, rapid development creates impact on the connectivity of aquatic habitats, *e.g.* construction of dams and weirs affects upstream and downstream migration of aquatic species, construction of other obstacles such as roads also impedes larval dispersal, threatens the survival of aquatic organisms, and eventually affects the productivity and sustainability of inland capture fisheries. In the Southeast Asian region, several infrastructure-construction projects are approved every year for power generation and/or irrigation, *e.g.* hydropower projects in the Mekong River Basin and other riverine systems and irrigation dams to improve agriculture production in several watersheds of the region. The accumulated impacts from these development projects would result in decreasing fishery resources and productivity from inland waters impinging the cultural, social, and economic values of people in the region (Baumgatner, 2014). Only a few of the many development plans takes into consideration the appropriate mitigation measures that could minimize the impacts of constructing such structures on inland aquatic habitats and fishery resources. Promoting the adoption of appropriate designs of facilities, *e.g.* fishways, is therefore necessary to mitigate the impacts of these constructions and operations of cross-river obstacles to fishery resources, particularly during the peak migration of the aquatic species.

2.1.4 Complexity of Inland Capture Fisheries and Linkages with Other Sectors

Inland fisheries in the Southeast Asian region are characterized by "diversity" and "complexity" in relation with the variation of targeted aquatic species, fishing methods, aquatic environment, life styles of fishers and residents, developmental stages of each area or country, roles of inland fisheries in each area or community, and also the complicated relationships with other sub-sectors surrounding inland fisheries and fishers' livelihood (IFRDMD, 2016). Taking into consideration such complexity, several types of fisheries management measures have been developed and could be used in each country or area corresponding to the specificity of the areas, climatic conditions, fishing methods, and also policies of the respective Southeast Asian countries.

Recognizing that human activities such as urban development, industrialization, massive plantations, agricultural intensification, tourism, and other development constructions are among the major causes that affect the status and sustainability of inland capture fisheries in the Southeast Asian region, it is necessary that operations as well as activities related to the use of inland waters by all components and sectors should be harmonized keeping in mind the need to strike a balance between prosperity and sustainability of the resources and environment. Nevertheless, insufficient data and information that could justify the importance of inland capture fisheries makes it difficult for the fisheries sector to convince the public and policy makers on the significance of conserving the aquatic habitats and balancing the needs and trade-offs between fisheries and the other sectors.

2.1.5 Inland Capture Fisheries Compared with Aquaculture

In addition to inland capture fisheries, freshwater aquaculture also contributes to fish production and nutritional requirements of people in the Southeast Asian region. Therefore, it is necessary to understand the strong link between inland fisheries and aquaculture, especially the interaction of these two sub-sectors, *e.g.* the use of inland fishery resources in capture-based aquaculture, the role of hatcheries in supporting culture-based fisheries (Bartley and Jorgensen, 2010). Aquaculture also provides alternative livelihoods and food resources to fishers leaving the capture fisheries sub-sector. However, the total production and recent growth rates of inland capture fisheries and freshwater aquaculture show differences in the trends. While the total production from inland capture fisheries in Southeast Asian region has grown from by 2.2 times over the past 15 years from 1.36 to 3.03 million metric tons with value reaching 3.7 billion US$ in 2014, that of the region's freshwater aquaculture has grown by 5.9 times in the last 15 years from 1.29 to 7.56 million metric tons valued at 7.4 billion US$ in 2014. Although such production trends (**Figure 64**) seem to signify the increasing important roles and the potentials of freshwater aquaculture compared with that of inland capture fisheries, such a situation should not mislead the public as there are several aspects that freshwater aquaculture could not provide the production

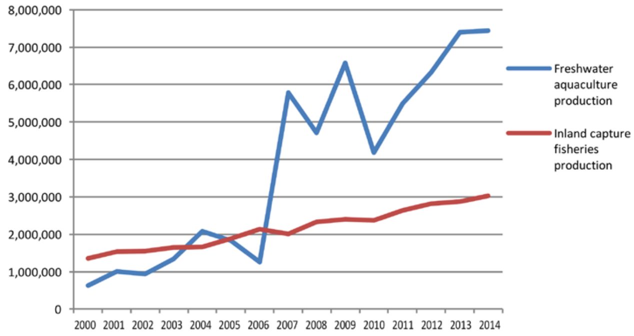


Figure 64. Production trend of inland capture fisheries and freshwater aquaculture in Southeast Asia

Source: *SEAFDEC (2005a; 2006; 2008a; 2008b; 2009a; 2010a; 2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a)*

substitutes from inland capture fisheries. For example, in terms of its contribution to food security for the poor and disadvantaged groups of people dependent on the harvest of natural resources, inland capture fisheries serve as important sources of micronutrients and calcium requirements from small fishes. Furthermore, the possible impacts of freshwater aquaculture on the environment, *e.g.* restriction of access to inland water bodies, discharge of effluents that contaminates natural aquatic habitats, spread of diseases and pathogens, culture of few commercial species impacting biodiversity and genetic diversity in natural habitats, introduction and contamination of non-indigenous or invasive species, should also be considered.

2.2 Challenges and Future Direction

In mitigating the impacts caused by human activities (fisheries and non-fisheries sectors) on the sustainability of inland capture fisheries and assuring that the sub-sector would continue to provide significant contribution to food security and livelihood of people in the region, there are various approaches that should be taken into consideration.

2.2.1 Improvement of Data Collection and Dissemination

The inadequacy of reliable data and information on inland capture fisheries and its contribution to the well-being of the people in the region is one of the most important issues that should be addressed, as such a situation threatens the sustainability of the sub-sector. Lack of necessary data led to the low attention given by planners and policy makers on the need to conserve the aquatic habitats, and as a result, priorities are given to other sectors sharing the same water resources or to some extent, even converting aquatic habitats or diverting water resources to other development purposes. Recognizing that fishery statistics is important as basic information to support planning and policy making, valuation of inland capture fisheries and related aquatic ecosystems should be pursued taking into consideration either the direct or indirect benefits that could be derived from the ecosystems. While it is also well-recognized that collection of relevant data and information is a prerequisite, the need to analyze, interpret, and disseminate such information is also equally crucial in order that the importance of inland capture fisheries is appropriately acknowledged, and trade-offs with other sectors could also be balanced to ensure the sustainability of inland capture fisheries in the future.

2.2.2 Habitat Conservation and Restoration

Inland waters contain large numbers of aquatic species that are adapted to the many different types of environment. In recent years, rapid increase of population and human activities in the Southeast Asian region has generated severe consequences on the conditions of inland waters, such as pollution, degradation of water quality, and so on. The negative effects of anthropogenic activities threaten the habitats of aquatic species and inland capture fisheries as a consequence (FAO and MSU, 2016). Several measures have been developed to conserve the environment although every conservation measure needs collaborative efforts among sub-sectors using the inland waters. Building the awareness not only of fishers but also of the other sub-sectors should be promoted so that measures to conserve the habitats of aquatic species are adapted by all concerned sub-sectors. At the same time, local knowledge, social structure, traditional culture, education, and other factors should be considered simultaneously.

2.2.3 Application of Fish Passage to Mitigate the Impacts of Cross-river Obstacles

Inland capture fisheries in the Southeast Asian region are increasingly threatened by riverine development projects including construction of cross-river obstacles that create barriers to fish migration. The effect of such migration barriers however could be mitigated by the establishment of fishways, which are channels around or through fish migration barriers that allow free passage of fishes during their migration. Although fishways have been set up in many riverine development projects worldwide and helped mitigate factors that hinder the sustainability of inland fisheries globally, it is important that fishway design criteria are established to cater to local aquatic species, and not just adapted from studies conducted elsewhere. Initiatives have therefore been undertaken by many countries in the Southeast Asian region to come up with fishway designs that are appropriate for the region.

Lao PDR is one of the countries where several projects had been implemented with respect to installations of fishways taking into consideration the emerging international concern over the country's national policy that supports hydropower generation as cost-effective source of energy. During the past decade, support from several agencies and organizations, *e.g.* the Australian Center for International Agricultural Research (ACIAR) and Mekong River Commission (MRC), had been extended to the country for the sustainable development of its water infrastructures that include maintaining upstream and downstream fish passage, improving understanding of the technologies that facilitate fish migrations onto and from floodplains, and enhancing the country's capability to apply low-head fish passage technologies at various levels and improve biodiversity in the floodplains.

In other Southeast Asian countries, a number of cross-river obstacles have been constructed for several purposes, *e.g.* hydropower generation, irrigation, domestic water supply, flood control, among others. Although most of these obstacles have low-water head (*e.g.* less than 7 m) but the accumulated impacts of such construction particularly to the upstream-downstream migration of fish could also be enormous. During 2015-2017, SEAFDEC with support from ACIAR undertakes a project to design and construct experimental fishway facilities in an easily accessible site to facilitate on-station research where different parameters could be controlled and experimented, focusing on vertical-slot design and targeting at low-head weirs. In addition, public awareness and understanding have been enhanced through on-station demonstrations on the use of fishway to mitigate the impacts of cross-river construction on the inland fishery resources.

To encourage future application of fishways, investigation should be made to evaluate and enhance their effectiveness. Furthermore, methodologies for analyzing the cost-benefit analysis of fishways should also be developed considering the costs of construction, operation, and maintenance of the facilities; expected increased incomes from harvests of the fishery resources; benefits to human health; as well as other ecosystem services that could be rendered from the improved connectivity of habitats through the fishways.

2.2.4 Mitigating the Impacts of Freshwater Aquaculture

The rapidly increasing freshwater aquaculture activities could negatively affect the inland capture fisheries and freshwater environment. Freshwater aquaculture in the Southeast Asian region often uses floating cages in natural water bodies and seedstocks are fed intensively. In some areas, it is possible that introduced species escape from cages or culture ponds into the natural environment expelling the native species, including economically important species and endemic species. Seedstocks that are introduced from different water bodies could also bring with them unknown diseases that are passed into the natural environment. Excessive feeding of cultured fish results in the eutrophication of water bodies and degradation of water quality leading to degraded aquatic resources as a consequence. Competition for the use of waters and areas could also happen between inland fishers and fish farmers (FAO and MSU, 2016). The development of freshwater aquaculture should therefore be promoted in accordance with the carrying capacity of inland water bodies and should take into consideration the possible effects of such aquaculture operations on the water bodies, environment, and existing inland capture fisheries.

3. MARINE SPECIES UNDER INTERNATIONAL CONCERN

3.1 Sharks and Rays

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) promotes the conservation and protection of endangered species of sharks, skates, and rays (elasmobranches) to ensure that their international trade does not threaten the survival of the species in the wild. Meanwhile, FAO promoted the International Plan of Action for Conservation and Management of Sharks (IPOA-Sharks) which was adopted during the Meeting of the FAO Committee on Fisheries (COFI) in 1999. The IPOA-Sharks also intends to provide a framework for the development of national, sub-regional, and regional plans as well as assessments of sharks in the member countries' respective waters and also for transboundary species of sharks.

The Southeast Asian region has rich biodiversity of elasmobranch species. It has been recorded that at least 180 species of sharks, 30 species of skates, and 160 species of rays inhabit the Southeast Asian region from freshwater environments to the deep seas (SEAFDEC, 2016g). The AMSs developed and implemented their respective National Plans of Action for Sharks (NPOA-Sharks) subsequent to that of the IPOA-Sharks published in 1998, by updating the status of the resources, biodiversity, socio-economic aspects as well as information related to trade. Records also show that in the Southeast Asian region, almost all parts of sharks and rays including their meat, skin, liver as well as cartilages, are fully utilized.

In Southeast Asia, sharks and other elasmobranchs are by-catch of hook-and-line, gillnet, trawl net, purse seine net, and other fishing gears. Even though the Southeast Asian waters have one of the richest elasmobranch diversity of the world, the status of production and utilization of sharks and other elasmobranchs is still largely underdetermined due to insufficient data including information on catch and landings at identified species level. Moreover, information on trade as well as on the biological parameters of many shark species are also difficult to establish due to the limited capacity in collecting fishery data of most countries in Southeast Asia. Nevertheless, SEAFDEC reported that the total landing of sharks and rays of the AMSs in

Table 58. Production of sharks of the Southeast Asian countries from 2008 to 2014 by quantity (metric tons)

	2008	2009	2010	2011	2012	2013	2014
Brunei Darussalam	29	15	19	N/A	N/A	6	N/A
Indonesia	125,336	40,960	49,651	59,403	45,651	56,720	57,521
Malaysia	7,346	7,236	6,793	14,735	6,536	7,833	8,004
Philippines	2,380	2,635	2,798	2,556	2,300	2,129	1,955
Singapore	17	20	10	29	24	24	59
Thailand	2,834	2,826	2,936	2,574	2,338	2,064	2,308
Total	**137,942**	**59,392**	**62,207**	**79,297**	**56,849**	**68,776**	**69,847**

Source: *SEAFDEC (2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a)*

Table 59. Production of rays of the Southeast Asian countries from 2008 to 2014 by quantity (metric tons)

	2008	2009	2010	2011	2012	2013	2014
Brunei Darussalam	69	56	63	N/A	N/A	47	N/A
Indonesia	113,012	44,660	44,478	45,084	56,403	56,067	61,953
Malaysia	11,642	15,031	13,770	13,021	15,612	15,774	17,275
Philippines	2,370	2,591	2,713	2,501	2,276	2,163	1,918
Singapore	117	143	105	112	115	93	77
Thailand	6,245	6,219	6,089	5,646	4,296	4,195	4,445
Total	**133,455**	**68,700**	**67,218**	**66,365**	**78,702**	**78,339**	**85,668**

Source: *SEAFDEC (2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a)*

2014 was approximately 69,847 and 85,668 metric tons, respectively (SEAFDEC, 2014), showing a decrease in harvest of sharks and rays in Southeast Asia of about 49.36% and 35.81%, respectively over a seven-year period. Information on the production trends of major species of sharks and rays in the AMSs as reported in the Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a) are shown in **Table 58** and **Table 59**, respectively.

Information on the trends of marketing and trade as well as competitiveness of sharks and rays at national and regional levels in the Southeast Asian region compared to its trade partners in the world are very important to provide an indication of the extent of commercialization activities of these commodities. Profiling the middlemen, their marketing activities, and practices are therefore crucial to determine the economic roles of each type of middlemen along the supply chain and the value creation on the products. Information on various factors could also provide the indicators of the commodification and marketization of sharks and rays at national and regional level, *i.e.* the major players, value-adding activities, roles of prices on the supply and demand of shark and ray products, and consumer preferences. Moreover, such information could also provide valuable inputs towards designing a sustainable development plan for conservation of sharks and rays from all angles, *i.e.* production, supply, demand, marketing, and resource management.

Meanwhile, during 2013-2016, nine species of sharks and 12 species of rays were listed in Appendix II of CITES, and trading of aquatic species listed under Appendix II of CITES is regulated. Moreover, during the Sixteenth Conference of Parties CITES (CoP16-CITES) in 2013, five species of sharks and all three species of manta rays were also listed in Appendix II. These included the oceanic whitetip shark (*Carcharhinus longimanus*), porbeagle shark (*Lamna nasus*), scalloped hammerhead shark (*Sphyrna lewini*), smooth hammerhead shark (*Sphyrna zygaena*), great hammer-head shark (*Sphyrna mokkaran*), giant manta ray (*Manta birostris*), Alfredi manta ray (*Manta alfredi*), and new species of giant manta (*Manta birostris*). Three years later, during the CoP17-CITES, another four species of sharks and all nine species of mobula rays were listed in Appendix II of CITES, these are the silky sharks (*Carcharhinus falciformis*), thresher sharks (*Alopias pelagicus*, *A. superciliosus*, *A. vulpinus*), and all nine species of devil rays (*Mobula* spp.). In the subsequent CITES-CoP17 in 2016, various issues and concerns on the listing of various aquatic species (including sharks and rays) in the CITES Appendices had been noted and compiled (**Box 5**), which could be reflected in the common position of the AMSs to be raised during the subsequent CITES-CoP.

Based on studies by Ahmad and Lim (2012) and Ahmad *et al*. (2014), silky sharks, all hammerhead sharks, two manta ray species (*Manta birostris*, *M. alfedi*), all three species of thresher sharks and six species of mobula rays (*Mobula japanica*, *M. kuhlii*, *M. thurstoni*, *M. eregoodootenke*,

Box 5. Issues and concerns that could be reflected in the common position of the AMSs during CITES-CoP

a. Most Heads of Delegations of Party are largely from national terrestrial environmental departments, and thus, might have limited knowledge and interest in fisheries issues especially on their impacts to national socio-economies and livelihoods of local fishers
b. Very successful, well-funded NGO media and engagement campaign centering on the message that 'marine species need saving from extinction' as well as other kinds of campaigns, are held continuously and simultaneously during the CITES-CoP, while attractive posters, flyers, books, souvenirs, and the like, are widely distributed for free before the voting
c. Repeated narrative mostly from environmentalists and NGOs seem to indicate that National Fisheries Management and RFMOs are 'not working' and are 'largely ineffective' to conserve and manage sharks and rays resources
d. Most Heads of Delegations of Party believe that CITES is working, despite no clear mechanism or discussion for measuring its effectiveness or efficiency
e. Based on past experiences during CITES-CoP, especially with regards to commercially-exploited aquatic species, the Parties seemed to largely 'favor' and support all proposals to list sharks and rays in any Appendices of the CITES

M. tarapacana and *Mobula* spp.) inhabit the Southeast Asian waters. These species are mostly caught as by-catch either in purse seine and longline as well as in gillnet fisheries targeting the commercially-important bony fish species. Based on the data collected from August 2015 to July 2016, mobula rays and thresher sharks are among the common species caught in Indonesia, while *Sphyrna lewini* is caught in Myanmar and Malaysia (SEAFDEC, 2016g). Meanwhile, from the regional and national studies conducted by SEAFDEC and the AMSs from 2003 to 2016, there are 182 species of sharks, 148 species of batoids (including rays and skates), and 7 species of chimaeras found in the Southeast Asian region (**Table 60**).

Table 60. Number of species of sharks, batoids and chimaeras Southeast Asian countries

Country	Number of species		
	Sharks	Batoids	Chimaeras
Cambodia	11	54	0
Indonesia	117	106	4
Lao PDR	0	3	0
Malaysia	70	91	1
Myanmar	59	87	0
Philippines	94	66	3
Thailand	76	82	2
Viet Nam	52	54	0

3.1.1 Challenges and Future Direction

The AMSs should improve their national statistics by recording the landing of sharks, batoids and other elasmobranches at species level, as this constitute the major issues and challenges on sustainable utilization of elasmobranches in Southeast Asia. Furthermore, AMSs should enhance the understanding of stakeholders on the importance of sharks and rays in the region, establish fisheries management measures for conservation and management of sharks and rays, and compile and regularly update their respective information on harvests and utilization of sharks and rays.

Considering that Parties are largely in 'listing mood' especially for sharks and rays. a trend which is expected to continue in the coming CITES-CoP in 2019, the AMSs should strengthen their effort in compiling relevant information especially scientific data for preparation of the Non-detriment Findings (NDFs) for sharks and rays as required by CITES. Listing of economically important species under CITES Appendix II could affect the livelihoods of local fishers and traders, especially that some countries consider such species as protected under their national laws and regulations without scientific data. Furthermore, no legal trade and import of their products by CITES Parties would be permitted without an NDF. In this regard, data collection at species level must be continued in the Southeast Asian region for the development of NDFs for individual species.

The consequences of the listed species could affect and become a burden to the Scientific Authority and Management Authority of the AMSs due to lack of human resources and expertise in the identification of by-products which are available in many forms in the trade channels. In general, there are no specific catch or trade documentation schemes for sharks and rays in the Southeast Asian region, although general catch documentation systems exist in some countries to monitor the species composition of the shark fin trade. Such systems should be enhanced and sustained as the compiled information would provide insights into the trade. Established mechanisms adopted in the trade channels should be given more focus and that national and regional trade study should be carried out taking into consideration such mechanisms.

Consultations at regional level should be pursued to obtain better understanding on the relevant events that led to the listing of commercially-important species of sharks and rays in the CITES Appendices, and the lessons that could be gained from these events, to ensure that similar concerns would not be repeated in the future and that real gains are achieved. More efforts at national and regional levels are needed, *e.g.* capacity development, species identification, and development of guidelines on NDFs, especially for the Southeast Asian region. In this regard, SEAFDEC would come up with the 'Regional Guidelines' for conducting NDFs based on locally available data and current fisheries issues.

3.2 Eels

Anguillid eels (Family Anguillidae) are distributed throughout tropical and temperate waters, except for the Eastern Pacific and South Atlantic (Silfvergrip, 2009, in Crook and Nakamura, 2013). There are 19 species of eels under Genus *Anguilla* that had been reported in the world, of which 11 species are found in tropical waters (Ege, 1939 in Watanabe *et al*., 2009), and 10 species or subspecies are distributed in the Southeast Asian region (**Figure 65**), namely: *Anguilla bicolor bicolor* McClelland 1844, *A. bicolor pacifica* Schmidt 1924, *A. marmorata* Quoy and Gaimard 1824, *A. celebesensis* Kaup 1856, *A. nebulosa nebulosa* McClelland 1844, *A. interioris* Whitely 1938, *A. borneensis* Popta 1924, *A. bengalensis* Gray 1831, *A. luzonensis* Watanabe, Aoyama & Tsukamoto 2009, *A. japonica* Temminck & Schlegel, 1846 (Ege, 1939 in Watanabe *et al*., 2009; Castle and Williamson, 1974; Arai *et al*., 1999; Fahmi, 2015; Watanabe *et al*. 2009; Yoshinaga *et al*., 2014).

The global production of eels has risen dramatically from 17,750 metric tons in 1950 (only 3% came from aquaculture or eel farming) to 280,000 metric tons in 2007 (96% from eel farming), after which the production stabilized in 2008-2010 (FAO, 2012 in Crook and Nakamura, 2013). However, wild populations of Anguillid eels have declined considerably over the last 30 years because of several factors, including fishing for trade (Dekker *et al*., 2009 in Crook and Nakamura, 2013).

In the present situation, only Indonesia and Philippines have provided the data on the production quantity of Anguillid eels from inland capture fisheries in Southeast Asian waters (**Table 61**). The trend of the total production of Anguillid eels (captured, excluding aquaculture) had been increasing since 2012, although the reasons or causes of such increases remain unknown.

The need to promote the conservation and management of eel resources has been attracting much attention while the resources of the temperate Anguillid eels, such as *A. japonica* (Japanese eel), *A. anguilla* (European eel) and *A. rostrata* (American eel), have rapidly decreased. Since 2009, *A. anguilla* has been listed in CITES Appendix II virtually prohibiting their export and import. To compensate the shortage of supply from these temperate Anguillid eels, tropical Anguillid eels such as *A. bengalensis* (Indian mottled eel), *A. bicolor bicolor* (Indonesian shortfin eel), and *A. marmorata* (marbled eel) became the most economically-important Anguillid eel species in the region. It is therefore necessary that these resources should be conserved and managed properly, to ensure that these would not become critically endangered and be listed on the CITES Appendices.

SEAFDEC had summarized the current situations and issues on both eel fisheries and eel culture in the Southeast Asian region in the "Regional Policy Recommendations on Conservation and Management of Eel Resources and Promotion of Sustainable Aquaculture" (SEAFDEC, 2015c) for sustainable management of tropical Anguillid

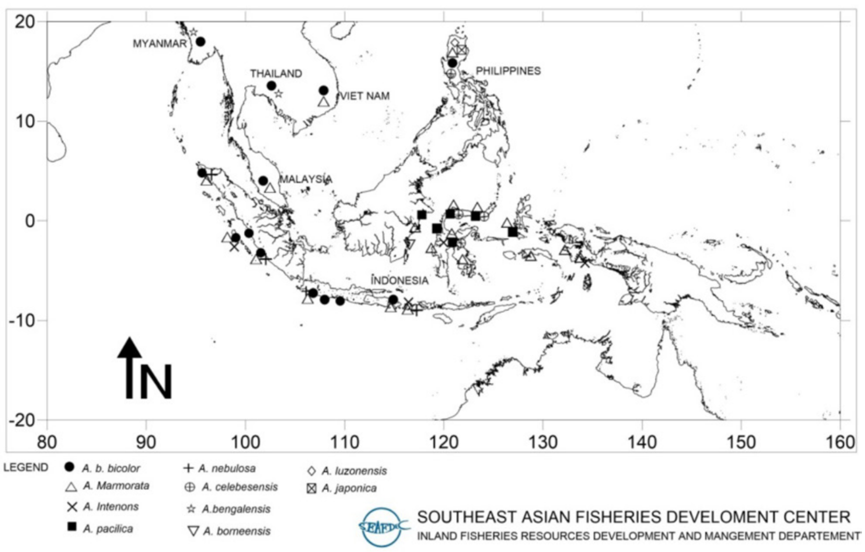


Figure 65. Distribution of Anguillid eels in Southeast Asia
Source: *SEAFDEC/IFRDMD (2016)*

Table 61. Production of Anguillid eels from inland capture fisheries in Indonesia and the Philippines from 2007 to 2013 by quantity (metric tons)

Country	2007	2008	2009	2010	2011	2012	2013
Indonesia	1,235	645	1,060	1,149	557	2,691	2,939
Philippines	NA	710	835	719	867	1,149	2,489

NA: Data not available
Source: *SEAFDEC (2010a; 2010b; 2011; 2012a; 2013; 2014; 2015a; 2016a)*

Box 6. Challenges and issues on conservation and management of tropical Anguillid eels

- Catch statistics is one of the most fundamental data to monitor the present status and recent trend of both fisheries and fishery resources. However, data and accuracy on catch statistics of Anguillid eels in the region had not been sufficient (Honda *et al.*, in press). In addition to concerns on precision of the statistics itself, there had been confusions resulting from the different naming and classification of the stages or size classes of juvenile Anguillid eels in each country and/or area. Furthermore, catch statistics of Anguillid eels are sometimes mixed with other look-a-like species, such as the rice-paddy eels.
- Regulations on trading of eels are available in several countries, *e.g.* export of eels smaller than 150 g is prohibited in Indonesia and smaller than 15 cm in length in the Philippines. Effective implementation of these laws and regulations is therefore crucial to conserve the eel seed resources.
- Considering the migratory nature of Anguillid eels, *i.e.* from the deep oceans to freshwater rivers, their migratory routes along rivers could be long with obstacles and conditions that hinder migration. In addition to fishery, utilization of inland waters by human activities also causes the decrease of eel resources due to habitat alteration, pollution, and so on, which could create negative impacts on eel habitats in inland waters resulting in decreased eel resources. Extensive habitat loss also plays an important role together with regional climate phenomena and overfishing, in the decline of the Japanese eel in East Asia. Integrated management planning is therefore necessary for the restoration and protection of Anguillid eel's habitat (Chen *et al.*, 2014).
- Regarding the eel culture industry in the Southeast Asian region, reports indicated very low survival rate of juvenile eels in artificial ponds and aquariums posing serious problems for the management of eel farms as well as efficient use of natural eel seed resources.

eel resources in the region. These recommendations had been adopted by the Forty-seventh Meeting of the SEAFDEC Council in April 2015. Nonetheless, the typical challenges and issues that should be improved are indicated in **Box 6**.

After the surveys on Anguillid eel fisheries and eel culture conducted in the SEAFDEC Member Countries, the "Way forward for Enhancing the Sustainability of Catadromous Eels in Southeast Asia" is summarized and the detailed issues and required concrete actions to solve these problems are also identified (*http://www.seafdec.or.id/*). The SEAFDEC Member Countries have been requested to exert efforts in conserving the Anguillid eel resources of the region in a coordinated manner.

3.3. Sea Turtles

The Southeast Asian region has one of the biggest sea turtle nesting populations in the world. Six out of the seven species of sea turtles are confirmed to nest or inhabit the Southeast Asian waters. These are the leatherback (*Dermochelys coriacea*), green turtle (*Chelonia mydas*), Olive Ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricate*), loggerhead (*Caretta caretta*), and the Kemp's Ridley (*Lepidochelys kempi*) which can only be found in eastern Indonesia waters. The flatback turtle, although its nesting locality is restricted to Australian territories, forages within the Indonesian waters (Limpus *et al*., 2002). The green turtle is the most dominant species in Southeast Asia and serves as the guideline in the formulation of management plan.

Indonesia had been recognized as the main habitat of green turtles in the region, recording more than 100 nesting beaches throughout country followed by Philippines, Malaysia, Myanmar, Thailand, Viet Nam, and Cambodia. Selingan Island in Sabah, Malaysia has been reported to have the highest number of nesting beaches for green turtles in the region with annual nests that range from 10,000 to 12,000. For the leatherback turtle, the nesting population at Indonesia's Irian Jaya nesting beaches is reported to be the highest in the region recording more than 100 nestings annually followed by Philippines and Malaysia as recorded in 2010. However, lack of comprehensive tagging activities on sea turtles is the main issue that needs to be addressed in order to obtain the actual nesting population of sea turtles in the region.

The waters of Southeast Asia are also the main feeding grounds for the green and hawksbill turtles, where sea grass beds and coral ecosystems are their main foraging habitats. Results of the migration study on adult female sea turtles using satellite technology in the Southeast Asian countries conducted from 2008 until 2012 with funding support from SEAFDEC/MFRDMD, had indicated several possible sea turtle foraging habitats in the region such as Brunei Bay (Malaysia and Brunei Darussalam), Derawan Archipelago (Indonesia), Palawan Island (Philippines), Andaman Island (Myanmar), Sipadan and Mabul Islands (Malaysia), and Riau Archipelago (Indonesia and Singapore). In most of the foraging habitats, large groups of sea turtles consisting of various ages, spend their life in the foraging habitats for feeding and leave the habitats for nesting somewhere in the region. Hence, it is essential for each country in the region to protect the sea turtles and their habitats in the mainland as well as in open seas.

3.3.1 *International-related Issues on Utilization of SeaTurtles*

Illegal take and trade of marine turtles can assume various forms, from poaching of animals and eggs from nesting beaches to illegal taking of the animals from the sea. Typically, green and leatherback turtles are hunted for their meat; while the hawksbill turtle for its carapace as raw materials for various craftworks; while the eggs of loggerhead and olive ridley turtles are considered a delicacy. Turtle meat consumption reportedly still occurs in 75% of the Indian Ocean and South-East Asia (IOSEA) Signatory States, while trade in shell products seems to be predominant in many countries of East Asia.

Poaching of green and hawksbill turtles appears to be perpetrated mainly by Chinese and Vietnamese turtle fishers operating in the Coral Triangle area, especially in the waters of Indonesia, Malaysia, and Philippines. The main regional trade route for whole turtles and turtle derivatives seems to originate from Indonesia, Malaysia, and Philippines. Such products are directed mainly towards East Asia, where the demand is on the rise. For example, the mainland Chinese markets demand for turtle meat and other parts for medicine, and the Japanese and Taiwanese markets demand for the turtle scutes (*bekko*) to be used for traditional crafts. Therefore, the establishment of strong cooperation among the countries is highly needed for combating sea turtle poaching, exploitation activities, as well as illegal trade of sea turtles and their derivatives.

Some countries in the region have enacted legislations to prohibit direct take and domestic trade in turtles and turtle derivatives, with a number of countries having increased fines or tightened prohibitions in recent years. However, there is still considerable room for improvement in some countries where existing fines are inadequate as a deterrent to illegal activity, where lack of harmonization of legislations across states or provinces induces domestic trade, and where there is existing legislation but this is poorly enforced.

3.3.2 Conservation and Management of Sea Turtles in Southeast Asia

Recognizing the importance of protecting and conserving sea turtles and their foraging habitats, SEAFDEC/MFRDMD as a regional institution responsible for the conservation and management of sea turtles, developed the Regional Plan of Action (RPOA) of Sea Turtle Foraging Habitats in Southeast Asian Waters in 2014. The said RPOA has six objectives, and each Southeast Asian country could set their respective deadlines for carrying out the RPOA based on their capabilities. The objectives of the RPOA are to: 1) protect and conserve sea turtle foraging habitats; 2) reduce direct and indirect causes of sea turtle mortality in foraging habitats; 3) strengthen research and monitoring of sea turtle foraging habitats; 4) increase community participation through information dissemination and education; 5) strengthen integrated management of sea turtles; and 6) secure funding for Sea Turtle Conservation.

Several programs and actions had been proposed in order to achieve these objectives, which were prepared as guidelines for each AMS to carry out according to their own capability. The outputs and indicators of each activity are also proposed in the RPOA for the evaluation of the country's achievements.

3.3.3 Existing Measures Undertaken by Relevant AMSs

Sea turtles are highly migratory species and inhabit the seawaters and foraging habitats in the Southeast Asian region. Sea turtles that forage in one particular habitat might have originated from several nesting sites located at several countries in the region. Hence, strengthening regional cooperation on protecting and conserving the sea turtles and the ecosystem in their foraging habitats is highly recommended. Regional cooperation and collaboration of expertise, manpower, and facilities is vital to ensure that the RPOA could be effectively implemented.

Most Southeast Asian countries had already established their respective national laws on protecting and conserving the sea turtles as well as developed their own National Plan of Action (NPOA) on Conserving and Protecting Sea Turtles and Their Habitats. In addition, all Southeast Asian countries had their own laws responding to the CITES regulation, considering that all sea turtles species are listed in Appendix I, meaning that international trade of the species for commercial purpose is prohibited. Moreover, the IUCN also listed the hawksbill turtle as critically endangered, while the green, olive ridley, and loggerhead sea turtles have been categorized as threatened.

Furthermore, most of the countries in the region have their own educational and awareness programs targeting various groups of communities for the conservation and protection of sea turtles and their habitats. Universities, NGOs, and local governments had been involved by assisting the national government in the implementation of such programs. For instance in Malaysia, at least 200,000 people had participated annually in the program conducted by provincial agencies with assistance from NGOs and universities. The establishment of national networking between federal and local agencies, NGOs, institutes of higher education, and local community groups is very essential for the implementation of the programs as well as to assist governments in the enforcement of the relevant national laws.

3.4. Sea Cucumbers

Sea cucumbers are echinoderms and the most traded species, with leathery-like skin and elongated or cucumber-like body. There are more than 1,400 species worldwide but only less than 80 species are considered commercially-important (Purcell *et al*., 2013). Sea cucumbers are more diverse in the tropical areas, particularly in Southeast Asia which is considered as the center of biodiversity, particularly the Indo-Malay-Philippine Archipelago, also known as IMPA (Carpenter and Springer, 2005). Fifty-two species, mainly from the Genus *Holothuria*, *Actinopyga*, *Bohadschia* and *Stichopus* are being actively exploited in the East and Southeast Asian region (Choo, 2008a).

Spatially, they are distributed from very shallow intertidal mangrove and sand or mud flats to sea grass beds and down to coral reefs and deep sea beds (Battaglene, 1999; Hamel *et al*., 2001). Some sea cucumbers are filter feeders but many are benthic grazers, ingesting, processing, and excreting large amounts of benthic material which affords ecological benefits to the sea floor.

Sea cucumber fishing is an important livelihood in coastal communities (Choo, 2008a), and harvesting of sea cucumbers from the wild has been a tradition in many Southeast Asian countries. Being ecologically-associated with the shallow intertidal areas like mangroves, mud or sand flats, sea grass beds, and shallow reefs, sea cucumbers have been quite easily gleaned off, a chore easily engaged in by women and children (Mills *et al*., 2012; Siar, 2003). These are collected by hand or with simple tools like nets and spears in the tropical Indo-Pacific region (Mercier and Hamel, 2013).

The value of sea cucumbers for humans is not from their varied shapes and color as fresh or live commodities but maximized when they are dried and processed into *trepang or beche-de-mer*. Post-harvest processing of sea cucumbers require relatively simple and traditional technology that basically involves cleaning, boiling, and drying (Mercier and Hamel, 2013). These processed products are mainly reserved as exotic food ingredients in Chinese restaurants. Sea cucumbers have also been known and used for their many medicinal and therapeutic properties, making them important raw materials in pharmaceutical and nutraceutical products (Bordbar *et al*., 2011). The status, trends, challenges, and prospects of sea cucumber fisheries and aquaculture presented here focus only on countries within Southeast Asia, even though recent advances in the production and culture of sea cucumbers have been done in other countries.

3.4.1 Status and Trends

Sea cucumber production is not particularly for the domestic market in most Southeast Asian countries but is primarily targeted for export to neighboring nations like Hong Kong, Taiwan, and China (Choo, 2008a). The extent of sea cucumber exploitation around the world is to supply the main market which is Hong Kong before being distributed to other consumers is shown in **Figure 66**.

Figure 66. The route of Hong Kong sea cucumber market

Source: *Anderson* et al. *(2011)*

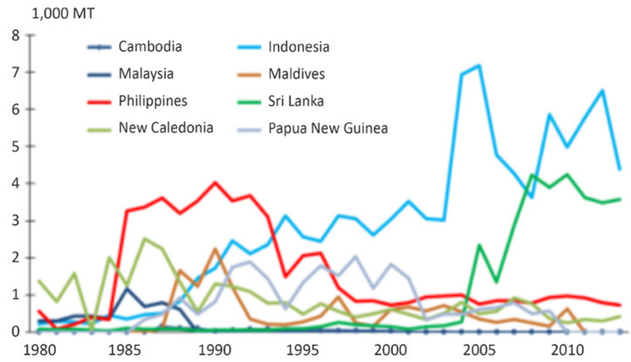


Figure 67. Sea cucumber production of selected countries in 1980-2013 by quantity

Source: *FAO Fishstat J Database - Capture Production 1980-2013*

Wild sea cucumber fisheries production was seen to be low before 1980s but increased more than six times in the 1990s (Anderson *et al*., 2011). However, because of the relative ease in their harvesting and the increased demand for *trepang*, drastic decline in sea cucumber stocks throughout the region (Bell *et al*., 2008; Choo, 2008a; Conand, 1993) has been felt with negative impacts on coastal livelihoods in some areas (Mills *et al*., 2012). the FAO statistics can be quite underestimated (Choo, 2008b), nevertheless it shows the boom-and-bust trend of the sea cucumber fisheries (**Figure 67**).

The total production of sea cucumber in the Southeast Asian countries from 2000 to 2009 reported to be highly fluctuating, ranged from about 4,000 to 29,700 metric tons annually (SEAFDEC, 2012b). A regional inventory of sea cucumber species in Southeast Asia was consolidated by SEAFDEC, listing a total of 137 species from eight countries (SEAFDEC, 2009b). The top ten important species based on local market prices from the Southeast Asian countries is presented in **Table 62**. *Holothuria scabra*, commonly known as sandfish, ranked as the

Table 62. Top 10 important sea cucumber species in Southeast Asia

Scientific Name	Common name	Local price (US$/kg, dried)
Holothuria scabra	sandfish	30-105
Holothuria nobilis / H. whitmaei	black teatfish	17-105
Holothuria fuscogilva	white teatfish	17-88
Actinopyga lecanora	stonefish	7-66
Stichopus horrens	dragonfish	24-58
Stichopus hermanni	curryfish	58
Actinopya echinites	deepwater redfish	12-54
Thelenota ananas	prickly redfish	12-51
Thelenota anax	amberfish	4-51
Bohadschia argus	leopardfish	9-27

Source: *SEAFDEC (2009b)*

number one important species, commanding a local market price of more than US$100/kg (SEAFDEC, 2009b). However, in Hong Kong and Guangzhou, China processed sandfish can reach up to more than US$1,500/kg, coming in as a close second to the Japanese sea cucumber *Apostichopus japonicus* priced at more than US$2,000/kg (Purcell, 2014). Black teatfish *H. nobilis* and *H. whitmaei*, as well as the white teatfish *H. fuscogilva* are also among the favored ones. The two black teatfish species are considered as allopatric – geographically isolated but historically the same species—*H. nobilis* is distributed in the Indian Ocean, while *H. whitmaei* occupies the Pacific Ocean (Uthicke *et al*., 2004).

Nevertheless, there are no regulations that prevent the overfishing of sea cucumbers (Choo, 2012). For instance, sea cucumber resources in Semporna, Sabah, Malaysia being at the center of the Sulu-Sulawesi-Mindanao Seas, appear to be heavily fished (Choo, 2012). In general, fishers have moved away from gleaning to free-diving at night, which indicates that overfishing is occurring on the shallow reef flats. Sea cucumber fishery in Semporna has also followed the boom-and-bust trend observed in neighboring countries, and species that are of high value (*e.g. Holothuria whitmaei* and *H. scabra*) and were abundant in the 1980s and mid-1990s are now rare, while medium-value and low-value species that were not fished before are now being harvested (Choo, 2012). *Actinopyga echinites* and *Bohadschia* sp. are caught in greater abundance compared with the other species.

Global decline in wild sea cucumber stocks has been evident in many countries and characterized by collection areas shifting from nearshore to offshore, harvested average body size decreasing, and target species changing from high-value to low-value (Anderson *et al*., 2011). Clearly, the progressive decrease in sea cucumber populations was caused by overexploitation and overfishing, unsustainable fisheries management, and increasing market demand for *trepang* or *beche-de-mer* products worldwide (Gamboa *et al*., 2004; Purcell *et al*., 2013).

Although some sea cucumber fisheries have existed for centuries, catch trends of most individual fisheries following the boom-and-bust patterns since the 1950s, had been declining nearly as quickly as they had expanded (Anderson *et al*., 2010). Regional assessments revealed that population declines from overfishing occurred in 81% of sea cucumber fisheries, the average harvested body size decreased in 35%, harvesters moving from nearshore to offshore regions in 51% and from high-value to low-value species in 76% (Anderson *et al*., 2010). Thirty-eight per cent of sea cucumber fisheries remained unregulated, and illegal catches were of concern in half (Anderson *et al*., 2010). Anderson *et al*. (2010) also suggested that development patterns of sea cucumber fisheries are largely predictable, often unsustainable, and frequently too rapid for effective management responses.

Brunei Darussalam

Sea cucumber fisheries in Brunei Darussalam is only limited to two fishing licenses awarded in 1993, with combined reported production of 65 kg and peaking at 1,463 kg in 2005 but declined to only 193 in 2006 (Wahabs, 2009). Although catches were reported in bulk and generally termed as mixed sea cucumbers, Wahabs (2009) listed eight species of mostly deep water sea cucumbers. Among these, *Holothuria rigida* locally called *timun laut susu* was considered the most expensive at US$80/kg when dried. Sea cucumber oil and other extracts are being sold locally, but most of processed sea cucumber meat is exported to Sabah in Malaysia and the Philippines.

Cambodia

Sea cucumbers locally known as teak, are known to be abundant in Koh Sdach and Koh Rong group of islands in Southern Cambodia, where collection commonly come in conflict with neighboring Phu Quoc islands of Viet Nam (Villanueva and Ut, 2007). Also called as *chhloeung*, sea cucumbers have been harvested more intensively starting in 2004 when compressor diving has been employed although more traditional collection has been recorded since 1985 (Sereywath, 2009). A famous market for sea cucumbers at Sihanoukville received dried products in the order of 500 kg per month from 2002 to 2004. In 2009 however, middlemen at this market stopped operation when landings of dried sea cucumbers considerably dropped to less than 30 kg per month. Sereywath (2009) added that only less than 10% from the markets of Sihanoukville is locally consumed, since most are sold to the capital city of Phnom Penh and eventually exported to Viet Nam and Thailand.

Indonesia

Indonesia is currently the top exporter of wild-caught sea cucumbers globally, after it surpassed the Philippines in mid-1990s (**Figure 67**). Collection of sea cucumbers in Indonesia was known even during the Dutch colonization period in the nineteenth century (Wiadnyana, 2009). Essentially, fishing for sea cucumbers in this country has more than 500 years history (Navarro *et al*., 2014). According to Tuwo and Conand (1992), Indonesians harvest sea cucumbers traditionally using small boats with 2-4 fishers for a day trip, then process the animals at the shore. On the other hand, some fishers use bigger boats equipped with diving equipment that search for sea cucumbers for weeks and months, processing their harvest onboard. About 53 species of sea cucumbers were listed for Indonesia in the 1970s (Clark and Rowe, 1971 as mentioned by Wiadnyana, 2009) but only eight of these were considered as economically-important species, like the *Holothuria scabra* and *H. nobilis*. Recent studies have taxonomically verified 33 of the more than 50 species, however, country statistics from the Ministry of Marine Affairs and Fisheries still considered *trepang* as an aggregate single commodity (Setyastuti and Purwati, 2015). Dried sea cucumbers are mostly exported to Hong Kong and other East and Southeast Asian countries like South Korea, Singapore, Viet Nam, and some to Taiwan, Malaysia, and USA, but interestingly, not so much are exported directly to China (Tuwo and Conand, 1992; Wiadnyana, 2009).

Malaysia

Sea cucumber fishing in Peninsular Malaysia and Sarawak is mostly small scale where collection is being done manually by hand through gleaning or diving (Ibrahim, 2009). However, some are unintentionally caught in nets of shrimp trawlers operating in the waters of Sabah. Collection of sea cucumbers in Malaysia has been mostly from the eastern regions of Sabah in the island of Borneo. Forty-four species of sea cucumbers are known to be found in Malaysia, with *Holothuria scabra* or *bat putih* and *H. nobilis* commanding the highest commercial value (Ibrahim, 2009). Sea cucumbers, generally called *gamat*, have been traditionally exploited mainly for its medicinal benefits (Vaitilingon *et al*., 2016) and used to produce soap and other cosmetic products. Sea cucumbers for this purpose are mostly from the Genus Stichopus like the curry fish *Stichopus hermanni* and warty sea cucumber *S. horrens* (Choo, 2004). Another species important for local food consumption is the *Paracaudina* sp. or *beronok*,

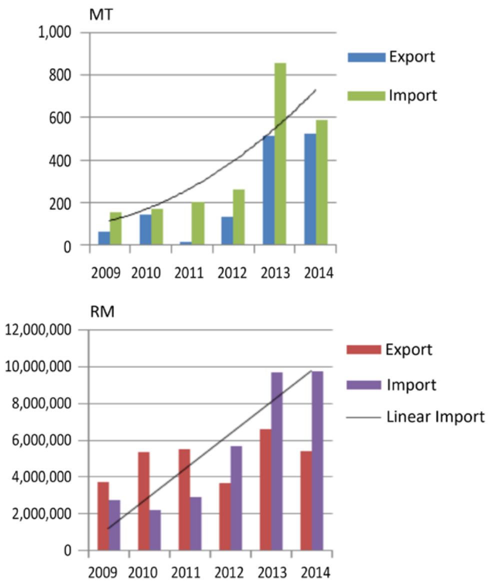


Figure 68. Sea cucumber export and import in Malaysia from 2009 to 2014 by quantity (metric tons) *(above)* and value in Malaysian Ringgit: RM *(below)*

Source: *Department of Fisheries Malaysia (2009-2014)*

commonly harvested from mudflats and mangroves. The annual import and export quantity and value of sea cucumber in Malaysia are shown in **Figure 68**.

In Malaysia, sea cucumbers genera other than *Stichopus*, *e.g. Holothuria*, *Actinopyga*, *Pearsonothuria*, *Bohadschia*, *Thelenota*, and order Molpadiida are commonly known as *bat*, *balat*, and *timun laut*. The *Stichopus* species, frequently used as main ingredients in traditional medicine (*i.e.*, *gamat* oil and *gamat* water) especially in Peninsular Malaysia, are locally known as *gamat*. The same commercial name is used by Sabah and Sarawak residents, although in Sabah, sea cucumbers inclusive of *gamat* are commercially marketed as food, and there are minor uses as fishing poison (*e.g.* holothurins from *Holothuria atra*) and in traditional medications. Few studies related to sea cucumbers (Echinodermata: Holothuroidea) in Malaysia were reported and published until the year 2005.

Myanmar

Pin-lai-myawt is the local name of sea cucumbers in Myanmar which have been traditionally harvested for many years in the southern region of Tanintharyi. While in the northern regions of Ayeyarwardy and Rakhine, harvesting only began in 1989 when the Open Market Economy was declared (Pe, 2009). About 10 species of sea cucumbers are known in Myanmar with *Stichopus* and *Thelenota* species being mostly considered as highly valuable. Like many countries worldwide, sea cucumber capture fishery production is declining in Myanmar, resulting in most fishers risking to fish the sea cucumbers for long duration up to months in the farther islands of the Andaman Sea using old boats (Pe, 2009).

Philippines

In the Philippines, collection of sea cucumbers started more than 100 years ago (Gamboa *et al*., 2004; Trinidad-Roa, 1987). Women have been engaged in this activity by gleaning for shellfish including sea cucumbers in shallow intertidal shores (Siar, 2003). Of the more than 100 sea cucumber species in the Philippines, about 25 are targeted regularly and processed as *trepang* (Schoppe, 2000). Sea cucumber fishing provides an important source of income to many poor fishers in coastal communities (Choo, 2008b). Total sea cucumber exports are valued at an average of more than US$2 million per year, making it one of the country's major export commodities (Gamboa *et al*., 2004; Juinio-Meñez *et al*., 2012). Sea cucumber fishery in the country involves a multi-species collection, and among the various species, *Holothuria scabra* is the most expensive, commanding a price of up to US$105/kg in the local market (Labe, 2009). Capture production dramatically increased from about 300 metric tons in 1984 to more than 3,000 metric tons in 1985, and reached the highest annual harvest of about 4,000 metric tons in 1990. However, the following decade saw a steady decline and since 1998 production from wild catch had an average of between 700-800 metric tons per year (FAO Fishstat 1950-2014).

Singapore

Singapore acts more of an importer for sea cucumber products rather than a producer. Singapore is known as one of the top three markets for sea cucumbers, together with Hong Kong and Taiwan (Conand, 2001). It is also considered as one of the major re-exporting countries for sea cucumbers.

Thailand

Munprasit (2009) listed 102 species of sea cucumbers found in Thailand, of which 11 species are edible and *H. scabra* is considered the most important species. These are traditionally harvested in shallow coasts, mainly by hand picking. Fishing is also active and can take days and weeks in the Andaman Sea, while processing is done onboard fishing boats. Although processing method in Thailand is slightly different among species and areas, like in Phangnga and Chonburi Provinces, such processes commonly involve gutting, cleaning, boiling, smoking, and drying. Dried sea cucumber products are mainly exported to Hong Kong, Japan, and China, while Thailand also receives sea cucumber imports from countries like Madagascar and Tanzania (Munprasit, 2009).

Viet Nam

A total of about 90 species of sea cucumbers are found in Viet Nam (Hung, 2009). Sea cucumbers are abundantly harvested especially in the Provinces of Khan Hoa, Con Dao, Truong Sa, Bin Thuan, and Kien Giang in southern Viet Nam, particularly in Phu Quoc Islands (Hung, 2009; Villanueva and Ut, 2007). More than ten edible species are sold, particularly in the southern region and Ho Chi Minh City markets, including the highly priced sandfish *H. scabra* (US$50/kg). Decline in wild capture production has been reported especially that Scuba diving has been employed as a main fishing equipment for fishers. For example, Phu Quoc Islands deliver about 3 metric tons of fresh sea cucumbers per day in late 1990s but this volume was reduced to only 300 kg/day a decade after. Production of sandfish has been augmented by aquaculture in ponds in the Nha Trang region, where sea cucumber culture has been done since mid-2000, commonly in alternate cropping with shrimps (Pitt and Duy, 2003; Pitt *et al*., 2001).

3.4.2 Issues and Challenges

Conservation

Sea Cucumbers as Protected Species

In Malaysia, the present Fisheries Regulations on the Control of Endangered Species of Fish 1999 under Fisheries Act 1985 protects the following marine species: dugong, six species of whales, thirteen species of dolphins, one species of whale shark, and four species of giant clams. Sea cucumbers are not included in the list of endangered species in Malaysia, neither are they considered as endangered by IUCN (Mohd Nizam Basiron and Zahaitun Mahani Zakariah, 2004). Without research on the status of sea cucumber resources in Malaysia and the level of its exploitation it would be difficult to evaluate the resource status. However, in the long term it would be of interest to the country to undertake research studies before making any decision to include sea cucumbers in the list of protected species (Mohd Nizam Basiron and Zahaitun Mahani Zakariah, 2004).

Lack of data on the status of sea cucumber resources and its level of exploitation in Malaysia is a serious impediment to the management of this valuable natural asset (Mohd Nizam Basiron and Zahaitun Mahani Zakariah, 2004). It is therefore through the Fisheries Research Institute (FRI) in cooperation with local universities that research activities in this area are intensified to better prepare Malaysia for the conservation and management challenges of sea cucumbers.

Nonetheless, some sea cucumber fisheries have been successfully managed through fisheries laws, rights systems, permits and fishery cooperatives. Japan for example, has succeeded in drawing back overfishing of sea cucumber resources and restocking the resource' depleted areas (Akamine, 2004). Holothurian fishery in southeast Alaska, United States is carefully controlled, where harvest levels are set based on the lower 90% bound of a biomass estimate, and areas are fished on a 3-year rotation schedule and separate areas are left closed as controls (Clark *et al*., 2009). Sea cucumber fishery in British Columbia, Canada initially followed the typical boom-and-bust pattern, but management stepped in, reduced quotas, added license restrictions, and implemented adaptive management (Hand *et al*., 2008), and as a result, the CPUE and catches recovered (Hand *et al*., 2008). Although still confronting problematic corruption and declining abundance, implementation of a co-management regime in the Galapagos has increased the effectiveness of license and quota control, and reduced conflict between management and fishers (Shepherd *et al*., 2004).

Aquaculture

Decline in wild populations of sea cucumbers, particularly of the commercially valuable species like the sandfish *Holothuria scabra* has driven a revolution towards aquaculture. Production technology for the sandfish started early in 1980s in India (James, 1996). Enhancement and adoption followed in many countries, including Australia and the Pacific islands like New Caledonia and Solomon Islands with projects spearheaded by the WorldFish Center. Early adaptors in Southeast Asia were Viet Nam with hatchery production and pond culture (Duy, 2012) while sea-based nursery systems and community-based sea ranching have been initiated in the Philippines (Juinio-Meñez *et al*., 2012; Juinio-Meñez *et al*., 2013), with research support from the Australian Centre for International Agricultural Research (ACIAR). Other countries in the region also have production trials mostly supported by universities and governmental fisheries agencies like those in Malaysia, Thailand, and Indonesia.

An important requirement for a successful spawning run is having a group of healthy mature broodstock, and conditioning these breeders is essential (Agudo, 2006). At the Research Institute for Aquaculture No. 3 in Nha Trang, Viet Nam, broodstocks are collected from nearby holding ponds and conditioned for about one month in indoor tanks with sand (Duy, 2010). However, sandfish stored in tanks for longer durations tend to shrink with accompanying decline in reproductive performance as observed in experiments conducted at SEAFDEC/AQD in the Philippines. Returning the breeders to their natural habitats, usually in holding pens or sea ranch areas, provides better recovery of the animals. Stability in production has been difficult to implement, mainly because of limited sources of healthy wild breeders and inconsistent health and condition of these broodstocks.

Hatchery technology is being established, especially for the sandfish *Holothuria scabra*. In the Philippines, SEAFDEC/AQD has done experimental production since 2008. Since then, the life cycle and duration of developmental phases have been established for local conditions (**Figure 69**).

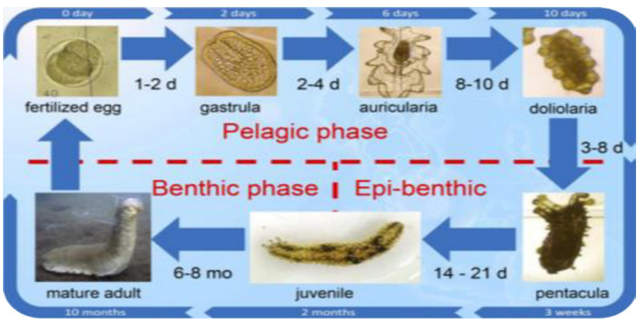


Figure 69. Life cycle and development of sandfish *Holothuria scabra*

Sea cucumbers commonly aggregate and spawn synchronously in the wild, so that groups of 20-60 breeders are commonly used for spawning in hatcheries as well. Spawning induction through desiccation and thermal shock is generally used, which is the most practical method that provides quite reliable results with mature breeders. Hatchery management and protocols (*e.g.* feeding) are fairly established as well (Agudo, 2006; Duy, 2010). The main limitation in hatchery production is the availability of good quality live algal feed. For this reason, sea cucumber hatcheries require a dedicated phycology laboratory to produce live feeds for the developing sea cucumber larvae that usually takes 30-45 days. *Chaetoceros calcitrans* or *C. muelleri* are species of algae that are commonly used in sea cucumber hatcheries, although the benthic diatom Navicula is also fed to early settled juveniles. Spirulina which is commercially available in dry powdered form is used to coat settlement plates. In most cases, success in hatchery operations is dependent on the capacity and efficiency in producing and upscaling these essential algal food items.

Development of larvae and their ultimate survival into juveniles had been unstable in many hatcheries. Purcell *et al*. (2012) reviewed the global hatchery production for sandfish and reported generally poor survival of early larval stages that commonly hovers around 1%. In Kedah, Malaysia, sandfish spawning runs produced generally high settlement (survival) rates at 23.70% during settling of pentactula (15 days old) larvae but steeply reduced to only 0.47% at 45 days during the early juvenile stage (Vaitilingon *et al*., 2016).

Maintenance of good water quality for larval rearing also affects growth, development, and survival of sea cucumber larvae in the hatcheries. For sandfish *H. scabra*, Agudo (2006) recommends maintaining the following water parameters: temperature at 26-30°C; dissolved oxygen at 5-6 ppm; salinity at 27-35 ppt; pH 6-9; and ammonia at 70-430 mg/m^3. Similar recommendations were made for rearing *H. spinifera* larvae: water temperature at 28-32°C; salinity at 35 ppt; and pH at 7.8 (Asha and Muthiah, 2005). Deviations from these ideal water conditions usually result in delayed larval development and high mortality. Problems in maintaining good water quality are often associated with high costs of infrastructure, capital, and operations especially with related equipment like pumps, filtration and disinfection lines, and life support systems like aeration, heating and cooling, and pH control.

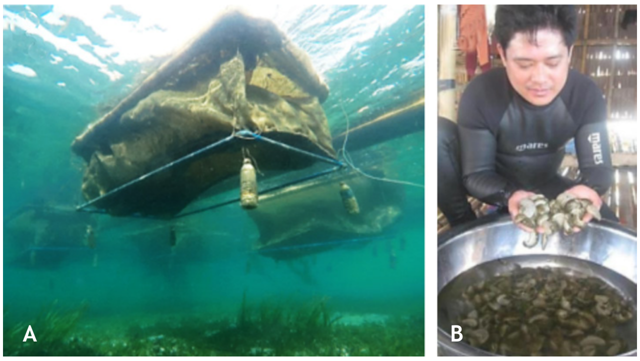


Figure 70. (A) Sea-based floating nursery hapa nets used for rearing sandfish juveniles until 3-6 g; (B) 1-2 month-old sea cucumbers for stocking in sea ranching areas in the Philippines

After 30-45 days in hatchery, sea cucumber larvae like those of the sandfish, settle on conditioned plates. In order to reduce the time spent of early juveniles in the hatchery, various nursery systems have been tested and developed. In Viet Nam, marine ponds with sandy substrate are being used as nursery areas with fine hapa nets (usually 1×1×1 m) held by wooden sticks or tree branches (Duy, 2010). In the Philippines, some nursery systems were also tested but floating sea-based hapa nets (1×2×1 m) were found to be the most practical (Juinio-Meñez *et al*., 2012). Floating nursery nets are fine-meshed and are suspended just below the water surface by floats (PVC pipes or bamboos) and weighed down by sinkers (**Figure 70A**). However, problems and challenges still remain, especially in addressing issues of net fouling, predation, and unpredictable weather. In the Philippines, 1-2 month-old sea cucumbers (**Figure 70B**) are harvested for stocking in sea ranching areas.

Various grow-out options are available, especially for the sandfish. Ponds were proven to be useful in Viet Nam where sandfish growth of 1-3 g per day is common, reaching more than 300 g in 9-14 months, translating to more than 2.5 metric tons/ha (Duy, 2012). Similar growth was also observed in nursery trials in Malaysia where sea cucumber juveniles reaching 20-30 g in weight in 3-4 months in floating nets suspended in brackish water pond (**Figure 71**). Problems in Viet Nam are limitations in density (1 individual/m) and long duration culture. These are the reasons why most farmers still resort to culturing shrimp (mainly *Penaeus vannamei*) because of higher annual returns by culturing at least two batches per year. In the Philippines, typical ponds are not conducive for full grow-out culture of sandfish because of various constraints that include: 1) tendencies of low salinity (typically brackishwater); 2) substrate being too muddy and silty, having been converted from mangrove areas and used mainly for shrimp or milkfish culture; 3) being typically shallow (less than 1 m); and 4) unpredictable weather that limits culture duration.

Nonetheless, sea ranching of sea cucumbers, particularly of the sandfish *H. scabra*, has shown good prospects in terms of community-based production and restoring wild stocks through natural spawning as demonstrated in a pilot site in Bolinao, Pangasinan, Philippines supported by the University of the Philippines-Marine Science Institute (Juinio-Meñez *et al*., 2013; Olavides *et al*., 2011). However, there were problems associated with sea ranching which include the long culture duration of one to two years and the relatively low survival and recovery rates of stocks at 20-30%, mainly because of predation and unstable conditions at sea ranch sites. In other countries like Malaysia and Thailand, farming of sea cucumbers especially in pens at shallow coasts has been limited only to collection of wild juvenile sea cucumber stocks. Similarly in Indonesia, the two main problems of sea cucumber farming are the long farming period and the low number of seeds available from the wild (Tuwo, 2004).

3.4.3 Future Directions

Aquaculture

Declining wild population of sea cucumbers because of overfishing has been made clear (**Figure 67**) and collection of wild juveniles for attempts to rear sea cucumbers in captivity in pens and ponds further threatens the supply of wild stocks. Future efforts should be geared towards developing and enhancing hatchery and aquaculture production. It is along this basic objective that research, like the ACIAR-funded project involving Philippines, Viet Nam, and Australia (ACIAR-FIS-2010-042), focused on the expansion and diversification of production systems for sea cucumbers.

Figure 71. Floating nets for sea cucumber juveniles in brackishwater pond *(left)*, and juveniles weighing 20-30 g in 3-4 months *(right)* for stocking in ponds

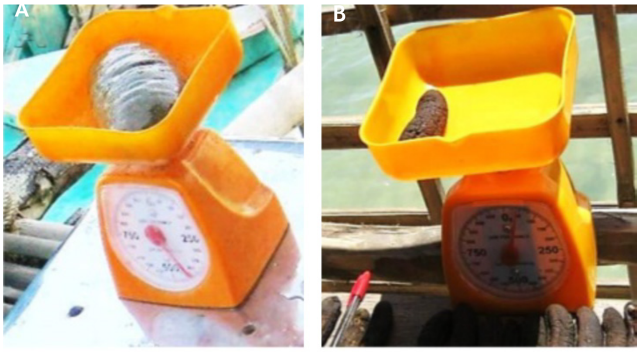
Successful and sustainable production in hatchery primarily involves good quality broodstock. Currently, dependence on breeders that are conditioned in the natural habitat is common, although some hatcheries like those in Viet Nam maintain good supply of breeders in nearby ponds. Still, sea cucumber broodstock conditioning, at least for the sandfish, is a major bottleneck in most hatcheries that needs to be given due importance. Efforts at SEAFDEC/AQD in the Philippines, for example, are addressing some of these concerns by conducting research and experiments on conditioning management protocols, as well as looking into suitable maturation diets for sandfish to ensure good quality gametes and optimize fecundity of adult female broodstock. Maturity detection and use of biopsy techniques to ensure only individuals with ripe gonads are selected for spawning trials, are the aspects for research and development. Spawning induction is straightforward and even simple techniques like desiccation or temperature shock yield successful releases of male and female gametes from mature and ready individuals. However, some batches of fertilized eggs can still be of low quality. Detection and separation of "bad eggs" or a protocol to decide whether to discard an entire batch is crucial to minimize risks of low quality production.

Optimal larval development is a key to ensuring good quality juveniles, and in order to attain this, algal feed and feeding protocol as well as good water quality parameters are established. However, dependence on live feed is often a limitation in hatcheries. Currently, promising results have been shown in larval rearing of sandfish solely fed with commercial concentrated algal pastes (Duy *et al*., 2015). Moving forward, exploration of algal food substitutes is important. Larval settlement into pentactula phase was shown to be high at more than 20% survival from sandfish eggs. However, those that are eventually harvested as stage 1 (S1) or early juveniles (4-10 mm) are common only at 1%. There are critical cues and requirements between these development stages that need further investigation and research in order to optimize survival of larva to juveniles and maximize hatchery production of sea cucumbers.

Grow-out culture of sea cucumbers whether in ponds, pens, or tanks is mainly challenged by the limitation in terms of stocking density and long duration culture period. In basic aquaculture, these problems are often addressed by developing suitable alternative and supplemental feeds at various phases of culture. This is an area where a huge gap in knowledge of the tropical species exists, although for other species like the temperate eel *Anguilla japonica*, formulated feeds had been developed and used in aquaculture production in Japan and China. One drawback of using formulated feeds is the inappropriateness of its use in a sea ranch system like in the Philippines where natural and often protected, sea grass areas are being utilized. So, a careful protocol that would enhance production and promote environmental conservation should be put in place.

Aside from direct environmental damage due to intensification of culture, it is widespread that some aquaculture practices result in habitat modification, wild seedstock decline, and population genetic diversity disruption (Naylor *et al*., 2000). Particularly for sea cucumbers, pond and pen constructions alter coastal ecosystem dynamics, while translocation of stocks may change the unique genetic composition among native populations. In New Caledonia, genetic diversity similarities among sea cucumber populations rapidly changed after a few hundred kilometers along the same coast (Uthicke and Purcell, 2004). Similar initial results, from a sea cucumber genetics study being conducted by the University of the Philippines in Diliman, Philippines show distinct genetic populations of sea cucumbers being restricted in localized areas of the country (Ravago-Gotanco and Juinio-Meñez, pers comm). Therefore, future culture production should consider using only locally-produced stocks from locally-sourced broodstock.

The full economic value of sea cucumbers is not realized until these are processed into its dried form called *trepang* or *beche-de-mer*. In a local market in Palawan, Philippines, a single processed sandfish commands 300% more value than selling it fresh or live (**Figure 72**). Therefore, to optimize commercial benefits from aquaculture of sea cucumbers, its post-processing component needs to be incorporated into the production cycle. In addition, since prices for *trepang* are also dependent on species, size, and processing quality, regulations need to be established and enforced in order to minimize, if not stop, harvesting of undersized and undesirable sea cucumbers.



Live sandfish (~400g @ US$5/kg) = $2/pc

Processed (~5g @ US$110/kg) = $6/pc

Figure 72. (A) Fresh and (B) processed sandfish in Palawan, Philippines

Most countries in Southeast Asia do not have specific regulations for sea cucumbers. Some licenses are issued for fishing boats catching (but not targeting) sea cucumbers in countries like Brunei Darussalam and Thailand. In a review conducted among 37 countries and states globally, 38% of fisheries are unregulated, while 51% reported illegal, unregulated and unreported (IUU) fishing, and regions including Indonesia and Philippines have IUU catches that greatly exceed those from legal fishing (Anderson *et al*., 2011). On the other hand, in an attempt to start some regulatory foundation on sea cucumber harvesting in the Philippines, a national standard on the quality of dried product for sandfish was ratified in late 2013 (PNS/BAFPS, 2013). This includes specifications on moisture content (less than 15% by weight), salt content (less than 2.5%), acid soluble ash (2.5%), and a minimum length of 5 cm, among others. This minimum length of the dried product was taken as the minimum size acceptable for global export quality, and translates to at least 320 g of live specimen. So, future harvests should target animals that are more than this minimum size requirement.

Sea cucumber fishery has been a traditional culture of Southeast Asian countries for centuries, but aquaculture of these species is relatively young. The boom-and-bust nature of wild harvesting and the alarming decline in wild stocks put pressure on aquaculture to be developed and enhanced quickly. It is clear however, that there are many gaps in the production and culture technology, and many more aspects need modifications and enhancements. This does not only include protocols for domestication of breeders, larval or juvenile rearing, and grow-out phases of production, but importantly needs to cover post-processing component as well. This further encompasses areas involving the socio-economic and governance aspects to ensure equitable benefits among stakeholders and maintain a sustainable supply of wild and cultured stocks to meet the increasing global demand for *trepang*.

Management

In the light of the lack of strong local governance, international regulations that control trade, such as CITES Appendix II, could be one of the best hopes for the conservation of the highly valued sea cucumber populations (Anderson *et al*., 2010). Appendix II listing would require exporting nations to certify that their sea cucumber exports would not be detrimental to the survival of the species (Anderson *et al*., 2010). Alternatively, import tariffs can benefit the long-term conservation of renewable resources and usually benefit the exporting country (Brander and Taylor, 1998). Unfortunately, the process by which international regulations are developed is often too slow to react to the global expansion of high-value invertebrate fisheries to effect meaningful conservation (Berkes *et al*., 2006). Where sufficient governance exists, Anderson *et al*. (2010) suggested two important steps to manage existing and future holothurian fisheries. First, the expansion rate of new fisheries had to be best reduced to a level where management has time to react to early warning signs of resource depletion. Second, lacking of changes in the regulations, catch trajectory and patterns of serial spatial, species and size expansion or depletion are largely predictable. Knowledge of the impending sequence of events can therefore be pre-emptively incorporated into the management of new and existing high-value marine fisheries. Anderson *et al*. (2010) concluded that there is urgent need for better monitoring and reporting of catch and abundance data and proper scientific stock and ecosystem impact assessment to ensure more sustainable harvesting of sea cucumbers.

3.5 Seahorses

Seahorses (Family Syngnathidae) belong to genus *Hippocampus* consisting of 35 genera of pipefishes, pipehorses and seadragons and falling within the order Gasterosteiformes (Vincent, 1996). Of the 47 known species of seahorses in the world, nine species are

Table 63. Seahorses (*Hippocampus* spp.) identified in Southeast Asia

Scientific Name	FAO Common Name	Distribution in Southeast Asia	
		Confirmed	Suspected
Hippocampus barbouri	Barbour's seahorse	Indonesia, Malaysia, Philippines	
H. bargibanti	Bargiban's seahorse	Indonesia, Philippines	Malaysia
H. comes	Tiger-tail seahorse	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	
H. denise	Denise's pygmy seahorse	Indonesia, Malaysia, Philippines	
H. histrix	Spiny seahorse	Indonesia, Malaysia, Philippines, Viet Nam	Brunei Darussalam, Myanmar, Singapore, Thailand
H. kelloggi	Great seahorse	Indonesia, Malaysia, Philippines, Thailand, Viet Nam	Brunei Darussalam, Myanmar, Singapore
H. kuda	Black seahorse	Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam, Myanmar
H. mahnikei	Japanese seahorse		Thailand, Viet Nam
H. spinosissimus	Hedgehog seahorse	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam
H. trimaculatus	Flat-faced seahorse	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam

Source: *Lourie* et al. *(1999); Lourie* et al. *(2004); Koldewey and Martin-Smith (2010)* confirmed to be distributed in the Southeast Asian region with some species still not confirmed (**Table 63**).

Recently, there has been an increasing interest to culture seahorses not only to address unsustainable trade for traditional medicine, aquarium fishes, and curios, but also mainly to reduce the pressure on the wild stocks. Seahorses have been harvested from Asian waters for use in traditional medicines such as *jamu* medicine in Indonesia and the Philippines, *kanpo* in Japan, *hanyak* in Korea, as well as traditional Chinese medicines (TCM) which require an estimated 20 million seahorses every year (Vincent, 1996). In May 2004, all species of seahorses were listed in Appendix II of the Convention on International Trade of Endangered Species of Flora and Fauna (CITES), which implies that 'sustainable' trade is still allowed but must be controlled in order to ensure that their use is compatible with their survival.

3.5.1 Trade in Seahorses

Since the mid-1980s, seahorses have been collected and traded internationally to supply the aquarium, curio and home decor, and traditional medicine industries. Trade has grown rapidly, including a ten-fold increase in quantity from the mid-1980s to the mid-1990s. As of 1995, over 20 million seahorses and 32 countries were involved in the seahorse trade (Vincent, 1996). Since the mid-1990s, seahorse collection and export continued to grow both in quantity and in the number of countries involved (at least 72, including 46 exporting and 45 importing nations). However, in recent years, trade has ebbed slightly, possibly as a result of a collection ban in the Philippines (Vincent *et al*., 2011).

Since 1996, Thailand has been a major exporter of seahorses, but the role of other countries has varied with time over the past 15 years. India, Philippines, Viet Nam, Mexico, Tanzania, and China have all been major sources of dried seahorses at various times. Indonesia, Viet Nam, Sri Lanka, and Philippines until 2005, were the major source countries for live seahorses, the dominant markets of which are similar to the rest of the coral reef wildlife trade, *i.e.* the US and the European Union as the primary markets (Vincent *et al*., 2011).

Tracking the seahorse trade is a significant challenge. Seahorses are collected by either small-scale, artisanal operations (approximately 5% of trade) or as the result of by-catch from shrimp and demersal fish trawling (approximately 95% of trade) because they have similar size and habitat requirements with shrimps, and are slow swimmers. In both capture methods, catch data are rarely recorded, making it difficult to monitor the exploitation patterns over time. When seahorses are declared on import and export systems, they are rarely differentiated by species and mixed species assemblages are often shipped together in the same container (Vincent *et al*., 2011). Listing of seahorses in Appendix II of CITES has improved such a situation in recent years. According to CITES trade data, 28 out of 48 known species are involved in trade, including 18 species harvested for traditional medicine and/or curios whereas 27 species are used in home or public aquariums (Vincent *et al*., 2011).

3.5.2 Impact on Wild Seahorse Population

There have been few scientific studies on the ecological impacts of seahorse collection by comparing similar locations with and without collection. As an alternative to this approach, a number of scientists, most notably *Ms. Amanda Vincent* and the non-profit organization Project Seahorse, have inferred the status of seahorse populations through examination of trade data and catch reports, as well as interviews with fishers from various countries. Results from the interviews with fishers and exporters commonly indicate declining abundances and catches in many countries across the world. From such results, Vincent (1996) concluded that seahorse catch declined by 15-20% between 1990 and 1995 in Southeast Asia. At that time, large size seahorses had become increasingly rare, which drove collection to less desirable small size individuals, including juveniles.

Vincent *et al*. (2007) also studied the impacts of seahorse fishing in central Philippines by examining the catch per unit effort (CPUE) from 1996 to 1999. The analysis found that between 2.94 and 3.43 seahorses were collected per fisher per night. These values are considered to be very low and are likely indicative of depleted populations. Comparisons between CPUE data and information gleaned from interviews with fishers and buyers indicated that there were major declines in seahorse populations over time. Fishers reported that 50-100 seahorses were collected per fisher per night during the 1960s and 1970s, but this number declined to 10-50 seahorses per fisher per night from 1980-1985 to less than 4 seahorses per fisher per night in 2000. The diminished CPUE suggested that seahorses are overfished in central Philippines.

Similar indicators of seahorse decline have been reported in other areas of Southeast Asia. In Viet Nam, for example, seahorses are collected as by-catch from shrimp and demersal fish trawling. Seven species are collected including *Hippocampus spinosissmus*, *H. trimaculatus*, and *H. kuda* being the most common species in trade. From 1980 to 2001, trawling effort increased 250% and the associated by-catch concomitantly increased as a result. Around 2.3 million seahorses were collected each year from Viet Nam, with most animals exported through unofficial channels to China for TCM. CPUE was estimated to range from 0.33 to 2.50 depending on the region and year. These consistently low CPUE values indicate a seahorse population that is dispersed, patchy, and declining. Overall, seahorses were estimated to have declined by 30-60% during the preceding two to five years.

Fishers and traders also reported decreasing seahorse abundance in nearby Malaysia and Thailand (Perry *et al*., 2010), where in Malaysia, fishers indicated population declines of 68±24% over 12.5 years. Most interviewees simply stated that there were now considerably fewer seahorses than in the previous years, however, some indicated that the reductions resulted from overfishing. In Thailand, 81% of the interviewed seahorse collectors and traders suggested that seahorse catches were declining and none of the interviewees thought that seahorse populations had grown. Fishers and traders estimated that the seahorse catch had declined by 22-96% over 2.50-15.00 years in Thai waters. As was the case for central Philippines and Viet Nam, the causes of seahorse declines in Malaysia and Thailand were attributed to over-exploitation and habitat degradation.

3.5.3 Breeding and Rearing of Seahorses

The first efforts to breed seahorses commercially started in China in 1970s, and in 1980s literature from mainland China conveyed the impression that seahorse culture was well understood. Technical problems encountered were vulnerability to diseases and the need to provide the right diet for seahorses. However, economic crisis in 1980s led to widespread closure of seahorse farms in China. Also in 1970s and 1980s, experimental breeding and rearing of seahorses were tried in small-scale systems in research institutions in Australia, Japan, and Venezuela (Fan, 2005). Commercial development of seahorse aquaculture, particularly the big-bellied seahorse *H. abdominalis* was undertaken in 1990s in Australia, New Zealand, and the USA. In Southeast Asia, Viet Nam showed growing interest for the culture of *H. kuda* (Pham, 1993).

In late 1990s to early 2000s, considerable research efforts were carried out leading to the publication of additional information on breeding and rearing of seahorse. Research was conducted on increasing the scale of operations in the rearing of *H. trimaculatus* in India using 2,000 L tanks for broodstocks and 30 L rearing tanks (Murugan *et al*. 2009). In the Philippines, illuminated floating bamboo and nylon mesh cages were used for grow-out rearing of juveniles (Garcia and Hilomen-Garcia, 2009). Globally as of 2010, at least 13 species of seahorses have been used in commercial culture or in ongoing research studies. Nonetheless, technical challenges in the areas of diseases, nutrition, and species-specific rearing techniques still remain (Koldewey and Martin-Smith, 2010).

Broodstock management and larval rearing

Most of the recent studies on seahorses have focused on establishing suitable technologies for effective broodstock development and maintenance as well as captive breeding through improvement in the husbandry techniques, particularly on feeding. Seahorses are ambush predators that feed on a variety of mobile preys consisting mostly of planktonic crustaceans such as mysid shrimps, amphipods, copepods, or any tiny larvae that can fit into their elongated snouts (Woods, 2002; Kendrick and Hyndes, 2005; Kitsos *et al*., 2008). In Malaysia, Nur *et al*. (2015) reported that the best reproductive performance was obtained in *H. barbouri* broodstock fed with post-larvae shrimp, although frozen mysids can also be used in its culture. This observation corroborates with findings of SEAFDEC/AQD that the reproductive performance of *H. comes* markedly improved when fed with mysid shrimp alone or in combination with *Artemia* (brine shrimp) and *Acetes* (Buen-Ursua *et al*., 2015). Significantly higher brood sizes were obtained from seahorses fed with mysid shrimps as a single diet or combined with the other natural food than *Artemia* only, *Acetes* only and *Artemia*+*Acetes* (107-152 broods). Shorter parturition interval was also observed in seahorses fed single diet of mysid, or mysid in combination with other natural food (13-26 days) than those fed with single diet of *Artemia* (60 days). In Viet Nam, Troung (2011) reported on a successful culture of seahorse with total production of about 30,000 animals from three small hatcheries in Khanh Hoa Province. Broodstocks were collected by divers or taken from F1 generation. Seahorses were fed on frozen mysids and *Acetes* with vitamin A, C, and E added to the feed, to improve gonad quality and strengthen fish larvae. In India, Murugan *et al*. (2009) observed significantly higher reproductive efficiency when the three spotted seahorse *H. trimaculatus* were fed with amphipods than seahorses fed with sergestid shrimp. Furthermore, lower number of deformed larvae was observed in seahorses fed with amphipods.

Larval rearing of newborn and juvenile seahorses (0 day-6 months old)

Technologies have been developed by SEAFDEC/AQD for the larval rearing of newborn and juvenile seahorse, *H. comes*. The use of UV-treated seawater for rearing of newborn seahorses gave better survival and growth than when sand-filtered and chlorinated seawater are used. The use of copepods as replacement for brine shrimp as food for newborn seahorse was also evaluated since brine shrimp is expensive and copepods are abundant in brackishwater ponds. However, depending on the source, the copepods sometimes harbor high bacterial load. Newborn seahorses fed with copepods treated with formalin bath had better survival than those stocks fed with untreated copepods. Survival of two-six months old juveniles is more stable mainly due to their ability to feed on mysid shrimps and *Acetes*. In Viet Nam, Troung (2011) reported that seahorse fry were fed with copepod three times per day from birth to 40 days old. In addition, enriched *Artemia* nauplii (DHA Selco, INVE) were fed to fry from 10 days onwards. In India, Murugan *et al.* (2009) observed higher survival rates in nine and 12 days old juvenile *H. trimaculatus* fed with copepodites compared to those fed *Artemia* nauplii. On the other hand, higher survival was observed in zero to six days old juveniles fed with copepod nauplii than those fed rotifers. Survival of pelagic phase juveniles was higher under continuous lighting conditions with light intensity of 2000 l×. Juvenile and adult *H. trimaculatus* can tolerate salinity not lower than 26 and 17 ppt, respectively.

Nursery and grow-out in illuminated sea cages

Garcia and Hilomen-Garcia (2009) reared juvenile *H. kuda* in illuminated sea cages using thawed *Acetes* as feed. After 10-12 weeks of rearing, body weight and stretch height of seahorse fed with *Acetes* in the lighted cage were heavier and longer. Survival in all groups ranged from 9% to 74%. Survival of seahorse in lighted cages with *Acetes* feeding was consistently lower as a likely result of crustacean and piscine predators being attracted by light and the odor of left-over *Acetes*. The protocol may be improved to provide possible alternative livelihood to seahorse fishers.

The diet composition and feeding periodicity of *H. barbouri* reared in illuminated sea cages showed that adult seahorses consumed more variety of prey (copepods, larvae of decapods, polychaetes, fish, and euphausid shrimps) than juvenile seahorses (Garcia *et al*., 2012). The gut of seahorses was generally full at daytime but declined in the evening, particularly among juveniles. Lighting of cages at midnight increased the number of filled guts at dawn (0400 h). Results showed that *H. barbouri* may be cultured in cages feeding on copepods attracted by night illumination.

Troung (2011) reported that during grow-out, seahorses held in recirculating tanks were fed *ad libitum* twice a day with frozen feed such as mysids and *Acetes* collected from the wild. Adult enriched *Artemia* was also used in combination with frozen feed. Seahorses are susceptible to diseases from bacteria and viruses, while antibiotic treatment is not effective in many cases.

In 2009 until 2011, a *H. barbouri* demonstration project was conducted in the Spermonde Islands in Sulawesi, Indonesia to examine the potential of culturing the species as ornamental marine species for coastal management and conservation efforts (Williams *et al*., 2014). Culture units (8 × 5 m) constructed in a family's yard area produced 200-400 animals/month/unit. At allowable quota of 200 animals/month, price paid by exporters (Indonesian Rupiah Rp$30,000/animal) and at exchange rate of Rp11,000 ~ US$1, the profit is seven times the monthly income (~US$350/month profit *vs* < US$50) for a male head of a Pulau Badi household. Ownership, dedication, and ability of owners to solve problems are critical factors in the early phase of the project. Solar energy system was used to lower maintenance cost and sustainable feed systems was established to ensure availability of feed when local wild harvests of mysid shrimps were low in supply.

3.5.4 Resource Enhancement and Restoration Initiatives

Founded in 1996, the Project Seahorse is a marine conservation organization committed to the conservation and sustainable use of coastal marine ecosystems in general and seahorses in particular, and has been considered the foremost authority on seahorses. Project Seahorse was the first to study seahorses underwater, discover their huge trade, identify the threatened status of seahorses, and the first to launch seahorse conservation measures such as marine protected areas, fisheries management, selected aquaculture ventures, trade regulation, improved governance, and consumer engagement. Since 1998, ecological changes have been monitored around no-take reserves in Danajon Bank in Bohol, Philippines for a total of eight reserves and five distant water reference sites.

As part of resource enhancement strategies for seahorses, SEAFDEC/AQD conducts activities that focus on the refinement of breeding and seed production techniques and development of release strategies such as selection of release sites, assessment of the release micro habitat, collection of baseline data on wild populations, and development of tagging techniques that are essential to evaluate the survival and efficiency of stocking strategies. Studies were also done to develop appropriate transport techniques from the hatchery to release site. Preliminary results showed 100% survival of juvenile *H. comes* at stocking density of three individuals per liter for up to 12 h of transport duration. Furthermore, the use of fluorescent visible implant elastomer (VIE) tags was tested and found to be an appropriate tagging technique for seahorses (Woods and Martin-Smith, 2004).

3.5.5 Challenges and Way Forward

Captive breeding of seahorses aims to produce seeds for stock release to protect these internationally threatened and overexploited species in Southeast Asia. Breeding and seed production techniques have been developed; however, these still need further refinements. UV sterilization of water and formalin treatment of natural feed resulted in higher survival of the newborn seahorses, which is crucial for stable mass production of seahorse juveniles. Timely and sufficient supply of the necessary food organisms is

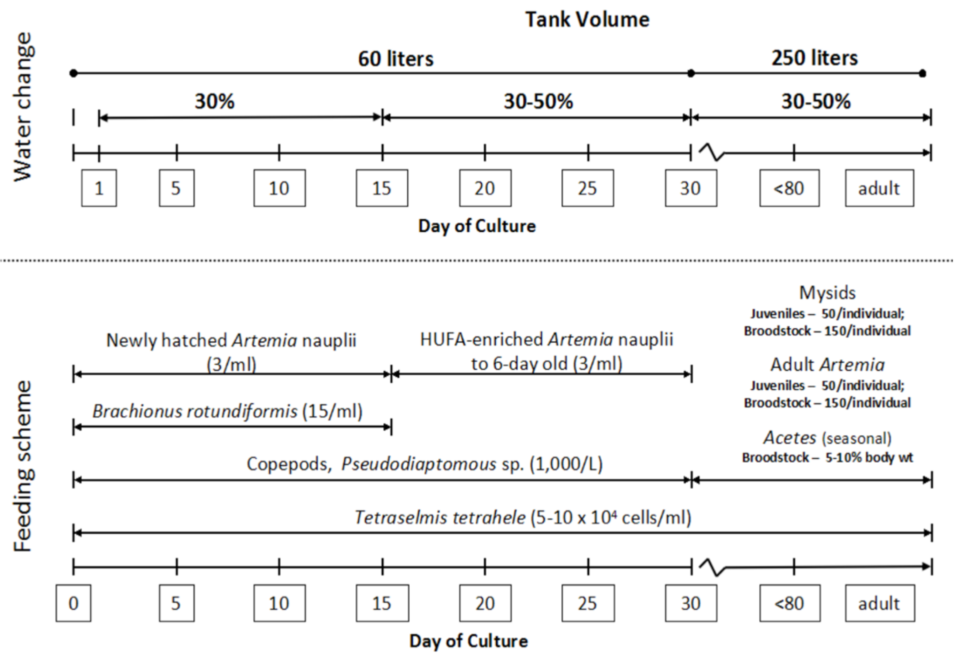


Figure 73. Feeding and water management scheme for seahorse culture

an important key factor that will help ensure the success of seahorse seed production. **Figure 73** shows the feeding and water management schemes for seahorse culture. Development of techniques for mass production of mysids and copepods as natural food to support seahorse seed production needs to be pursued to ensure available supply for seahorse hatchery maintenance. Furthermore, an efficient and reliable water supply system is important in maintaining maximum efficiency in the management of the seahorse hatchery. Significant breakthroughs at SEAFDEC/AQD on breeding and nursery rearing of tiger tail seahorse *H. comes* included improved reproductive performance and higher survival and growth rates in newborn and juvenile seahorses. Experiments also found that nursery and grow-out culture of seahorses in illuminated sea cages are feasible, and hence could also provide an alternative culture method to growing of seahorses in the hatchery.

Resource enhancement strategies for seahorses include assessment of the seahorse natural stocks to establish baseline information on the wild seahorse population. Such information will be useful contributions to marine conservation of seahorses to protect the natural resources and fisheries management. Participatory involvement of the communities in the management of the natural resources is important and needs to be promoted through dissemination of information, protection, and conservation of the coral and seagrass areas which are the natural habitats of seahorses.

3.6 Coral Reef Ornamental Species

Coral reef ecosystems are valuable source of food and income to coastal communities around the world. Yet destructive human activities have now put nearly 60 percent of the world's coral reefs in jeopardy, according to a 1998 World Resources Institute study (Bruckner, 2000). Pollution and sediments from agriculture and industry, and overexploitation of fishery resources are the biggest problems, but the fragility of reef ecosystems means that even less damaging threats can no longer be ignored. Prominent among these is the harvest of corals, fish, and other organisms for the aquarium, jewelry, and curio trades, as well as live fish for restaurants.

With more than 100,000 km^2 of coral reefs along the coastlines of Southeast Asia, the region has more coral reef area than any other parts of the world. The region's reefs contain the highest coral biodiversity in the planet. It contains over 3,000 species of fish comprising around 20% of the world's marine fish species, and over 50% of the world's coral species.

In the last 50 years, Southeast Asia has undergone rapid industrialization and population growth. As human populations have grown, so have pressures on the natural systems that sustain us. Economic market expansion has stimulated the construction of ports, airports, cities, and other infrastructure—often in ecologically sensitive areas. As a result, coastal resources are being stressed at unsustainable rates. However, exploitation is not only local in nature, as trade in live reef food fish and ornamentals has fueled region-wide overexploitation of lucrative species, often using destructive capture techniques. Many of the region's reefs have already been severely damaged.

Malaysia's coral reefs cover an estimated 3,600 km^2, most of which are found in Sabah and Sarawak, and on the eastern coast of Peninsular Malaysia. Coral diversity is highest in Eastern Malaysia, which is home to about 550 species. However, the country's coral reefs face a number of environmental threats. Agricultural development in Peninsular Malaysia contributes to sedimentation and nutrient runoff rates higher than would otherwise be the case. In East Malaysia, destructive fishing practices such as cyanide fishing are prevalent, particularly in Sabah. In Sarawak, the major threat that coral reefs face is river sedimentation. Overall, the major factors driving sub-optimal coral reef conservation are gaps in institutional capacity relating to management and enforcement, as well as resource-use conflicts (Asian Development Bank, 2014).

It is estimated that 14-30 million fish, 1.5 million live stony corals, 4 million pounds of coral skeleton, 65-110 thousand pounds of red and black coral, and 9-10 million other invertebrates are removed each year from ecosystems across the world to supply the aquarium, curio or home decor, and coral jewelry industries. Together, these three industries are known as the global trade in ornamental coral reef species. This trade has a collective annual value estimated in the hundreds of millions of dollars and is an extensive industry that involves over 45 source countries. Although collection of coral reef ornamental species primarily occurs in Southeast Asia, the majority (> 60%) of collected animals are exported to the United States (Thornhill, 2012).

3.6.1 Trade in Coral Reef Ornamental Species

Trade in coral reef ornamental species supports a multi-million dollar industry but in some places threatens vulnerable coral reef species and ecosystems due to unsustainable practices and lack of effective regulation. Trade includes over 1,800 species of fish, hundreds of species of corals, over 500 species of other invertebrates, and live rocks (Dee *et al*., 2014). To supply this trade, fishers deplete the fish populations as they rely on destructive fishing practices.

Destructive fishing practices and overexploitation of certain fish species cause significant effects on populations of coral reef fishes and other organisms, as well as on reef ecosystems. Nearly 25,000 metric tons of reef fish are harvested alive each year for the fish food trade, with an annual retail value of about US$1 billion (Bruckner, 2000). Unfortunately, cyanide fishing is the preferred method for capturing these fish, which currently occurs in at least 15 countries, including major exporters like Indonesia and Philippines (Dee *et al*., 2014). One of the most deadly poisons known, cyanide usually only stuns the fish, but it destroys coral reef habitats by poisoning and killing non-target animals, including corals. Other chemicals, including quinaldine and plant toxins, are also used to capture reef fishes alive. Field data on these practices are hard to come by because they are illegal, and thus fishers are secretive about them.

Destructive fishing practices probably figure in the high mortality rate of organisms while they are in transit. A 1997 survey of US retailers found that one-third to more than one-half of the aquarium fish imported from Southeast Asia die shortly after arrival (Bruckner, 2000). No conclusive studies on the reasons have yet been published, but these deaths are believed to be due to the poisons used in capture or the stress of handling and transport, or both. The need for replacements is one factor that keeps the demand high and thus contributes to overexploitation.

International trade in marine ornamental fishes has been going on for decades, but the growing popularity of reef aquaria has increased the types and the quantity of species in trade. More than a thousand species of reef fishes and hundreds of coral species and other invertebrates are now exported for aquarium markets. The coral reef wildlife trade targets species ranging from the foundation of coral reefs (*e.g.* corals and live rocks for aquariums and home decor) to top predators (*e.g.* sharks for teeth, jaws, and other curio items) (Dee *et al*., 2014). The vast majority of fishes come from the reefs in the Philippines and Indonesia, considered to be the world's most biologically diverse marine areas, and most stony corals come from Indonesia. But the commercial harvest of ornamental reef fishes and invertebrates (other than stony coral) occurs on reefs worldwide, including those under US jurisdiction. In 1985, the world export value of the marine aquarium trade was estimated at US$25 million to US$40 million per year. Since 1985, trade in marine ornamentals has been increasing at an average rate of 14 percent annually. In 1996, the world export value was about US$200 million. The annual export of marine aquarium fish from Southeast Asia alone is, according to 1997 data, between 10 million and 30 million fishes with a retail value of up to US$750 million (Bruckner, 2000).

According to an analysis of one year US import records, damselfish (Pomacentridae) constitute over 50% of the quantity of fish in trade. This is followed by wrasses (Labridae), angelfish (Pomacanthidae), gobies (Gobiidae), surgeonfishes and tangs (Acanthuridae), cardinalfishes (Apogonidae), wormfishes (Microdesmidae), butterflyfish (Chaetodontidae), dragonets (Callionymidae), and sea basses and groupers (Serranidae) as the top 10 families of marine aquarium fishes imported to the US (Thornhill, 2012).

Malaysia has a relatively small ornamental fishery industry. In 2000, up to 50,000 fishes were exported annually at an export value of around US$100,000. In 2010, ornamental fish output totaled 3.5 million individuals, most of which were freshwater species, but the value and trade for marine aquarium fish is still unknown (Asian Development Bank, 2014).

Despite the potential impacts of collection, the stock status and sustainable harvest levels of most ornamental species remain largely unknown and unmonitored. The life history, demographic, and population data required for traditional stock assessments are typically unavailable. In general, stock assessments for many species in the trade may be difficult because rare species are targeted. Furthermore, it often targets juveniles, affecting the population's age structure, and brightly-colored males, potentially skewing the sex ratios of the population (Dee *et al*., 2014).

3.6.2 Impact of Trade in Coral Reefs Ornamental Species

It is widely known, that collection of marine tropical fishes for the ornamental fish industry has caused extensive damage to coral reef environments throughout Southeast Asia. Although there are no firm estimates of the impact that trade is having on overall coral reef health, it is unlikely that it is minimal, as some believe. Indeed, although the diversity, standing stock and yield of coral reef resources are extremely high, most coral reef fisheries have not been sustainable for long when commercially exploited. Indonesia, the world's largest exporter of coral reef organisms, is a case in point. Because of overfishing and destructive practices such as using cyanide to stun fish for capture, coral mining, and blast fishing, only five to seven percent of Indonesia's reefs were estimated in 1996 to have excellent coral cover. Unfortunately, because of the growing international demand for aquarium organisms and live food fish, overharvesting in nearshore waters has simply pushed commercial ventures to expand their harvesting into more remote ocean locations.

Corals in trade may be live specimens, skeletons or "live rock" which is a coral skeleton with coralline algae and other coral reef organisms attached. Often broken out of the reef with crowbars, live rock is a reef structure and removing it harms the habitat for other species. Extraction of stony corals and live rock is known to increase erosion, destroy habitat, and reduce biodiversity. It is likely that the destruction of coral reef ecosystems will continue unless conservation efforts are improved.

The stony coral trade is dominated by exports from Southeast Asia and the South Pacific. In 2005, Indonesia supplied about 91% of international market demand, while the rest is distributed among countries such as Fiji, Bahamas, Solomon Islands, and Tonga (Timotius and Shahrir, 2009). The United States either prohibits or strictly limits the harvest of stony corals in most of its own waters not only because of the key role that corals play in the ecosystem but also of the widespread concern that the organisms are vulnerable to overexploitation. But the lucrative US market remains open to foreign corals, and over the period of 2000-2010, the US accounted for an average of 61% of global trade, while the European countries took 31% (Wood *et al*., 2012).

Until about a decade ago, more than 90% of the corals harvested for international markets were sold for decoration; these were harvested live, bleached, and cleaned to remove tissues, and exported as skeletons. Although the trade in coral skeletons has remained fairly constant since 1993, the quantity of live specimens for the aquarium trade has grown at a rate of 12% to 30% per year during the 1990s. In 1997, live corals constituted more than half of the global trade (Bruckner, 2000). Trade of live corals continued to show an overall increasing trend, rising from nearly 600 thousand pieces in 2000 to 1.1 million in 2009 (Wood *et al*., 2012).

Aquarium coral specimens are typically fist-sized colonies that represent six months to ten years of growth, depending on the type of coral. Most often, these are slow-growing, massive species with large fleshy polyps, many of which are uncommon or are vulnerable to overexploitation because of their life history characteristics. The flowerpot coral (*Goniopora* spp.) and the anchor or hammer coral (*Euphyllia* spp.) are the most abundant corals in trade, partly because they must be continually replaced. Surviving poorly in captivity, these species are also easily damaged during collection, susceptible to diseases, and acclimate badly to artificial conditions.

The preferred corals for the curio market are the "branching" species as they grow faster than most corals destined for the aquarium trade. However, they are traded at a significantly larger size. Colonies in trade are often more than a meter in diameter, representing a growth of a decade or more. In addition, these species are most susceptible to crown-of-thorns sea star predation, physical damage from storms, and bleaching.

3.6.3 Efforts to Improve Conservation

Several exporting countries have recognized the potential threats associated with the marine ornamental trade and have taken steps to address them. Some have implemented various measures to protect coral reef species, including marine protected areas (MPAs), harvest regulations (*e.g.* gear type, permits, quotas), and/or required documentation (*e.g.* quarantine certification). For instance, Philippines banned the collection of giant clams, seahorses, and black and scleractinian corals (Dee *et al*., 2014).

Instead of banning coral collection, Australia has developed an effective management strategy designed to ensure sustainability of the resource. Coral reef habitats have been zoned for different uses, including no-take areas. Collectors are licensed and collection of coral is permitted only in selected areas that amount to less than 1% of the reefs in a region. Collectors have harvested 45 to 50 metric tons of corals per year for 20 years, with no noticeable impact on the resource (Bruckner, 2000).

Although there are no harvest quotas for most ornamental species, Indonesia has established collection quotas for many scleractinian corals. Approximately one million pieces of live corals are permitted for export annually, including a growing number of farmed corals (Dee *et al*., 2014).

In Malaysia, the lack of stock assessments and quotas for the many species leave MPAs as the most widely used measure for coral reef and fish conservation.

3.6.4 International Efforts

The primary international mechanism regulating the coral reef wildlife trade is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which is an agreement among 175 countries. All stony corals including live rocks are listed in Appendix II of CITES. Commercial trade in Appendix II species is permitted under CITES, provided that the exporting country finds that the take does not constitute a significant risk to the species in the wild or its role in the ecosystem. Statistics on the type and number of coral reef species in trade, sources, and importers have been available since 1985. However, most of the ornamental marine fishes involved in trade were not CITES listed (Dee *et al*., 2014).

3.6.5 The Role of Mariculture

One way to reduce the pressure on coral reef ecosystems is to improve the ability to farm desirable organisms for trade. This would make it possible to create a stunning reef aquarium using only captive-bred or cultured organisms, including live rock, stony and soft corals, giant clams, fishes, and algae. Mariculture can be an environmentally sound way to increase the supply of such organisms, and it has proven successful for many invertebrates and certain fishes.

There is now a growing trend towards fragmentation and propagation of corals. Most branching corals, for instance, can be propagated from small clippings taken from a parent colony and achieve a five-fold to ten-fold increase in biomass in a year or less. More than 75 species of corals can be captive-bred, but only fast-growing corals such as *Acropora*, *Pocillopora*, *Seriatopora*, *Hydnophora* and *Montipora* appear to be economically profitable. Until now Indonesia is the biggest exporter of ornamental corals from both wild and cultured (Timotius and Shahrir, 2009; Wood *et al*., 2012).

Although mariculture of coral reef fishes has proven more complicated, a number of farmed fish species are being made available to hobbyists. While mariculture operations make up only a small fraction of the total current market, captive-bred fish currently account for less than 2% of the market and include only two or three dozens of the 800 or so species in trade. Wild-harvested coral reef invertebrates and fishes are still widely available, cheaper, and are often larger than cultured organisms.

3.6.6 Management Approaches

The impact of the marine ornamental trade must be reevaluated and additional strategies should be developed and implemented to better manage the detrimental impacts on harvested species and the ecosystem. Ensuring sustainability will require action, capacity-building, and education at each step of the trade, from harvest, through export and import, to the consumer market.

Ensuring a sustainable trade in coral reef organisms will require long-term international commitment to a policy that protects them from overexploitation and prohibits destructive harvest practices. The key step is for exporting and importing countries to establish data-gathering and monitoring systems to obtain accurate species-specific information on the trade in ornamentals, including both numbers of organisms traded and the extent of their survival from harvest to consumer.

Countries should complement trade statistics with *in situ* monitoring. Information on the life history of the species of concern, including its distribution, abundance, and role in the ecosystem; the life stage at which it is harvested; its longevity in captivity; and potential threats that affect the species and its habitat must be evaluated in order to determine sustainable harvest levels. It is unlikely that this will be practical for more than a handful of the most abundant coral reef species currently in trade. However, management plans that apply a precautionary approach and are linked with monitoring of collection sites can provide warnings about the more egregious signs of environmental deterioration or overharvesting. Management plans must include the limitation of harvesting to a geographic subset of each potentially harvested habitat. Geographic areas designated for harvesting may be combined with temporary closures or rotation of areas, as long as a significant percentage of areas remain permanently closed to harvest. Without effective law enforcement, the management plans will be useless. Choosing appropriate collection areas, education, and partnerships with local communities can enhance the effectiveness of enforcement.

Ultimately, any decision on whether a country should allow exports of coral reef species–and if so, at what level–must take into account the economic and social importance of the industry, the capacity of the resource to sustain harvests, and the effects of harvesting on the activities of other reef users. It is critical that the total quantity of organisms in trade does not exceed the natural rate of replacement, that the methods of collection should be as benign as possible, and that significant areas of habitat set aside for non-extractive uses. Mariculture alternatives must be critically examined to ensure that they do not contribute to additional coral reef losses through spread of disease or introduction of non-native species that can out-compete native organisms. By improving collection, handling, and transport, mortality will decline throughout the chain of custody. Improved survival in captivity would translate to a manageable demand for wild specimens, thereby diminishing the negative effects of the trade on the threatened coral reef ecosystems of the world.

The development of management plans that result in sustainable harvests is essential to the marine ornamental industry. But more importantly, such plans could also provide a crucial boost to local economies. Once it has become a sustainable industry, the trade in marine ornamentals could provide steady and permanent income for coastal communities in the Southeast Asian region.

3.7 Challenges and Future Direction

Throughout the past decades, the Southeast Asian countries have been confronted with even more stringent requirements that aim to ensure the sustainable utilization of fishery resources. Among several measures toward such direction are those that point towards conserving and assuring the existence of species that are possibly under threat, such as those specified under the framework of the Code of Conduct for Responsible Fisheries (CCRF), particularly the IPOA for Conservation and Management of Sharks, and transboundary and highly migratory species that are being managed by RFMOs.

In addition, CITES is another important Convention that aims to regulate the international trade of species that are listed under its Appendices. During the past decade, several proposals for listing of commercially-exploited species have been accepted for the CITES Appendices. Listing of aquatic species into the CITES Appendices could result in several problems in trading and sustainable utilization of the species, because of difficulties in identifying look-alike species and some species that are being traded only in part, or in processed forms. Furthermore, difficulties in issuance of Non-Detriment Findings (NDF) document to allow trading of some specimens could face problems due to several requirements, while down-listing or delisting of species from the CITES Appendices could also be complicated or almost impossible.

Moreover, listing of the commercially-exploited species of Southeast Asia into the CITES Appendices would result in discontinuity of data collection. Most developing countries tend to follow the results from the CITES Conference of Parties and add the said species into their respective list of protected species at the national level. As catching of such species is no longer allowed, catch data would no longer be recorded by the countries in any formal data collection system. This results in difficulties in monitoring the status and trends of such species in the future. While several aquatic species, either target or non-target species, have already been listed in the CITES Appendices, several commercially-exploited aquatic species are under consideration by the CITES Conference of Parties and could be accepted for listing in the near future. This concern therefore needs to be closely monitored and countries should be well prepared for any circumstance.

In order for the countries in the region to be always well prepared, monitoring of the status of relevant species that may be subject to international conservation and management measures should be enhanced. Countries may need to consider incorporating long-term data collection of such species in their respective national statistical systems. This would also facilitate the development of science-based management measures for such species at the national and regional level, as well as in coming up with common or coordinated positions that could be used during discussions on the species at international fora, particularly at CITES Sessions organized biennially. Furthermore, establishment of a mechanism in obtaining joint positions of the Southeast Asian countries towards CITES proposals needs to be considered. Other management measures that aim specifically at assuring sustainable utilization of the species as well as enhancing the wild population for species under international concern (*e.g.* from development of breeding and nursing technologies and stock enhancement strategies, etc.) should also be explored and documented for future reference.

4. UTILIZATION OF FISHERY RESOURCES

4.1 Status, Issues, and Concerns

The Codex Alimentarius Commission (2004) defines traceability or product tracing as "the ability to follow the movement of a food through specified stages of production, processing, and distribution." In an increasingly complex food system, traceability has become the most important tool to deal with issues and problems associated with food safety and quality assurance, thus allowing business to avoid the risks and gain the consumers' trust.

Through the strengthened ties between countries across the globe, bilateral trade is encouraged and facilitated, therefore, it is not uncommon for food to travel thousands of miles to reach a market. In trade, records of traceability are used as proof of compliance to food safety, biosecurity, and regulatory requirements, where these records also ensure that quality and other contractual requirements are fulfilled. Thus, it is imperative that traceability of food products is strengthened to support food safety worldwide. In situations where there is a food recall, robust traceability systems allow efficient tracing of affected products throughout the supply chain.

In the aquaculture supply chain, traceability is necessary to ensure the safety and quality of aquatic organisms and to verify that these are farmed in compliance with national or international management requirements or meet national security and public safety objectives. In trading with specific countries such as the United States of America (USA), the European Union (EU), and Japan, traceability is considered a vital tool and requirement for necessary market penetration.

Many AMSs export significant quantities of aquaculture fish and fish products annually to regional and global markets. As traceability becomes a trade requirement for eligibility to export aquaculture products to major markets such as Japan, EU, and USA, establishing a reliable traceability system is crucial for the sustainable development of the aquaculture industry in the Southeast Asian region. While tapping the demand for aquaculture fish in these markets, several large-scale aquaculture companies of the region are able to comply with the stringent export requirements. Governments and organizations around the world have also been developing different systems of seafood traceability, *e.g.* TraceFish (EU), TraceShrimp (Thailand). Some countries in the region which are major seafood exporters have begun implementing traceability systems for their aquaculture products such as Malaysia and Thailand (shrimp), and Viet Nam (catfish and shrimp).

Besides the stringent regulatory requirements, the greatest pressure for businesses to implement traceability system for aquaculture products has been coming from the general public. It is the new generation of educated consumers with higher level of awareness that drives a growing market demand for safety, security, and sustainability of aquaculture products. Consumers are getting more and more cautious over what they eat – whether the food comes from a safe and sustainable source, and whether production, transportation, and storage conditions could ensure food safety and quality.

National and Regional Initiatives

Implementation of traceability system for aquaculture products differs among the AMSs, for example, some countries which are major exporters of fish and fishery products implements traceability systems for their aquaculture products such as Malaysia (shrimp), Thailand (shrimp), and Viet Nam (catfish and shrimp). However, with increasing requirements for traceability in the international markets, there is an urgent need for all countries in the region to implement traceability systems in their aquaculture industry so as to comply with the regulations of importing countries. Nonetheless, countries on the one hand that already have their traceability systems in place allowing them to export their aquaculture products to the EU or USA for example, have already established a certain degree of legal framework as well as computerized or electronic traceability systems to track the aquaculture products from farm to fork. On the other hand, some countries that are in the process of implementing traceability systems have been enhancing their capabilities by building up the legal framework for traceability implementation and introducing traceability system to their industry through government support such as regulatory requirements, education and training. The status of implementation of traceability systems in AMSs is shown in **Box 7**.

At the regional level, SEAFDEC through its Marine Fisheries Research Department (MFRD) Programmes has initiated and implemented a project on traceability for aquaculture products in the region. Implemented from 2010-2015, which is in line with the 2011 ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 and with the SEAFDEC Program Thrust

Box 7. Status of implementation of traceability systems in ASEAN Member States	
Brunei Darussalam	Three private companies engaged in blue shrimp aquaculture implement traceability in their operations. Under such scheme, the shrimp farmer maintains records of date of stocking, feeding, and harvest. The country is the sole supplier of blue shrimp fry which are cultured by private companies, and harvested and sold to local shrimp buyers for domestic market or to a processing company which also operates shrimp hatchery in the country.
Cambodia	Although the country's aquaculture production is meant only for domestic consumption, the Fisheries Administration (FiA) has issued the Aquaculture Technical Guidelines and a technical manual on Good Aquaculture Practices (GAqP) which include some elements of product traceability, to ensure the safety and quality of aquaculture products. Training on GAqP has also been provided to fish farmers and model farms have been selected for GAqP certification. Considering that GAqP implementation entails high cost, many concerned fish farmers are finding it difficult to obtain better prices for their aquaculture products.

Box 7. Status of implementation of traceability systems in ASEAN Member States (Cont'd)	
Indonesia	Implementation of a traceability system for aquaculture products in Indonesia is being piloted in three provinces, namely: Lampung, East Java, and South Sulawesi. This traceability system is implemented since 2016, and the government has encouraged stakeholders to be involved in the implementation of this established traceability system. The Directorate General of Aquaculture of the Ministry of Marine Affairs and Fisheries as the competent authority for aquaculture conducted a number of training workshops, socialization programs, and activities to build the stakeholders' awareness on traceability to support the implementation of the traceability system in Indonesia. Various data and information gathering systems for internal record keeping in hatcheries, farms, processing plants, and feed mills as well as establishing farmers' identification have also been developed and promoted to support the implementation of the traceability system. However, a strong legislation is needed to ensure that the system could be carried out successfully. Currently, Indonesia is developing such a government regulation for the implementation of the traceability system that can help improve traceability of the country's aquaculture products.
Lao PDR	Presently, traceability for aquaculture products is yet to be implemented in Lao PDR. The country has only document inspection for import, export and transit of commodities, as well as inspection at the International Checkpoint before entering into Lao PDR.
Malaysia	The country's Aquaculture Product Traceability System has been developed to support its shrimp aquaculture industry in exporting their products to the USA and the EU. Developed in 2011 and fully established in 2012, the system mainly aims to ensure the availability of information on the origin and food safety of aquaculture products. Currently, the traceability system is paper-based but an electronic system is being developed. Malaysia has also implemented its Live Fish Traceability System for ornamental fish to certify the health of fish and minimize or prevent the spread of fish diseases.
Myanmar	Myanmar is in the process of implementing traceability systems throughout the supply chains of its aquaculture products. The Department of Fisheries (DOF) of Myanmar has already initiated GAqP for fish and shrimp farming since 2011, and recently, the DOF has issued GAqP certificates for a total of 1549.2 ha devoted to fish, shrimp, and soft-shelled crab farming. GAqP training is also being conducted for fish inspectors, extension aquaculture officers, fish farmers, and other stakeholders in the aquaculture supply chain.
Philippines	Traceability for aquaculture products in the Philippines is being implemented under the purview of the Bureau of Fisheries and Aquatic Resources (BFAR). As the competent authority for aquaculture and fishery products, BFAR implements programs and activities that enhance and strengthen the implementation of the traceability systems. Specifically, BFAR Administrative Circular Order No. 251 of 2014 on traceability system for fish and fishery products provides the requirements for documentation of traceability for wild caught, farmed fish, and other aquatic products. The Circular applies to all fishery and aquaculture business operators directly or indirectly involved in production and processing of fishery and aquatic products for export. Based on this Circular, the aquaculture supply chain is divided into three main sections, namely: 1) pre-production (hatchery and nursery, feed mill and aquatic veterinary products); 2) production (grow-out farm); and; 3) post-harvest (auction market, transport, processing establishment, cold storage, shipment). Each stage in these main sections of the supply chain requires a documentation system for traceability. For large operators, there is an internal traceability system for various stages of the supply chain, such as within hatcheries, farms, processing plants, and feed mills. However, external traceability that links all parts of the supply chain has yet to be strengthened. Nevertheless, the fact that most small-scale aquaculture operators and the auction markets have minimal records for traceability needs to be examined and addressed. The Code of GAqP developed by BFAR, which focuses on food safety, animal health, and traceability, was approved and adopted as a Philippine National Standard by the Bureau of Agriculture and Fisheries Standard (BAFS, 2014). Based on the RA 10654, ammendment to the Philippine Fisheries Code of 1988, fish farmers are required to implement the GAqP to minimize the risks associated with aquaculture production.
Singapore	The Agri-Food & Veterinary Authority of Singapore (AVA) is the national authority responsible for aquaculture development in Singapore and issues licenses to all marine food fish farms and land-based farms in the country. At the farm level, the AVA leverages on the Good Aquaculture Practice for Fish Farming (GAP-FF) scheme for the traceability of the country's aquaculture products. Launched in August 2014, the GAP-FF is a voluntary scheme which consists of a set of consolidated practices or Code of Practices (COP) formulated by AVA for on-farm safe and quality fish farming. The COP, which is based on the concept of Hazard Analysis of Critical Control Points (HACCP) and quality management principles, focuses on six key aspects, namely: farm structure and maintenance, farm management, farming and packaging practices, fish health management, farm environment, and human health and safety. The GAP-FF scheme is aimed at promoting responsible management practices in food fish farming as well as the guidelines for GAP-FF that provide the basis and framework for farms to implement some elements of traceability in their farm products. Under the GAP-FF's COP guidelines, farms are required to document all farming activities such as fish species, culture or stocking period, stocking size and density, source of stock, feeding regime, and seasonal stocking trends. Farms certified under this scheme must stock fish from known origin, *i.e.* from hatchery source for traceability purposes. Records and invoices of incoming fish stocks should be kept for verification and audit purposes, and there must be proper documentation of fish stocks in the various net cages and that records of fish movement between net cages must be tracked and updated. GAP-FF certified farms are encouraged to use dry formulated pelleted feeds which can be traced to source. Other than farm feeding records, the farms are also expected to have in place records on farm environment monitoring, health and disease treatment, and fish mortality. Prophylactic measures and disease treatment regime must be documented as part of health management records. In addition, certified farms are required to maintain and update farm Standard Operating Procedures (SOPs), instruction manuals, laboratory tests, log records, and other information required under GAP-FF certification. GAP-FF is a positive step forward in the implementation of traceability in the Singapore aquaculture industry. Only GAP-FF certified farms are allowed to use the GAP-FF logo when marketing their farm products. AVA conducts yearly audit checks on the GAP-FF certified farms and certification is also renewed

Box 7. Status of implementation of traceability systems in ASEAN Member States (Cont'd)	
Singapore (Cont'd)	annually after the audit checks. Currently, four farms have been certified with the GAP-FF scheme and more farms have expressed interest in joining the scheme. In response to changes in consumers' preference, some local farms are value-adding their aquaculture products. Harvested fish are sent to AVA-licensed fish establishments or processors for further processing into fillets before being sold to retailers such as supermarkets. AVA-licensed fish processors are GMP/HACCP certified and under the licensing conditions, these establishments are required to keep proper documented records for all their incoming raw materials as well as all outgoing finished products. This traceability system enables the manufacturer or distributor to promptly remove any unsafe products along the food supply chain in order to safeguard public health.
Thailand	Thailand has implemented traceability system for its aquaculture shrimp since 2002 as it is one of the main export products of the country's fisheries industry. From a manual paper-based system known as "Fry Movement Document" or FMD and "Movement Document" or MD, the Department of Fisheries (DOF) of Thailand with assistance from the French Government developed a computerized traceability system known as TraceShrimp in 2005 to provide a reliable traceability management tool not only for the Thai stakeholders in the aquaculture shrimp production and supply chain but also for their local and foreign buyers. TraceShrimp is a voluntary scheme managed by the DOF and requires membership by the Thai stakeholders. TraceShrimp member can give access to its local and foreign buyers all information on a given lot of shrimp identified by means of lot number, invoice number, delivery bill number, client or buyer name, or operation date through the TraceShrimp website. The lot of shrimp can be traced back all the way to the broodstock origins.
Viet Nam	In Viet Nam, the aquaculture product supply chain is managed by three agencies, where the stage from stocking to harvest is managed by the Directorate of Fisheries (DoF) under the Ministry of Agriculture and Rural Development (MARD); the stage from harvest to processing is managed by the National Agro-Forestry-Fisheries Quality Control Department (NAFIQAD), also under MARD; and the retail stage (sale in the market to consumers) which is managed by the Ministry of Industry and Trade. Ministerial Circular No. 03/2011/TT-BNNPTNT dated 21/01/2011 (hereinafter called Circular No. 03) is a Regulation that traces and recalls fishery products that fail to meet food quality and safety requirements. Circular No. 03, which provides the legal basis for MARD to regulate traceability of fisheries products from farming to processing, also applies to organizations and individuals involved in fisheries production and in fisheries business such as selling of feeds, chemicals, products for treatment and improvement of environment, seeds, equipment and materials for nursery and rearing. However, the Circular does not apply to households and individuals producing fisheries products for own use without selling these in the market; and producers of products of aquatic origin which are not used as food. Article 5 of Circular No. 03 requires that organizations and individuals involved in fisheries production and business in fisheries shall establish traceability system that meets the following requirements: • The system shall be under the one step back-one step forward principle to enable the identification and tracking of a product unit in specific steps of production, processing, and distribution • The system shall be able to trace the products' origin through information, including the system of product identification codes (coding) stored throughout production process of the establishment • Information shall be stored and provided to enable identification of production lots, receipts, suppliers and delivery, and recipients of the lots • Measures that clearly separate receipts of lots, production lots, and delivery of lots should be adopted to ensure accuracy of information The Ministerial Decision No. 1503/QD-BNN-TCTS of 5 July 2011 on the National Standard on Good Aquaculture Practices in Viet Nam and which was subsequently replaced by Decision No. 3824/QD-BNN-TCTS issued on 6 September 2014, makes it compulsory for fish farmers to adopt the Vietnamese Good Agriculture Practice (VietGAP) standards in their farming process. The VietGAP was based on the 1999 FAO Code of Conduct for Responsible Fisheries: General Principles, Technical Guidelines on Aquaculture Certification (FAO, 2011), AseanGAP, and other international standards (GlobalGAP and ASC, GFSI, ISO, Codex). The scope of VietGAP covers general requirements, food safety, animal health and welfare, environmental integrity, and socio-economic aspects. Starting in 2015, pangasius (catfish or tra) farming and processing have been obliged to apply the VietGAP standard. VietGAP certification is now applied for other aquaculture species such as shrimp and tilapia. Under the VietGAP standard, aquaculture farms shall record adequate information on the production process until harvest of each culture pond, and records must be kept for 24 months from harvest date. Therefore, all farms certified by VietGAP have adequate records that would make it easy to trace the products when required. The records related to traceability shall include: • ecords of receipt and delivery, use, storage of products, inputs • Records of handling of expired products and hazardous waste • Records of movement of farmed aquatic animals and identification of locations, products with or without VietGAP application • Records of seedstock • Diary of each culture pond • Records related to control and handling of diseases • Records of harvest, transportation including details of buyers As of 1 August 2015, Viet Nam catfish farmers have applied and obtained VietGAP certification for nearly 2,500 ha of aquaculture water surface area. The DoF/MARD has set up a website (*http://vietgap.tongcucthuysan.gov.vn/*) for VietGAP certified producers.

II: Enhancing Capacity and Competitiveness to Facilitate International and Intra-regional Trade. The goal of the project is to enhance the competitiveness of the region's aquaculture products through the implementation of traceability system not only in the aquaculture production and but also throughout the supply chain.

Specifically, the project aspired to establish and promote traceability systems for aquaculture products in the AMSs and enhance the capability and knowledge of stakeholders on the development and implementation of traceability systems for aquaculture products in the AMSs. A major deliverable output, the Regional Guidelines on Traceability System for Aquaculture Products in the ASEAN Region, was developed through a consensus of and in accordance with the collective inputs and efforts from all participating AMSs. The Regional Guidelines will serve as a useful resource and common reference which could be used by Member Countries to assist in their implementation of traceability systems for aquaculture products and in the formulation and development of national programs and activities to promote traceability in aquaculture products in the future.

Despite the progress made to have wider implementation of traceability system for aquaculture products, the industry (especially the small-scale) in the AMSs is still facing various issues and difficulties that include the following:

Inadequacy of resources

In the AMSs, the supply chain of aquaculture products largely comprises individual small-scale stakeholders, *i.e.* hatcheries, feed mills, farmers, middlemen, among others. These stakeholders, unlike big operators, usually face the challenges in maintaining their product quality. With inadequate resources, it would be difficult for them to maintain relevant records of their products. Being small in size and with limited income, small-scale stakeholders' operations are often tightly run with limited manpower and funds. Record keeping is a key component of a traceability system that usually entails the need to hire more manpower to establish and maintain the traceability system. This would require additional funds which is usually not available for many small-scale stakeholders.

Insufficient awareness

Another issue facing the implementation of traceability system for aquaculture products in the AMSs is lack of awareness or knowledge of the significance of tracing their products. The key stakeholders in the supply chain of aquaculture products are unaware about the benefits and advantages of having traceability system in their operations. Also, some traditional stakeholders are averse to change and are reluctant to implement any traceability system.

Complexity of the supply chain

The supply chain of aquaculture products in the AMSs is characterized by the presence of numerous small-scale aquaculture farms with limited production capacity. This results in the need for central buying stations and collection centers or middlemen to collect the aquaculture produce from various small farms. In addition, some stakeholders such as middlemen may be averse to sharing information (*e.g.* source of their raw materials) as such information are considered confidential. The presence of diverse stakeholders at each stage of the supply chain results in the mixing of raw materials and end products. The absence of cooperatives to manage these stakeholders accentuates the problem. This forms a complex supply chain framework that makes it more complicated to implement any traceability system.

Lack of legal framework

Some AMSs lack the necessary legal framework for enforcing the traceability of their respective aquaculture industries. Without any legal framework, various stakeholders lack the motivation and incentive to implement traceability system in their operations. For those who are willing, the absence of any technical guidance and assistance hinders the successful implementation of traceability system. In addition, the format of documents to track and record details of aquaculture products had not been established, making it more challenging for the small stakeholders to adopt any traceability system.

4.2 Way Forward

Traceability implementation can be mandatory or voluntary depending on the government or private sector's initiatives or obligations. Nonetheless, whether or not it is a regulatory requirement, traceability is now a common feature in international trade of fish and fish products. According to the FAO Expert Panel Review 5.2 on "Servicing the aquaculture sector: role of state and private sectors," in order to encourage traceability application and implementation, the Governments should provide training and promote capability building on traceability requirements and systems. Other roles of the Government could include provision of infrastructure facilities and financial incentives to enhance implementation of traceability systems to improve safety and productivity. Governments of the AMSs should therefore stipulate the pre-requisites of traceability application in their aquaculture industry through national standards, circular, laws and regulations. The Governments should also promote or impose the adoption of best practices, *e.g.* Good Aquaculture Practice (GAP) in their respective countries' aquaculture industry. The private sector, on the other hand, should comply with regulatory provisions to support government initiatives and programs and ensure product traceability. It is also necessary for the private sector to make sure that proper information and records pertaining to the various stakeholders in the aquaculture supply chain, provided to the government are accurately documented and maintained throughout the supply chain.

5. FISHERIES MANAGEMENT

5.1 Management of Fishing Capacity and Combating IUU Fishing

The rapidly growing fisheries industry in Southeast Asia since late 1970s has led to increased fishing capacity, especially with the introduction of highly efficient fishing gears such as trawlers and later on the purse seiners, as well as to the increasing capacities of processing plants. Promotion of the surimi industry in the region is one of the examples that significantly increased the capacities of processing industries, while increasing amounts of fish as raw materials are required to supply these processing industries. The fishing areas since the 1970s have been largely expanded to cover international waters particularly the South China Sea and towards the offshore areas of the Southeast Asian countries. The Economic Exclusive Zones (EEZs), which used to be only 12 nautical miles from shore and increased to 200 nautical miles after the adoption of the United Nations Convention on the Law of the Sea (UNCLOS) in 1982, has created significant impacts in many Southeast Asian countries. The expansion of EEZs to 200 nautical miles without effective Monitoring, Control and Surveillance (MCS) and fisheries management schemes was considered as one of the primary reasons that drives the fishing industries to operate illegal fishing activities, later identified as Illegal, Unreported and Unregulated (IUU) fishing in the EEZs of neighboring countries. There could be many forms of IUU fishing activities but among the major forms are unlicensed fishing, landing of fish in neighboring states, using double flags, and use of illegal fishing and practices, among others.

In the practical implementation, many AMSs consider that the implementation of MCS scheme plays a key role in preventing IUU fishing activities, particularly illegal fishing, and in enforcing the necessary countermeasures. Recently, the various market-driven measures enforced by fish importing countries are among the important issues that AMSs have been concerned with, and thus are putting high attention to comply with such requirements otherwise, trading of their fish and fishery products to these importing countries would be hampered. As a result, improvement of the effectiveness of fisheries management and combating IUU fishing are being promoted at national level. However, the measures or actions could not be implemented in an isolated manner by a single country. Thus, regional collaborative frameworks had been established and promoted through the RPOA-IUU and SEAFDEC. Specifically under the SEAFDEC frameworks, AMSs with support from SEAFDEC have developed several management tools, guidelines, and measures that aim to enhance cooperation among the AMSs in combating IUU fishing and improving the effectiveness of fisheries management. As one of key elements in fisheries management, promotion of effective fishing capacity is essential in making sure that fishing effort is matched with the available resources in order to protect important habitats as well as to enforce regulations that would safeguard the interest of specifically vulnerable groups of people and support the efforts to combat IUU fishing.

5.1.1 Management of Fishing Capacity

During the past three to four decades, Indonesia, Thailand, Philippines, Myanmar, Viet Nam, and Malaysia ranked among the top ten countries with the largest fishing industries in the world, which could be due to the introduction of new fishing gear technologies as well as post-harvest and processing facilities since 1960s leading to the rapid and intensive development of the fisheries industry in the region. The rising number of fishing fleet in the Southeast Asian region coupled with rapid increase in harvesting capacity has not been matched with the development of national capacities and regional or sub-regional cooperation to manage fishing effort with due consideration given to the sustainability of fishery resources. Limited management or regulation and control of active fishing capacity allow fisheries to operate in an "*open-access regime*" leading to continued increase in number of vessels and people engaged in fisheries. It has therefore become necessary to improve and implement licensing schemes and other capacity management measures that would effectively limit entry into the fisheries by replacing the present inadequately designed systems.

Recognizing the need to replace the "*open-access*" with the "*limited access*" regime to ensure sustainable utilization of the resources, several AMSs have been recently working towards improving the management of their respective countries' fishing capacity. These could be gleaned from the available legal institutional frameworks in relation to management of fishing capacity of the respective AMS that were compiled based on their inputs during the Regional Technical Consultation on Development of Regional Plan of Action for Managing of Fishing Capacity in December 2015, as described in **Box 8**.

Box 8. National policies and legal frameworks of ASEAN Member States on management of fishing capacity	
Brunei Darussalam	The country's policy on Sustainable Fisheries Management, Brunei Fisheries Limits Chapter 13, and Fisheries Order 2009 provide legislative infrastructure for the management of fisheries activities and fishing areas, as well as marine reserves and parks. This underlying policy has been translated into operational and field level management programs to ensure the: • protection of resources from over-fishing and destructive fishing activities • protection of breeding grounds (coral reefs and mangroves) and promote recruitment and recovery • promotion of responsible fishing and environment-friendly technologies
Cambodia	Legislative and institutional systems for fishing capacity management of the marine fisheries sub-sector in the country are included in the Law on Fisheries 2007: • Article 45: All types of fishery exploitation in the marine fisheries domain, except subsistence fishing shall be allowed only if in possession of a license and exploitation shall follow the conditions and obligations in the fishing logbook. The model of fishing logbook is determined by the proclamation of the Ministry of Agriculture Forestry and Fisheries (MAFF) • Article 47: Fishermen shall transship fishery products at a fishing port determined by the Fisheries Administration (FiA), while foreign fishing vessels that are permitted to fish in the marine fisheries domain shall inform the FiA prior to landing their catch in port in marine fisheries domain of Cambodia. Other terms and conditions on transshipment of fishery products and anchoring of the foreign fishing vessels shall be determined by FiA • Article 48: Based on precise scientific information that the fishing practices have been or are the cause of serious damage to fish stocks, FiA has the right to immediately and temporarily suspend fishing activities and propose for reexamination of the fishing agreement and seek for the decision from the MAFF • Under the NPOA for management of fishing capacity, marine capture fisheries is classified into two levels, namely: 1) national fishing, which is managed by MAFF and FiA; and 2) international fishing, which is managed the Cabinet of the Prime Minister Office. The NPOA had been drafted and the Inter-Ministries Joint Working Group was formed to accelerate the approval and implementation of the NPOA.
Indonesia	The legal frameworks governing the country's marine fisheries sub-sector include: • Act No. 31/2004 as amended by No. 45/2009 on Fisheries • Act No. 27/2007 as amended by No. 1/2014 on Coastal and Small Islands Management • Regulation of Government No. 60/2007 on Fish Resources Conservation • Ministerial Decree No. 45/2011 on Estimation of Fish Resources Potential in Fisheries Management Area (FMA) For fishing capacity management, Indonesia carried out data collection and reporting, moratorium to imported fishing vessels, prohibition of transshipment at sea, prohibition of catching lobster and crab, prohibition of trawls and seine nets, and establishment of closing area for fishing (conservation). The NPOA is still in the drafting stage and yet to be launched. The NPOA is referred to as technical guidance and the detailed action plan within the framework of the NPOA is in the process of development.
Malaysia	The country's Fisheries Act 1985 provides the legislative framework for the conservation, management, and development of its capture fisheries. The development of the country's fishing industry closely follows the National Agro-Food Policy 2011-2020 (NAP) which includes a provision that "Sustainable development of capture fisheries industry is important to ensure fisheries resources are preserved and could be sustained for the future." Phase 2 of NPOA-Capacity which focused on 12 identified issues and challenges and three strategies, was adopted. The strategies for the NPOA-Capacity are: 1) review and implement effective conservation and management measures; 2) strengthen capacity and capability for monitoring and surveillance programs; and 3) promote public awareness and education programs. The long-term objective of Phase 2 NPOA-Capacity is for the country to achieve an efficient, equitable, and transparent management of fishing capacity in marine capture fisheries by 2018.
Myanmar	The country's legal framework on management of fishing capacity is embedded in the Marine Fisheries Law (1990) and the law relating to fishing rights of foreign fishing vessels (1989). In addition, the country's regulations related to management of fishing capacity are in place. These include: 1) prohibition of building or importing new fishing vessels; 2) prohibition of fishing in high seas; 3) transforming of trawls into other fishing gears is allowed but other fishing gears cannot be transformed to trawls; 4) flag State and port State measures including the installation of VMS and implementation of Catch Certificate scheme. For the implementation for management of fishing capacity in Myanmar, the action plans include: 1) promotion of effective inspections for all fishing vessels at sea; 2) installation of VMS in all fishing vessels for effective MCS system; 3) use of TEDs and JTEDs in trawl fishing vessels; and 4) conduct of surveys on fishing capacity of each fishing gear group.
Philippines	The country's legal and institutional frameworks cover two classes of fishing vessels, namely: 1) commercial fishing – fishing with the use of fishing vessels 3.1 GT and above, and operating beyond 15 km from the shoreline; and 2) municipal fishing – fishing with the use of fishing vessels less than 3.1 GT and operating within the area of 15 km from the shoreline. Registration of commercial fishing vessels is under the mandate of the Maritime Industry Authority (MARINA) while registration of municipal fishing vessels is delegated to the Local Government Units (LGUs). Licensing of commercial fishing vessels is under the mandate of the Bureau of Fisheries and Aquatic Resources (BFAR) while licensing of municipal fishing vessels is the authority of the Local Government Units (LGUs). There is NPOA on Fishing Capacity Management as yet, however there are plans to develop the NPOA within the next five years. Nevertheless, a moratorium on the issuance of new licenses and other clearances had been established while building new boats and import of secondhand boats had been stopped. A joint mobile registration and licensing with MARINA have been promoted nationwide and an inventory of all commercial fishing boats had been carried out.

Box 8. National policies and legal frameworks of ASEAN Member States on management of fishing capacity (Cont'd)	
Singapore	Based on the country's legislative and institutional systems, fishing capacity is monitored through catch declaration and reporting as part of the licensing requirements imposed by the Agri-Food & Veterinary Authority (AVA) of Singapore. Licenses are no longer issued for inshore fishing vessels. On NPOA-Capacity, inter-agency engagements had been initiated to conduct regular discussions and coordination towards the development of the NPOA against IUU fishing activities, including the implementation of relevant measures under the PSMA. In addition, a review of the country's policies is being planned in preparation to the amendment of its Fisheries Act to further strengthen the country's enforcement powers.
Thailand	The country's legal and institutional frameworks related to management of fishing capacity are incorporated in the new Fisheries Act 2015 composed of 11 Chapters and 104 sections, put into force since April 2015. The enactment of this Law was primarily aimed at conserving the fishery resources, particularly those in freshwater or inland habitats, coastal habitats, and marine habitats. The Act includes a provision for the adoption of a regulation (instrument that requires a Cabinet approval) and a notification (instrument that can be issued by responsible Ministries in pursuant to the Act). Thus, a number of regulations and notifications have been adopted and issued for the management of both freshwater and marine fisheries. These comprised those on Fisheries Management, Fishery Zone, Promotion of Aquaculture, Standard of Fish or Fish Products, Importation and Exportation of Fish and Fish Products, Overseas Marine Fishery, Fees on License or Permit and Substitutes, Transferability, Competent Official, Administrative Measure, and Penalties. The Department of Fisheries (DOF) serves as the principal agency dealing with fishing, marine resources, and the management of maritime habitats. Although the Department of Marine and Coastal Resources (DMCR) and the Office of Natural Resources and Environmental Policy and Planning (ONEP) under the Ministry of Natural Resources and Environment (MONRE), have legal mandates that seem to overlap with those of the DOF, particularly in the maritime and coastal areas, these agencies have been working closely with DOF in order to achieve the goal of attaining sustainability in fisheries.
Viet Nam	The country's NPOA-Capacity was developed and adopted in principle in accordance with its legal documents such as the Fisheries Law (2003); Viet Nam's Marine Strategy to 2020; Government's relevant decrees, resolutions and decisions, as well as international legal documents such as International Convention on the Law of the Sea (1982); Code of Conduct for Responsible Fisheries (FAO, 1995); and the FAO Technical Guidelines of IPOA for the Management of Fishing Capacity. The specific objectives of the country's NPOA-Capacity are: 1) To reduce total trawl fishing boats by 15% in 2014-2017, and 12% in 2018-2025 2) Fisheries co-management is applied for eight coastal provinces in 2014-2017, and 28 provinces in 2018-2025 3) Fishing boats are controllable in consistence with allowable resources of each particular area in 2018-2025

Recognizing the importance of promoting the sustainable management of fishing capacity, the AMSs requested SEAFDEC to develop the Regional Plan of Action for Management of Fishing Capacity (RPOA-Capacity) during the Fourth Meeting of the ASEAN Fisheries Consultative Forum (AFCF) in 2012. The RPOA-Capacity was therefore developed through series of experts and regional technical consultations among the ASEAN-SEAFDEC Member Countries, the final version of which was supported and adopted by the Member Countries during the Forty-eighth Meeting of the Council of SEAFDEC (SEAFDEC, 2016c), Twenty-fourth ASWGFi and SOM-AMAF in 2016.

The RPOA-Capacity is meant not only to serve as guide for the management of fishing capacity in an ASEAN perspective but also to support the AMSs in the development and implementation of their respective NPOA-Capacity. The RPOA-Capacity is also intended to support efforts in enhancing regional cooperation on fisheries management and/or management of fishing capacity in the sub-regional areas, such as the Andaman Sea, Gulf of Thailand, South China Sea, and Sulu-Sulawesi Sea. The strengthened regional and sub-regional cooperation on the management and control of fishing capacity is expected to provide an effective platform for the AMSs to support the efforts in combat IUU fishing in the Southeast Asian region.

5.1.2 Fishing Vessel Registration and Fishing Licensing

The apparent severity of the fishery resources degradation in the Southeast Asian region brought about by uncontrolled practice of IUU fishing, prompted the AMSs to establish at the national level, systems and measures to combat IUU fishing in accordance with the Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Fisheries Management, which provides that: "*States should review the issues of excess fishing capacity at the national level and recommend where appropriate, measures to improve registration of fishing vessels, introduction of rights-based fisheries and reduction in the number of fishing boats and level of fishing effort using government incentives*" (SEAFDEC, 2003). One such measure is the establishment of a system for fishing vessels registration and fishing licensing. The progress made by the AMSs in this effort is summarized in **Box 9**.

Box 9. Fishing vessels registration and licensing systems by some ASEAN Member States	
Brunei Darussalam	The country's fishing licensing system is under Section 13 of its Fisheries Order 2009, which provides that all gears must be licensed to be able to carry out fishing activities in the country's waters. Fishing license is of three types, namely: license for individual fishing, small-scale fishing fleet license, and commercial fishing license. However, there are cases of misusing fishing licenses as small-scale fishers go fishing without any license. The country is therefore addressing such concern by enhancing the awareness of fishers and fishing communities through dissemination of information on fishing license using the media and strengthening the relevant surveillance activities to mitigate the misuse of fishing licenses.
Cambodia	The country's procedure of issuing fishing license is divided into two categories depending on the engine capacity of fishing boats. Fishing vessels with engine under 33 Hp and over 33 Hp should be registered with authorized agencies such as the Marine Fisheries Administration Inspectorate and the Fisheries Administration, respectively. The major problems on issuance of fishing license include low number of vessels applying for fishing license, inadequate enforcement of fishing licenses, and lack of understanding of fishers on the rationale of getting a fishing license. The country has attempted to solve the problems by strengthening law enforcement and intensifying the dissemination of information on fisheries laws and legal documents to fishers. Moreover, capacity building of fishery staff and fishers on the relevant issues is also being promoted while the cooperation among related agencies and local authorities is strengthened.
Indonesia	The country's Fishing Vessels registration is being implemented by two ministries: the Ministry of Transportation, and the Ministry of Marine Affairs and Fisheries. The requirements for registration include: 1) measurement of vessel as tonnage certificate, 2) vessel registration, 3) nationality certificate, 4) fishing vessel registration such as fishing vessel book, fishing vessel marking, and 5) license (fishing vessel license). The authorities issuing the fishing license are the district or municipal government, provincial government, and central government for fishing business license, fishing license, and fish carrier license to persons and companies that operate fishing vessels between 5 to 10, 11 to 30 and over 30 GT, respectively. However, the country is confronted with several problems on fishing license, the most common of which include: double flagging where a fishing vessel could have license from Indonesian authorities as well as license from the country of origin. In an effort to mitigate the problem, foreign vessels are required to complete the certificates from responsible agencies in the country of origin while ex-IUU boats are no longer issued with fishing licenses.
Malaysia	The objectives of the country's Fisheries Licensing Policy are: 1) to maintain fishery resources to ascertain sustainable yield, 2) to ensure the maximization of catch and to increase the level of income of inshore fishers, 3) to eliminate the competition and inter-sectoral conflicts through allocation of resources, 4) to ensure more equitable distribution of catches between traditional and commercial fishers, and 5) to restructure the ownership pattern of fishing units among various ethnic groups in accordance with the country's New Economic Policy. The issues confronting the country's vessel registration and licensing systems are overcapacity of fishing effort, insufficient funds and manpower, insufficient coordination between implementing agencies, and inadequate deregistration documents among others.
Myanmar	The country's Vessels Registration system is categorized into two types: national fishing vessels registration (inshore and offshore fishing vessels) and foreign fishing vessels registration. The national offshore fishing boats are inspected by the Department of Marine Administration (DMA) while the General Administration Department is in-charge of inshore fishing vessels registration. After the fishing vessels have been inspected, the Department of Fisheries (DOF) issue the fishing and fish carrier license to inshore vessels based on the recommendation of the General Administration Department. The registration of fishing vessels operating in national offshore waters should be inspected by DMA in accordance with the inspection procedures and rules of the IMO for registration. The DOF would only issue the necessary fishing and fish carrier license to the vessels after recording the fishing vessels registration from the DMA.
Philippines	Registration and licensing are critical components of any fisheries management scheme as such systems could determine the delivery system and management of fishery resources and habitats, particularly in archipelagic countries like the Philippines. The Bureau of Fisheries and Aquatic Resources (BFAR) is the authorized agency to issue licenses for commercial fishing boats, gear, and fish workers. While the Local Government Units (LGUs) in municipalities or cities issue the licenses for municipal fishing operations in coordination with the Fisheries Aquatic Resource Management Councils (FARMCs) and enact appropriate ordinances for such purpose, management of contiguous fishery resources such as bays which straddle several municipalities, cities, or provinces is carried out in an integrated manner and not based on political subdivisions of municipal waters in order to facilitate their management as single resource systems. Meanwhile, commercial fishing vessels must be registered with the country's Maritime Industry Authority (MARINA), which is under the Department of Transportation and Communication (DOTC) pursuant to RA 9295 (2004 Domestic Shipping Development Act), and is primarily responsible for registration of merchant vessels (including passenger, cargo, and fishing vessels). Nonetheless, no domestic ship shall be registered under the Philippine flag and issued safety as well as other related certificates until a Tonnage Measurement Certificate has been issued by MARINA.
Thailand	Vessels registration is carried out by the Marine Department, while fishing license is issued by the Department of Fisheries (DOF). The problems in the country's vessels registration include inadequate collaboration between the authorized officers from the Marine Department and DOF in terms of fishing vessel registration, operation of mobile units, and data sharing as well as lack of incentive in vessel registration for small-scale fishers. On fishing license, concerns include the fact that some fishers continue to use controlled fishing gears without licenses or use other licenses instead, while most fishers renew their fishing licenses late. In order to solve these problems, inspections by the fishery patrol units should be enhanced while dissemination of information to related fishers on renewal of fishing licenses one month prior to expiry should be intensified.

Box 9. Fishing vessels registration and licensing systems by some ASEAN Member States	
Viet Nam	Problems in vessels registration focused mainly on obtaining the necessary legal documents and understanding the regulations, but insufficiency of staff and budget hinders the implementation of policies and regulations, as well as inadequacy of understanding on the part of fishers on the rationale of vessels registration. For the country's fishing license system, the problems include the fact that fishing gears used as well as the corresponding fishing areas exploited have not been placed under the control of any authorized agency while enforcement of fishing licenses issued is generally weak. In order to address the problems, amending the country's Fisheries Law and related legal documents had been carried out and submitted to the National Assembly for approval. The amendments include provisions to strengthen the capacity of authorized agencies in charge of vessel registration and fishing license at all levels and enhance investments in equipment for management agencies, conduct of training for staff to improve their quality and effectiveness in their areas of operation, promote advocacy for fishers to understand, and then self-consciously comply with the provisions in legal documents including boat registration and fishing license.

At the regional level, initiatives had also been undertaken by regional and international organizations including SEAFDEC to support AMSs in the establishment and strengthening of vessel registration and fishing licensing systems, particularly through the development of Guidelines on Fishing Licensing and Boats Registration. Nevertheless, considering that IUU fishing is also a transboundary issue, sharing of information on fishing vessels among countries in the region has been promoted by SEAFDEC to enhance the effectiveness of measures in combating IUU fishing at the regional level. Toward this end, the Regional Fishing Vessels Record (RFVR) was established as a management tool to combat IUU fishing in the Southeast Asian region, particularly through enhanced cooperation among the AMSs in sharing their respective information on fishing vessels. The development of the RFVR is aimed at promoting the implementation of MCS system and ultimately, at preventing and eliminating IUU fishing activities in Southeast Asian waters. Through series of expert groups and regional technical consultations, the initial RFVR which starts with fishing vessels 24 meters in length and over (RFVR-24m) includes 28 elements of vessel information as shown in **Box 10.** The establishment of the RFVR-24m was also supported by the Special Senior Officials Meeting of the Thirty-Fourth Meeting of the ASEAN Ministers on Agriculture and Forestry (Special SOM-34th AMAF) in 2013. Based on the data on fishing vessels provided by the AMSs, the Database System for RFVR-24m was launched during the Forty-seventh Meeting of the SEAFDEC Council in April 2015.

The purpose of the RFVR is to provide the AMSs with reliable and rapid means of sharing information on AMS vessels engaged in "international fishing operations," *i.e.* fishing operations in foreign country's EEZ or in the high seas. However, the Database System for RFVR-24m is a closed system to be accessed only by the AMSs using the provided User's Account. It is envisioned that the RFVR would serve as practical ways and means of checking the behavior of fishing vessels by related authorities of AMSs, and of taking corrective actions against inappropriate operations of fishing vessels, thereby supporting the elimination of IUU fishing in the Southeast Asian region (Pongsri *et al*., 2014). For example, the AMSs can take appropriate actions against "double-flagging vessels, IUU fishing vessels, vessels avoiding port State control and engaged in poaching" by sharing information and identifying problematic vessels through the information in the RFVR Database. Therefore, the RFVR can be described as a "Shared Tool for AMSs to Reduce IUU

Box 10. Information from the AMSs on fishing vessels 24 meters in length and over

1. Name of vessel	15. International Radio Call sign
2. Vessel Registration Number	16. Engine Brand
3. Owner Name	17. Serial number of engine
4. Type of fishing method/gear	18. Hull material
5. Fishing License number	19. Date of registration
6. Expiration date of fishing licenses	20. Area (country) of fishing operation
7. Port of registry	21. Nationality of vessel (flag)
8. Gross tonnage (GRT/GT)	22. Previous name (if any)
9. Length (L)	23. Previous flag (if any)
10. Breadth (B)	24. Name of captain/master
11. Depth (D)	25. Nationality of captain/master
12. Engine Power	26. Number of crew (maximum/minimum)
13. Shipyard/Ship Builder	27. Nationality of crew
14. Date of launching/Year of built	28. IMO Number (If available)

Fishing," because RFVR could assist the AMSs in taking coordinated countermeasures against IUU fishing. Furthermore, it is also expected that if the AMSs could make full use of the RFVR Database then reduction of IUU fishing activities in the region would be successfully achieved. Although at this stage, the RFVR database system covers fishing vessels 24 meters in length and over, it is anticipated that the database system could be expanded to cover also the vessels less than 24 meters in length in the future.

5.1.3 Traceability of Capture Fisheries

From the global and regional points of view, IUU fishing still remains active around the world. Such situation led to the international community's increasing recognition of the need to promote port State measures which was developed later to be a legally-binding instrument. Adoption by the European Union (EU) of a market-driven measure known as the "EC Regulation 1005/2008" to prevent, deter and eliminate illegal, unreported and unregulated (IUU) fishing implies that countries exporting their fish and fishery products to the EU must comply with the EC Regulation 1005/2008 which was made effective since January 2010. On the other hand, many Regional Fishery Management Organizations (RFMOs) have also initiated their respective Catch Documentation Schemes as means of discouraging IUU fishing in the RFMOs' areas and/or high seas as well as tracking fish catch being traded in their management areas and minimizing opportunities for products taken by IUU fishing from reaching the markets. Therefore, countries party to the tuna RFMOs such as WCPFC and IOTC, for example, have to implement the RFMOs' Catch Documentation Schemes to be able to import and export tuna and tuna products. Under such circumstance, the Member Countries asked SEAFDEC to take proactive role in facilitating the ways and means of sharing experiences and information, *e.g.* difficulties faced by the fisheries industry, areas of negotiations with EC Regulation, possible solutions and options, in order to enhance the capacity of Member Countries in complying with the requirements of the EC Regulation. Thus, the issues pertaining to EC Regulation 1005/2008 have been immensely discussed at the Thirteenth Meeting of the Fisheries Consultative Group of the ASEAN-SEAFDEC Strategic Partnership (FCG/ASSP). While expressing support on the development of common catch documentation system to facilitate intra-regional trade of fish and fishery products in the Southeast Asian region, the FCG/ASSP Meeting suggested that such catch documentation system should conform to and align with those of relevant RFMOs and the EU Catch Documentation, in order to comply with the requirements of the RFMOs and the EU.

Results of the in-depth study carried out by SEAFDEC on the flow of fish trade within the Southeast Asian region and country requirements for catch certification (**Table 64**) indicated that intra-regional trade of fish and fishery products among the AMSs are significantly important not only in terms of quantity but also in value. In 2007, the Ministry of Marine Affairs and Fisheries (MMAF) of Indonesia reported that about 216,300 metric tons of fisheries products from Indonesia valued at US$ 180 million are exported to other AMSs such as Malaysia, Singapore, and Thailand. For the import and export of fish and fishery products within the region, trading countries would still require catch documentation in order that their fish and fishery products could be re-exported to other importing countries.

Table 64. Catch certification needs of the Southeast Asian countries

Certifications for fish trade from ASEAN MEMBER STATES	Implementation requirements for the countries		
	EC-Catch Certification	RFMOs-CDS	ASEAN CDS
1) Fish/fishery products for the EU	Y		
➢ Raw fish from commercial fisheries in EEZ	Y		
➢ Raw fish from small-scale fisheries in EEZ	Y		
2) Re-exporting fish products to EU	Y		
➢ Raw fish from other ASEAN countries	Y		
➢ Raw fish from foreign vessels	Y		
3) Importing raw tuna from RFMOs area		Y	
➢ by foreign fishing vessels		Y	
➢ by other ASEAN countries		Y	
4) Exporting of tuna products	Y	Y	
➢ To EU and other Regions	Y	Y	
5) Import-export fish among AMS			**Y**
6) Import fish from other AMS and Re-export to other region			**Y**
7) Export fish from AMS to other region (consideration for EU)			**Y**
8) Import from outside region and re-export within the AMS region			**Y**

There are also cases that small-scale fisheries are required to adopt the simplified catch documentation or certification in order to comply with the requirements of importing countries. Therefore, it would be of advantage to the ASEAN-SEAFDEC Member Countries if a regional catch documentation system is developed taking into consideration the format, standard, and information requirements of the existing schemes of importing countries, but simplified in order to enhance applicability for small-scale fisheries in the region. The development of such regional catch documentation known as the ASEAN Catch Documentation Scheme or ACDS, therefore took into consideration the requirements of the AMSs. Nonetheless, the development of the ACDS requires harmonization of all relevant schemes, including the EC Catch Certification, and the RFMOs Catch Documentation that are being adopted by their respective parties, as well as the existing schemes of the respective AMSs. Along this process, the AMSs worked together with importing countries in developing the ACDS that could facilitate not only intra-regional trade in fish and fishery products, but also enhance the cooperation among the AMSs for the realization of the ASEAN Economic Community (AEC) by 2015.

The ACDS is also an essential part of the ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain adopted by the AMSs. Upon obtaining the AMSs' commitment of support during the Forty-fifth Meeting of the SEAFDEC Council in April 2013 and the Special Senior Officials Meeting of the Thirty-fourth Meeting of the ASEAN Ministers on Agriculture and Forestry (Special SOM-34th AMAF) in August 2013, SEAFDEC worked with its Member Countries through series of expert meetings and consultations, and developed the first draft of ACDS database. In addition, development of the electronic system of Catch Documentation Scheme was carried out in mid 2016 in cooperation with collaborating agencies such as the USAID-Oceans and Fisheries and SwAM/Sweden. Meanwhile, pilot-testing of the electronic system which was initiated in Brunei Darussalam would be expanded to other AMSs such as in Myanmar, Cambodia, and other countries later on. In addition, the electronic system would be also applied for small-scale fisheries such as for swimming blue crab in Cambodia and Thailand. The flowchart of e-ACDS appears in **Figure 74**.

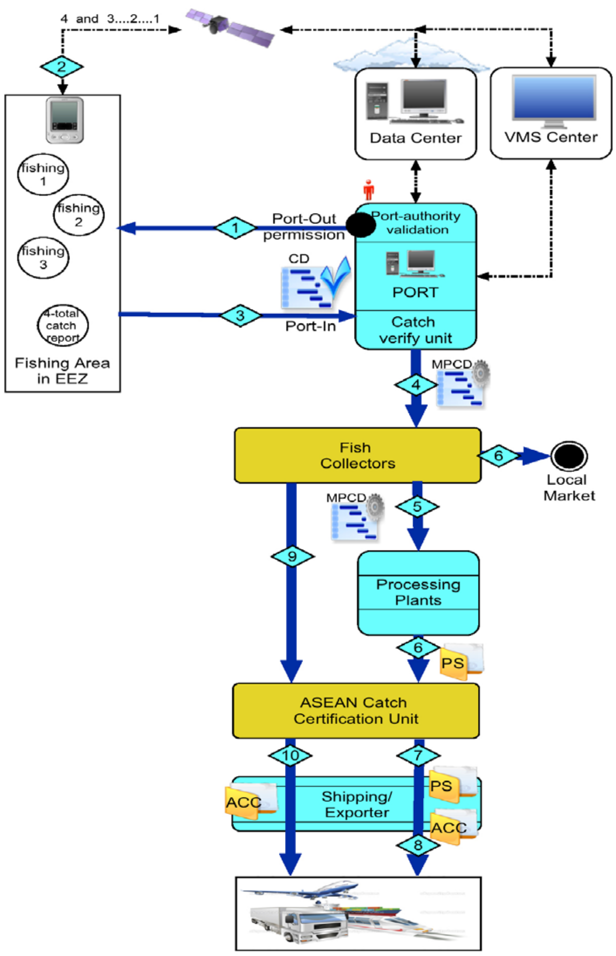


Figure 74. The e-ACDS system for ASEAN Region

The main nature and scope of the ACDS are: 1) the ACDS is established to improve the traceability of marine capture fisheries in the AMSs and enhance intra-regional and international trade of all AMSs; 2) the ACDS is used for transshipment, landings of domestic products, exports, imports, and re-exports, under jurisdiction of AMS, a catch certificate and details of transshipment shall accompany all catches, and there should be no waiver of this requirement; 3) the ACDS will cover catch from small fishing vessels (which meet the criteria) that can contribute to trade among the AMSs, and accordingly a simplified catch document would be applied; and 4) non-AMS's existing Catch Certification may be recognized as equivalent to the ACDS based on its minimum requirements.

5.1.4 Port State Measures

As stipulated in the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU), the implementation of Port State Measures (PSM) is one of the effective means for combating IUU fishing. In supporting the implementation of PSM, FAO identified the human resources development requirements and developed the "Model Scheme on Port State Measures" in 2005 which stipulates the international minimum standards for PSM (FAO, 2007). Subsequently, to ensure effective implementation of PSM, FAO also adopted in 2009 the "Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing" or PSMA as a legally binding instrument with the objective of "preventing illegally caught fish from entering international markets through ports" (FAO, 2009b). Thus, port State needs to take actions on restricting entry into port, use of port, access to port services, among others, by foreign-flagged fishing vessels. In addition, inspection and other enforcement activities are included in the PSMA which has already been put into force as the Agreement was ratified by 25 States (including Southeast Asian countries, namely: Indonesia, Myanmar, and Thailand). The status of implementation of the PSMA by some AMSs is summarized in **Box 11**. Although several countries in the region have already established their respective national PSM systems and designated ports and the required legal frameworks to support the implementation of the PSMA, raising awareness is still required to achieve a deeper understanding on the implications of enforcing the PSMA, including institutional responsibilities as relevant to the laws and regulations of each of the ASEAN-SEAFDEC Member Countries.

Box 11. Status of implementation of port State measures of some ASEAN Member States	
Brunei Darussalam	• Not a signatory to the FAO-PSM agreement. However,regular coordination and collaboration with other national enforcement agencies through the Maritime Security Taskforce have been conducted • Laws and regulations support PSM implementation • Implementation of National Plan of Action (NPOA) to prevent, deter and eliminate IUU fishing was launched in 2011 • Two ports designated for local commercial fishing vessels and no designated port for foreign fishing vessels • Active collaboration with other countries in the region in assessing the status of fisheries resources, combating IUU fishing, developing appropriate regional and bilateral MCS measures, harmonized PSM and sharing fisheries-related information
Cambodia	• Laws and regulations support PSM implementation (not full support and need some changes) • Revision of legal framework to support PSM and combating IUU fishing such as: o Conservation and management of living resources in high sea o Registration of fishing vessels o Sanction system o Creation of a reliable inspection scheme, observer program and supervision of transshipment, and monitoring of catches o Vessel monitoring system (VMS) obligation • In the process of developing NPOA-IUU which will also include PSM • PSM has not been applied since no foreign vessels unload fish catch in the country • No designated port for PSM
Indonesia	• Signed the PSMA and ratified the FAO PSMA in national law in 2016 • Followed the IOTC resolution on PSM to prevent, deter and eliminate IUU fishing • Five ports designated for PSM implementation (Bungus, Jakarta, Palabuhanratu, Bitung, Ambon) • At present, no foreign or joint venture fishing vessels operate in the EEZ • Requirement of foreign fishing vessels for information prior to entering into port • Implement the EC-Catch Certification, the CCSBT CDS, and IOTC resolution on CDS for big-eye tuna statistics • Decrees, laws and regulations support PSM implementation • NPOA-IUU linked to the implementation of PSM • Conduct some capacity buildings on PSM and relevant activities for staff concerned
Malaysia	• Designated port in Penang and Langkawi under IOTC requirement for foreign fishing vessels to enter • Domestic law supports the implementation of PSM • Foreign fishing vessel is required to get written approval prior to landing fish • Continuous capacity building on PSM for officials from relevant agencies • NPOA-IUU developed in 2013 • Appointment of first 16 port inspectors in June 2016
Myanmar	• Signed for accession the FAO PSMA in 2010 • Decree for laws and regulations to support PSM implementation • Local and foreign fishing vessels have to be inspected at check points before entering the landing site • Designated five ports for foreign fishing vessels which operate in Myanmar EEZ (Pathein, Yangon, Myeik, Kauthaung, Thandwe) • Implemented a check point as one stop service to inspect fishing vessels when they go to fishing ground and come back to port • Implementation of catch certification scheme based on EU regulation • Preparing NPOA-IUU to be linked to the PSMA
Philippines	• One designated port for foreign vessels in Davao and is planning to designate more ports in General Santos • Fishing vessels must submit prior notification information to the one-stop action center • Enacted law and regulation to support PSM implementation • Foreign fishing vessel is required to submit catch documentation in support of PSM implementation • Developed the NPOA-IUU in 2013 which include PSM • Signed the instrument of accession to the 2009 FAO PSMA in 2016 and the document was delivered to and received by the Senate of the Philippines on 25 January 2016 for concurrence or ratification • Conducted capacity building and training for PSM implementation for local inspectors and relevant staff • Coordinate with other countries for implementation of PSM
Singapore	• Three ports for import, export, and transshipment of fish: Jurong Fisheries Port, Jurong Port, and Senoko Fisheries Port • Advanced notification of arrival required for foreign fishing vessel • Compliance with CCAMLR's Catch Documentation • Collaborate with ICCAT in issuance of re-export certificates for Big-eye Tuna and Swordfish • Close inter-agency coordination between agencies

Box 11. Status of implementation of port State measures of some ASEAN Member States (Cont'd)	
Thailand	• Implemented pilot project on PSM in Phuket in 2012-2014 • Forty-six ports have been designated for PSM then reduced to 27 ports in the present and implementation activities on PSM • Accession to the 2009 FAO PSMA • Significant enforcement activities • Requirement prior to port entry • Relevant activities to PSM (Traceability System, MCS) • Decree law and regulation to support PSM implementation • Development of NPOA-IUU with support PSM implementation • Developing "Processing Statement and PSM Linked System" (PPS) • Updated inspection manual base on information provided by MoU and NPCI
Viet Nam	• No designated port for foreign fishing vessels • Requirement for information prior to port entry • Law, decree, and regulation to support PSM implementation • Development of NPOA-IUU with support of PSM implementation • Capacity building on vessel inspection to support PSM implementation for relevant staff

Source: *SEAFDEC, 2016b*

At the regional level, the importance of PSM in combating IUU fishing in the Southeast Asian region has been well recognized by the Senior Officials responsible for fisheries from the ASEAN-SEAFDEC Member Countries. Under such circumstance, the Senior Officials adopted the Plan of Operation on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2010 in June 2011, which includes a provision on the need to "*build up capacity among Member Countries, including functions for regional and sub-regional cooperation, to effectively meet the requirements of Port State measures and Flag State responsibilities*." However, implementation of the PSMA requires thorough understanding on the required actions by concerned authorities, as well as cooperation at the national (inter-agency), regional and international levels, particularly on information exchange. To address such requirements, the "Concept Proposal on Regional Cooperation for Supporting the Implementation of Port State Measures in the ASEAN Region" was supported by the Forty-eighth Meeting of the SEAFDEC Council and the Twenty-fourth Meeting of the ASWGFi to serve as a regional approach for implementation of the PSM Agreement. The Proposal focused on the harmonization and enhancement of database systems, development of SOPs for port inspections, capacity building, and sharing of information to support its effective implementation at the regional level. Nevertheless, in order for this approach to be effective, the full operation of PSM for all foreign-flagged vessels from the high seas or countries outside the region is necessary. In addition, regional cooperation of the AMSs is crucial to support the implementation of PSM for all foreign-flagged vessels of the AMSs. Moreover, implementation of PSM should be aligned with the international and regional agreement and measures, and should apply the existing ASEAN-SEAFDEC regional management measures such as the ACDS, the ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain, and RFVR.

In order to strengthen implementation on PSM Agreement in the region, capacity building by imparting knowledge and understanding on PSM is important for stakeholders concerned, *e.g.* general public, inspectors, fishery managers, and policy markers taking into consideration "Annex E" of the PSM Agreement (FAO, 2009b). Furthermore, awareness on the rationale to implement the PSM Agreement is also required for concerned stakeholders, such as fishing boat operators, boat owners, exporters, importers, and others, to enable them to understand the situation while supporting the port authorities to effectively implement the PSM Agreement.

5.1.5 MCS Systems and Networking

Fishery resources need to be properly managed to sustain their contributions to the nutritional, economic, and social well-being of the world's growing population. Monitoring (M) – data collection and analysis, Control (C) – legislation and administrative ordinances, and Surveillance (S) – law enforcement are some of the basic elements in developing the MCS systems. MCS is one of the tools or mechanisms that could be used to keep track of the implementation of fisheries management plans aimed at maximizing the economic opportunities and benefits from State's waters within sustainable harvesting limits. MCS systems encompass not only traditional monitoring and enforcement activities but also the development and establishment of modern data collection systems that incorporate information from traditional coastal fisherfolk. Under the MCS, enactment of legislative instruments and implementation of existing management plans through participatory techniques and strategies need to be strengthened. Regional cooperation among the ASEAN-SEAFDEC Member Countries can facilitate the exchange of fisheries related data for the purpose of enhancing cooperation on MCS networks and fisheries management.

Moving towards this direction, a common understanding of the scopes and provisions stipulated in legislations of the countries in the region is necessary. Furthermore, the extent of extradition agreements among countries, cost-saving schemes, and efforts to increase the negotiating power of concerned countries are also crucial. In the wake of the entry into force of the legally-binding Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unregulated and Unreported Fishing, implementation of coordinated flag and port State control combined measures to address IUU fishing activities is called upon. Various government agencies not directly concerned with fisheries (*e.g.* environment authorities, national defense, coast guard, customs, and immigration) should be involved in dialogues on matters such as determining priorities, allocating resources, and on sharing of information as MCS networks are developed. The need to move in this direction was also expressed during the 2008 RPOA Bali Workshop on the development of good MCS practices and MCS networks in the sub-regions. The detailed definitions on M, C, and S are shown in **Box 12**.

Box 12. Definition of monitoring (M), Control (C), and Surveillance (S)

Monitoring (M) – include the collection, measurement, and analysis of fishing and related activities including – but not limited to catch, species composition, fishing effort, by-catch, discard, areas of operations, etc.; in which this information is primary data to use for decision making.

Control (C) – involves the specific terms and conditions under which resources can be harvested. These specifications are normally contained in national fisheries legislation and other arrangements that might be nationally, sub-regionally, or regionally agreed. The legislation provides the basis for which fisheries arrangements, via MCS, are implemented.

Surveillance (S) – involves the checking and supervision of fishing and related activities to ensure that national legislation and terms, conditions of access, and management measures are observed.

The increasing pressure from overfishing, degraded coasts and marine environment, increasing demand for land in coastal areas, and the need to assess the effects of climate change in the sub-regions of Southeast Asia require regional, sub-regional and/or bilateral dialogues on the measures to improve fisheries management, control and manage fishing capacity, build MCS networks, and safeguard important habitats. Specifically, sharing of information generated through the MCS networks is a fundamental operating principle for the development of MCS networks. It is also essential to create a network for sharing of information on the monitoring, control, and surveillance of fisheries and fisheries-related activities among the Southeast Asian countries. The development of MCS networks as a major tool to combat IUU fishing in the sub-regions and the region as a whole, could positively reduce the long-term damages on fish stocks and marine ecosystems that otherwise might be inevitable. One of the key actions to combat illegal fishing in the region more effectively is to strengthen coordination on the development of MCS networks among relevant line agencies in each country as well as between the countries of the region. Efforts are increasingly being made by SEAFDEC and the AMSs to initiate the processes of improving coordination among responsible institutions and extend such ambitions to groups of countries in the region or sub-regions of Southeast Asia.

5.1.6 Strengthening Regional Cooperation for Combating IUU Fishing

5.1.6.1 Development of the ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain

Several national and regional initiatives have been undertaken by the AMSs in collaboration with regional and international organizations in combating IUU fishing for over a decade, thus, to further harmonize the countries' initiatives in combating IUU fishing, the "Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain" was developed (SEAFDEC/MFRDMD, 2015b) through series of experts meetings and regional technical consultations with the ASEAN-SEAFDEC Member Countries. The Guidelines, which also took into consideration the relevant international trade-related measures that prohibit the marketing of fish and fish products derived through unsustainable means and from unsustainable sources, was adopted by the Member Countries and subsequently supported by SOM-AMAF in 2015, which later was renamed as the ASEAN Guidelines. Based on the provisions of the said ASEAN Guidelines, the AMSs are encouraged to: 1) manage fishing activities within their respective jurisdictions; 2) regulate transshipment and landing of fish or catch across borders; 3) prevent poaching in the EEZs of other countries; 4) control illegal fishing and trading practices of live reef food fish (LRFF), reef-based ornamentals, and endangered aquatic species; and 5) strengthen the management of fishing in the high seas and RFMO areas. The ASEAN Guidelines is meant to serve as basis for the AMSs in formulating relevant policies and provide an enabling environment for a clear direction and understanding of the need to prevent the entry of IUU fish and fishery products into the supply chain.

In order to promote implementation of the ASEAN Guidelines in the AMSs, the strategies and recommended appropriate measures to prevent the entry of IUU fish and fishery products into the supply chain have been introduced. The situation surrounding fisheries and trading in the AMSs, which differs from country to country, was carefully taken into consideration during the development of the strategies. Thus, the countries' initiatives to develop their respective appropriate national implementation plans based on their own legal and governance frameworks had been esteemed in the Guidelines. For smooth and effective implementation of such plans, the active participation of all stakeholders in decision making processes should be made essential. In addition, sharing of information among countries had been promoted to facilitate discussion for the development of effective, practical, appropriate actions and protocols at national and domestic levels, as well as for the harmonization of commercial measures among the AMSs in combating IUU fishing by preventing the trade of fish and fishery products from IUU fishing activities.

5.1.6.2 Strengthening of Regional Cooperation on Transboundary Issues

Over the years, sub-regional approach that facilitates the conduct of bilateral dialogues to discuss and explore effective ways of improving management of fisheries in order to sustain the fishery resources in each of the sub-regions in Southeast Asia has been initiated and promoted. Aside from bilateral dialogues among neighboring countries to address emerging transboundary issues, a series of Sub-regional Technical Meetings on effective fisheries management was also facilitated by SEAFDEC since 2013 with focus on the important transboundary aquatic species and integration of fisheries and habitat managements, as well as in controlling IUU fishing and destructive fishing activities. Bilateral dialogues were facilitated, such as the Thailand-Cambodia and Cambodia-Viet Nam dialogues for the Gulf of Thailand sub-region; as well as Thailand-Malaysia dialogues for the Andaman Sea sub-region. These bilateral dialogues are meant to provide opportunities for transboundary countries to agree on relevant activities to be conducted by neighboring countries including those that aim to combat IUU fishing and strengthen bilateral cooperation on management for sustainable utilization of transboundary fishery resources.

5.1.6.3 Development of the Joint ASEAN-SEAFDEC Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products

During the implementation of the 2011 ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries Development for Food Security Toward 2020, AMSs were confronted with emerging issues including market-driven measures on the need to address IUU fishing, food safety, traceability of fish and fishery products, and labor aspects in fisheries. The impacts of these emerging issues are experienced not only by the fisheries sector but also by the general economic sectors of the AMSs. Although the AMSs improved their respective fisheries management to alleviate the pressure from such impacts by enhancing cooperation among relevant national agencies, cooperation among countries within the region is necessary in order to come up with practical and harmonized approaches to address issues including the need to combat IUU fishing and enhance the competitiveness of the region's fish and fishery products traded in intra-regional or international markets.

Box 13. Actions agreed by AMSs and adopted through the Joint ASEAN-SEAFDEC Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products

1. Strengthening Monitoring, Control and Surveillance (MCS) programs under national laws and regulations for combating IUU fishing and enhancing cooperation among relevant national agencies within the country for effective implementation of laws and regulations for combating IUU fishing;
2. Intensifying capacity building and awareness-raising programs, including information, education, and communication campaigns;
3. Enhancing traceability of fish and fishery products from capture fisheries through the implementation of the "ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain," and "ASEAN Catch Documentation Scheme for Marine Capture Fisheries";
4. Enhancing traceability of aquaculture products, through the implementation of all ASEAN GAPs with certification scheme based on regulations of respective countries, and traceability systems that are harmonized with those of major importing countries;
5. Managing fishing capacity with a view to balance fishing efforts taking into account the declining status of the fishery resources in the Southeast Asian region, and establishing conservation measures based on scientific evidence;
6. Promoting the implementation of port State measures through enhanced inter-agencies and regional cooperation in preventing the landing of fish and fishery products from IUU fishing activities from all foreign fishing vessels, and encouraging the use of the "Regional Fishing Vessels Record (RFVR)";
7. Enhancing regional cooperation in managing transboundary fisheries resources through regional, sub-regional, and bilateral arrangements in combating IUU fishing, particularly poaching by fishing vessels, transshipment and transportation of fish and fishery products across borders of respective countries;
8. Regulating the quality and safety of ASEAN fish and fishery products all throughout the supply chain to meet standards and market requirements as well as acceptability by importing countries, and development and promotion of ASEAN seal of excellence or label;
9. Addressing issues on labor (safe, legal, and equitable practices) in the fisheries sector in the Southeast Asian region through strengthened cooperation among relevant national agencies within the country as well as establishing regional, sub-regional and bilateral cooperation, and collaboration via relevant ASEAN platforms, and helping to support the development and implementation of relevant labor guidelines for the fisheries sector;
10. Enhancing close collaboration between the AMSs and relevant RFMOs in combating IUU fishing; and
11. Undertaking collective efforts in developing preventive and supportive measures to strengthen rehabilitation of resources and recovery of fish stocks to mitigate the impacts of IUU fishing.

For this reason, the ASEAN-SEAFDEC Member Countries developed the "Joint ASEAN-SEAFDEC Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products" with the main objective of enhancing regional cooperation in sustainable fisheries development in light of the unification of the ASEAN Economic Community. After obtaining support and agreement during the Special SOM-36th AMAF (August 2015), the Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating Illegal, Unreported and Unregulated (IUU) Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products was adopted during the "High-level Consultation on Regional Cooperation in Sustainable Fisheries Development Towards the ASEAN Economic Community" in Bangkok, Thailand in August 2016 (**Box 13**). The Joint Declaration is envisioned to encourage all AMSs to implement the regional initiatives towards managing fishing capacity and combating IUU fishing in the Southeast Asian waters.

5.2 Management of Inland Capture Fisheries

Fish resources are renewable natural resources that can be used sustainably through rational exploitation which could be maintained under appropriate fisheries management measures. There are many successful examples of sustainable fisheries management in marine fisheries but the much needed systematic management measures in inland fisheries are still limited.

Fisheries management is defined as the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources, and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities to ensure continued productivity of the resources and accomplishment of other fisheries objectives (FAO, 1997). There are many measures and methods used to regulate the fisheries activities, especially in marine fisheries, *e.g.* regulating the mesh size and types of fishing gears, regulating the maximum number of fishers entering the fishing grounds, introducing closed seasons and areas, establishing fish sanctuaries, promulgating fisheries decrees, and so on. For inland fisheries in the Southeast Asian region, which could be closely related to the fishers' and fishing communities' livelihoods, management measures should be considered not only on the resources but also on the socio-economic aspects of the relevant stakeholders.

In the Southeast Asian region, there are many types of fisheries management measures that could be applicable for inland fisheries, *e.g.* co-management, community-based fisheries management, adaptive co-management, rights-based management, integrated management, government-based management, and Ecosystem Approach to Fisheries Management (EAFM). EAFM is one of the latest methods on managing fisheries activities with consideration given on the surrounding conditions around the fishery sector (Staples *et al*., 2014). Successful cases of the introduction of EAFM concept in marine fisheries could be adapted as appropriate, in inland fisheries.

Nonetheless, there are a variety of challenges that confront the promotion of inland fisheries management in the Southeast Asian region. These include lack of data and information, environmental degradation, overexploitation of resources and habitats, rapidly increasing population, and increasing demands for fish and freshwater. These challenges should be addressed while awareness building on the value of inland fisheries and inland waters in this region should be intensified and continued.

5.3 Responsible Fishing Practices

5.3.1 Management and Reduction of By-catch from Trawl Fisheries

In the Southeast Asian region, there have been discussions and debates over the need to reduce by-catch from fishing activities, particularly in trawl fisheries where catch is multi-species, and the amount of by-catch could be as much as or even more than the target species. There are also evidences of decreasing average sizes of landed fish and declining Catch Per Unit Effort (CPUE) demonstrating that overfishing occurs in several trawl fishing grounds in the region. Moreover, conflicts between fleet segments also commonly occur when zoning regulations are not enforced, *e.g.* larger trawlers encroaching on waters reserved for small-scale fishers. In Southeast Asia, although catch from trawl fisheries tends to be fully utilized and the concept of by-catch may not be fully relevant, it could be observed that some parts of the catch may be considered undesirable due to the poor quality and inadequate management.

By definition, by-catch is the catch of fish or other aquatic animals and plants that a fisher does not intend or want to catch, does not use, or which should not have been caught in the first place. However, in most of the region's fisheries, the latter part of the definition is more relevant than the former since it includes catch of juveniles of commercial species. A wide range of problems on by-catch have emerged in specific fisheries, including the capture of species that are protected, endangered or threatened, as well as juvenile fish. In some fisheries sectors, there is an increasing trend towards retention of by-catch consisting of juveniles and small-sized fish for human consumption or for utilization as aquafeed. Therefore, there is a need to address the by-catch and discard problems in the Southeast Asian region.

Several research and development programs have been established to support management options for trawl fisheries and reduction of by-catch, *e.g.* fishing gear and practices selectivity, area-season management, control of fishing effort or fishing capacity, enhanced data collection (data at landing sites and onboard fishing vessels, mapping of fishing ground characteristics; and development of socio-economic procedures to monitor the management impacts). In support of by-catch management, the FAO International Guidelines on Bycatch Management and Reduction of Discards were developed and adopted for the promotion of responsible fisheries by minimizing the capture and mortality of species and size, and provide guidance on measures that contribute towards more effective management of by-catch and reduction of discards.

Based on the International Guidelines on Bycatch Management and Reduction of Discards (FAO, 2011), a range of tools could be used to manage by-catch. These include:

- Input and output control (*e.g.* fishing capacity and effort control catch quotas)
- Improvement of design and use of fishing gears and by-catch mitigation devices
- Spatial and temporal measures
- Limits and quotas on by-catch
- Ban on discards (provided retained catch is utilized in manner that is consistent with the Code of Conduct for Responsible Fisheries)
- Incentive for fishers to compile with measures

To address the issues on by-catch from trawl fisheries, SEAFDEC collaborated with FAO since 2002, to implement the Project "Reduction of Environmental Impact from Tropical Shrimp Trawling through the Introduction of Bycatch Reduction Technologies and Change of Management" or "REBYC." The Project aimed to reduce capture of immature or juveniles of commercial species; and the harvest of other by-catch fish and non-fish species, *e.g.* turtles, sharks, marine mammals, and others. An important output of this Project was the development of Turtle Excluder Device (TED) together with enhanced awareness on responsible trawl fisheries. The Juvenile and Trash Excluder Devices (JTEDs) were also developed by SEAFDEC and promoted for application in the Member Countries. However, it was also recognized that modifications of fishing gear and practices alone would not be adequate for effective management of by-catch, as this needs to be supported by appropriate legal and incentive frameworks.

To continue the momentum on reduction of by-catch from trawl fisheries, the second phase of REBYC was implemented during 2012-2016 with the objective of contributing to more sustainable use of fishery resources and healthier marine ecosystems by reducing by-catch, discards and fishing impacts from trawl fisheries. This was carried out with the full recognition that the concept of trawl fisheries management should not be developed solely based on fishery perspectives but also from the holistic point of view taking into consideration the interaction among issues on trawl fisheries, *e.g.* fisheries resources, habitat, economic and social culture. Thus, the principles of EAFM were therefore promoted in trawl fisheries.

Considering that the various stakeholders engaged in trawl fisheries have varied objectives, the stakeholders' identification, prioritization, and engagement were among the first challenges that were addressed for the successful implementation of EAFM in trawl fisheries. Through stakeholders' engagement and looking at issues in trawl fisheries from the holistic viewpoint, integration of several management measures and tools were recommended in order to come up with regional strategy for by-catch management as well as area-specific management plan. Such measures and tools include:

- Gear-related measures, *e.g.* selective fishing gear and practices
- Area-based measures, *e.g.* zoning of fishing areas, spatial-temporal closure
- Obtaining better data on number of vessels, and recommendations for fishing effort and capacity management
- Identification of incentive packages to promote more responsible fishing

Furthermore, in order to deal with various stakeholders with multiple objectives, co-management has been applied along with the management plan, from implementation to monitoring, evaluation, and planning adaptation. In order to support management options in trawl fisheries management, it was also recommended that scientific studies and research works, *i.e.* on fishing gear and practices selectivity, area-season management, control fishing effort or fishing capacity, should be carried out. Catch data collection, *e.g.* at landing sites and onboard fishing vessels, and mapping of fishing ground characteristics, and establishment of socio-economic monitoring procedures are important processes to monitor the result of management. Standardized methods for catch and by-catch data collection should therefore be developed. Activities to support, not only adequate but also accurate data collection, are necessary and important to the SEAFDEC Member Countries. This is considering that the major hindrance encountered by some Member Countries is the inadequate support of national policies in developing data collection activities to obtain the necessary data set, which could be due to less priority or less concern given on data collection. Stock assessment is also a very important tool to determine the abundance of the fishery resources, and research studies on socioeconomics and incentives in trawl fisheries should also be undertaken.

Nevertheless, since research works by researchers alone may not generate acceptance from the fishers and stakeholders, collaboration with fishers is therefore necessary in order to fill the gaps in their indigenous knowledge. Promotion, awareness building on trawl fisheries management issues and how they relate to sustainability, as well as the measures available to make fishing more responsible comprise another important part of the by-catch management story. Private sector, fishers, policy makers, fisheries managers, officials, extension officers, and NGOs should therefore be provided with necessary training through workshops to enhance their knowledge on the best management practices and responsible trawl fisheries. In addition, IEC materials should also be developed to support trawl fisheries management for sustainable utilization of the fishery resources.

5.3.2 *Optimizing Energy Use in Fisheries and Reducing Carbon Emission*

Despite the importance of fish and fishery products for food security and well-being of people, the global fisheries production has been at risk of being unsustainable because fuel which is one of the most important inputs in fishing, has become costly and unaffordable for most small-scale fishers engaged in capture fisheries. During the past decade, drastic fluctuation of global oil prices could be observed (**Figure 75**), and such changes are caused by the demand and supply conditions for oil as well as other factors such as the changing policies and geopolitical tensions within the Organization of the Petroleum Exporting Countries (OPEC), which are beyond the control of the fisheries sector.

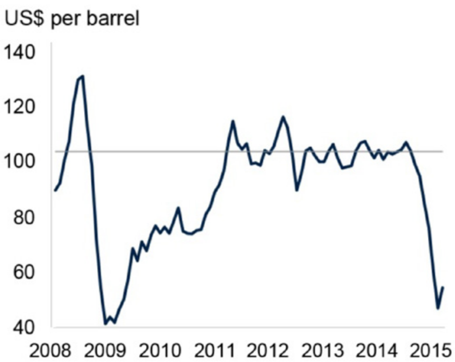


Figure 75. Recent development in oil price
Source: *World Bank, 2015*

Considering that the rising fuel prices have generally outpaced the increase in fish prices (Gulbrandsen, 2012), it has become difficult to offset the difference without landing more fish per unit of fuel used or reducing other fishing operation costs. Subsequently, the profitability of fishing operations in Southeast Asia is under threat, putting the sustainability of livelihoods of fishing families, communities, and others relying heavily on wild-caught seafood, in peril.

In order to reduce the impacts from changes in oil price to the profitability of fisheries sector, technologies to optimize energy use in fisheries are therefore necessary. One of the regional initiatives launched in late 2013 was the FAO-SEAFDEC "Fishing Vessel Energy Audit Pilot Project." The Project was meant to address the concerns not only on high and variable fuel costs but also on the associated greenhouse gas emissions from the commercial fishing industry. With particular focus in Thailand, the Project evaluated the fuel consumption of single-boat trawl fleet and identified the potential fuel savings through energy efficient fishing operations and practices.

The results of the Project indicated that fuel cost could range from approximately 35% up to more than 90% of total expenditures of trawling operations, small or large trawlers. Fuel consumption rate also depends on the engine's rotational speed (revolutions per minute or rpm) and speed in free-running or steaming condition, as well as on the use of refrigerating machinery. In addition, differences in hull design and propulsion systems also form part of the contributing factors. Based on the initial assessment from at-sea data collection, judicious use of engine's rpm is a key for reducing fuel consumption in fishing operations. This factor also provides immediate fuel savings and requires no installation cost as many trawlers are already equipped with tachometer. Another relatively inexpensive option is the installation of fuel flow meter which allows fishers to analyze the relationship between the engine's rpm and fuel consumption. In most cases, fishers are often surprised by how much fuel could be saved through modest throttle adjustments.

For other types of vessels and gears that are common in the Southeast Asian countries, the energy use pattern and energy saving options are summarized in **Box 14**.

The issue on high consumption of fuel by the commercial fishing industry is also a big concern because of its link to greenhouse emissions and climate change. According to Tyedmers *et al*. (2005), the global commercial fishing industry produces approximately 1.7 metric tons of greenhouse gas emissions for every 1.0 metric ton of live-weight seafood, and is responsible for just over 1% of greenhouse gas emissions from all sources combined. It has also been established that the boat's carbon footprint is directly proportional to the amount of fuel burned, *i.e.* one gallon of gasoline (approximately 3.79 L) could generate a carbon footprint of about 9 kg CO2 (IPCC, 2009).

Box 14. Energy use pattern and energy saving options for some types of fishing operation		
Fishing operations	**Energy use pattern**	**Energy saving options**
Trawling	Most fuel is used for dragging of trawl along the bottom (bottom trawling) or above the bottom (pelagic trawling). Less fuel is used for going to and from fishing grounds.	• Modify the trawls and trawl boards • Install the highest gear reduction available and a large diameter propeller with a propeller nozzle (depending on stern aperture) • Install advanced fish-finding equipment • Consider a changeover in fishing method to pair trawling or Danish seining
Passive fishing methods (*e.g.* gillnetter and longliner)	Most fuel is used for travelling to and from fishing grounds. The setting and hauling of passive fishing gear can be done with human power or low engine power using mechanical or hydraulic haulers.	• Reduce service speed • Keep the hull free from fouling • Use high gear reduction and an efficient propeller • Changeover from a petrol outboard engine to diesel engine
Trolling	Fuel is used both for traveling and for fishing.	• Changeover to diesel engine • Reduce service speed (except when fishing for tuna which require high speed) • Keep the hull free from fouling • Install a high gear reduction and large diameter propeller
Purse seining	Most fuel is used for going to and from fishing grounds and searching for fish.	• Reduce service speed • Install advanced fish-finding equipment • Keep the hull free from fouling • Install a high gear reduction and large diameter propeller

Source: *Gulbrandsen, 2012*

Box 15. Ways and means of reducing the use of fossil fuel in fisheries

Hull design

Reduction in engine power can be achieved by increasing the length of the waterline (LWL), making it possible to obtain a sharper bow and thereby reduce the resistance when other dimensions are kept the same. Although the weight of a boat itself is increased by the prolonged length, the overall effect on the hull resistance is beneficial. A limiting factor is the increased cost of the hull, which must be balanced against the fuel saving. Reducing the boat weight and utilization of sustain boat displacement should also be considered.

Engine power and operation range

Engine power refers to the way power delivery is measured. Usually, for fishing boats only the rating power is continuously measured. An internal combustion engine does not operate at its peak throughout the whole range of rpm of output. From a specific fuel consumption curve, the specific fuel consumption in the range 70-80% of maximum rpm shows that an engine burns fuel most efficiently.

Engine design

• ***Economical engine power and optimized fuel consumption***

The accepted guidelines for trawlers on economical engine power to reduce fuel consumption for small fishing vessels, suggested that a vessel should not be equipped with engines larger than 5 Hp/tonnage displacement (continuous duty DIN 6270 "A") and that it should be operated in service condition at about 3 Hp/tonnage actual output at maximum of about 80% rpm.

• ***Power margin definition***

Power margin is the excess capacity of a propulsion engine for sailing a boat at designed service speed. Therefore, it is necessary, but the question is how big such power margin should be. The recommended optimized margin requires about 1.6 to 1.7 of continuous rating power.

• ***Definition of engine size***

Engine power used for fishing boats is defined as the ship's displacement at service condition speed multiplied by economic service rate power per ton and margin power.

• ***Reduction of gear and propeller***

It is clear that a large reduction gear ratio can contribute to considerable fuel saving while the boat speed is kept constant. Higher thrust is available by adopting larger reduction ratios while fuel saving is in the inverse proportion to speed. In this case, higher reduction gear ratio means larger propeller diameter and increased draught. In shallow harbor entrances, this might be a limiting factor unless a certain type of limiting propeller is used. As a general rule, the maximum available reduction gear ratio should be chosen.

Engine operation and maintenance

When an engine is badly operated or not well maintained, loss in efficiency will be as high as 30% to 40%. Thus, it is necessary to operate the engine at properly maintained condition, such as maintaining the engine at ambient temperature through the use of cooling systems and ventilations. Cleaning operation of the engine must be carried out by replacing injectors or filters, and strainers regularly, and performing engine periodical check maintenance and inspection of the transmission system. Most especially, lubrication oil must be changed at certain grades and at intervals recommended by the engine manufacturer. To avoid dirt and water contaminating the fuel, an extra fuel oil filter and a water separator should be installed between the daily fuel tank and the engine.

Box 15. Ways and means of reducing the use of fossil fuel in fisheries (Cont'd)
Modification of fishing gear and methods The amount of fuel used to catch and land a metric ton of fish varies greatly with the type of fishing gear and methods as well as the fish resource including the distance to fishing grounds. The strength of the fish source (good fishing grounds) is of major importance in terms of fuel use. A poor resource or poor fishing ground means more fuel used per metric ton of fish landed.
Alternative fuel use Alternative fuels to petro-diesel include bio-diesel, LPG, LNG, CNG, ethanol, and hydrogen. A right choice of fuel may reduce fuel costs and improve business liability, as well as reduce greenhouse gas emission. This issue could have a bearing on the net cost of converting an alternative fuel (Sterling and Goldsworthy, 2006).
Alternative energy use Utilization of alternative energy relates to moving away from the use of chemical energy in the form of fuel and the conversion of the heat of combustion into mechanical work using a heat engine. Among the alternatives that have practical possibilities are wind, solar, and wave energies. However, there are two issues related to harnessing such energy, namely: collection and conversion of the energy to more usable form and storing the energy until it is required in fishing operations. For all these forms of energy, it seems unlikely that either or all of them combined would be able to satisfy the total energy demand of a typical fishery operation at least in the foreseeable future. Nonetheless, utilization of both wind and solar energy in fishing could be easily conceptualized based on the already proven and well-known technologies, although the practicalities and performance of such systems on fishing boats would depend on the exact application of the correct or emerging technologies used. Nevertheless, the utilization of wave energy could not yet be easily conceptualized as of the moment.

Source: *Chokesanguan, 2011*

It is therefore necessary for the fishery sector to explore and adopt energy saving technologies and practices that reduce reliance on fossil fuel and eventually achieve improved national financial economy. Toward this end, fuel and energy source alternatives should be identified while R&D on environment-friendly and efficient capture technologies should be pursued. Projects have already been initiated in the Southeast Asian region concerning measures to reduce fossil energy dependence in capture fisheries. There are many ways of reducing the use of fossil fuel in fisheries and fishing operations as shown in **Box 15**.

Involvement of and awareness-raising in addressing issues on energy use in fisheries, especially on the part of the private sector, should continue to be enhanced with the objective of reducing the use of fossil fuels in fishing operations. Meanwhile, relevant programs should be promoted in collaboration with concerned institutions including the academe, NGOs, research institutions, especially in developing advocacies relative to minimizing the contribution of fisheries to climate change.

5.4 Community-based Fisheries Management Approach

The coastal and inland areas of Southeast Asia provide the means of livelihood to coastal and inland dwellers, where hundreds of thousands of coastal and inland families are directly engaged in fishing activities and aquaculture including related activities such as fish processing, marketing, boat building, and net making, among others. The fishers' overdependence on the coastal fishery resources without appropriate rescue management, however, leads to overexploitation and degradation of the resources. Conflict on the multiple-use of the resources also threatens the livelihoods of dwellers in coastal fishing communities. In addition, communities have to pay more for fuel, food, and services, while the income generated from their production activities remains low. Unsustainable utilization of the fishery resources by coastal dwellers is one of the reasons that drive fishers in coastal communities to continuously intensify their fishing efforts to sustain their livelihoods.

Confronted with degrading fishery resources and without having any knowledge of appropriate resource management, coastal dwellers have to cope with low living standard and poverty. Considering that many fishing communities are outside of any social safety net systems that may exist in other areas of a country, it has become urgent to strengthen community fisheries organizations and build capacity for better development and management of the coastal and inland fishery resources and sustain the livelihoods in coastal communities. It is indeed important that appropriate coastal resource management and stable alternative livelihoods should be put in place.

Appropriate resource management is an indispensable activity that keeps fishery resource utilization sustainable. Autonomous resource management by community fishers' groups is the most effective and efficient way rather than the top-down management of coastal and inland fisheries by the government. However, community fishers alone can hardly establish and implement community-based resource management (CBRM) without governments' support and initiative.

In 2014, the ASEAN Regional Workshop for Facilitating Community-based Resource Management in Coastal and Inland Fisheries was organized in Phnom Penh, Cambodia to review the national activities on fishery resource management in coastal and inland fisheries, and share the results of case studies that could be used in identifying the key factors for improvement of national resource management plans and their successful implementation. Results of the Workshop indicated the need to ensure that legal and policy frameworks should clearly indicate the roles, responsibilities, and fishing rights of resource users, government, and concerned stakeholders. Moreover, the fishery resource boundaries should be clearly defined, and that the communities should have their respective active and responsible leaders. Furthermore, the Governments should provide access to legal and policy frameworks in support of the establishment of CBRM and rights-based fisheries as well as technical and financial support to enhance the adoption of CBRM by resource users and fisheries officers. The fishery resource boundaries should be clearly defined to ensure effective management of fisheries by the fishing communities. Community members, resource users, and stakeholders should be encouraged to actively participate in the implementation of CBRM and that their knowledge should be enhanced to make them fully aware of their rights.

5.4.1 Co-management/ Community-based Fisheries Management

Since its establishment in 1967, SEAFDEC has been extending technical support to the AMSs to enable the countries to attain sustainability in fisheries and contribute in enhancing the contribution of fisheries to food security in the Southeast Asian region. However, everything did not seem to come along fine since regional concerns over the unsustainable fisheries practices had impacted the fish supply for food security of the people in the region. For this reason, the ASEAN and SEAFDEC organized the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium "Fish for the People" in November 2001 where the ASEAN-SEAFDEC Ministers adopted the 2001 Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region. In a span of ten years, the AMSs have made significant strides in the implementation of the 2001 Resolution and Plan of Action, but efforts of the countries had been hampered by a number of emerging issues brought about by the changing environment not only because of climate change but also changes in the requirements for trade of fish and fishery products. Such changing scenario therefore called for the conduct of a sequel Conference, the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment".

Important fisheries-related issues and concerns were discussed during the sequel Conference, one of which focused on Enhancing Governance in Fishery Management which included Co-management as a sub-theme. Results from the discussions led to the establishment of the Resolution and Plan of Action for this particular sub-theme, to wit: *1) Adopt co-management at all levels and with all relevant stakeholders in the process of planning and policy formulation for management, conservation and rehabilitation of habitats and protective geographical features, as well as policy formulation on the use and management of natural and human resources to ensure that climate change responses are integrated into fisheries policy frameworks;* 2) *Strengthen the capacity of fisheries communities and the capability of fisheries related organizations, NGOs and the private sector to better implement necessary actions towards enabling the communities and local organizations to increase resilience, improve livelihoods, alleviate poverty, adopt alternative livelihoods, adapt to climate change in support of achieving sustainable development, and encourage the participation of women and youth groups in the process;* 3) *Enhance and promote the participation of local communities, fisheries associations and other stakeholders in fisheries management and co-management. In addition, communities should take part in fisheries and stock assessments by providing data, local ecological knowledge, and status of the stocks; and* 4) *Raise awareness of the need to develop financial incentives, especially for small-scale stakeholders and cooperatives, e.g. micro-credit, with national and regional institutional assistance for the responsible development of fisheries enterprises and developmental activities that will optimize socio-economic returns and food security*.

With financial and technical support from donors and collaborating agencies, SEAFDEC has been supporting the AMSs in their efforts to review the problems and constraints in fisheries data collection in coastal small-scale and inland fisheries at national level, and identify the key issues in fisheries data collection that should be addressed by the countries. In 2013-2017, the Japanese Trust Fund for SEAFDEC supported the organization of on-site training on "Facilitating Fisheries Information Gathering through Introduction of Co-management/Community-based Fisheries Management (Co-management/CBFM)." The training was aimed at building the capacity of provincial officers of the AMSs in planning and implementation of Co-management/CBFM. Results of monitoring the current situation in the AMSs were used to facilitate the planning and implementation of Co-management/CBFM in the AMSs.

In the Southeast Asian region, fishing areas are still considered as "open-access" for everyone to exploit, therefore most fishers tend to catch as much fish as possible without limit, leading to overexploitation of the resources. In such a situation, co-management and community-based management models could be adopted to address such concern as the models would help resolve the conflicts among fishers on the use of the resources while encouraging the fishers to protect the resources. Although most AMSs do not have legal frameworks on fisheries co-management, efforts have been made by SEAFDEC to promote co-management in their respective national jurisdictions through the establishment of pilot sites.

Viet Nam started promoting the concept of Co-management/CBFM in 2003, and has developed national guidelines on small-scale fisheries co-management for approval by the Government. A provision which states that "co-management is a management approach, in which the State shares its authority, responsibility, and management functions with the resource users," was included in the guidelines.

Thailand started implementing Co-management/CBFM models in 1997 through some activities that aimed to enhance the well-being of fishers' groups around the coast of Gulf of Thailand and Andaman Sea. These included providing improved infrastructures in local fishing piers and fish processing plants, enhancing extension works on coastal aquaculture, and promoting fish releasing activities and installation of Artificial Reefs (ARs). The latter activity was however faced with the difficulties in finding appropriate locations for installing ARs as the ARs were large and seemed to sink in the bottom of the sea, and there was no space to serve as a public place for fishers to use during the installation. In addition, monitoring of the ARs was not carried out after the termination of the project. Under the new Fisheries Law which was adopted in 2015 (some parts of which deal with the fishing communities), promotion of the co-management concept could be intensified as the Law stipulated the need to "promote the participation and support local fishing communities in the management, maintenance, conservation, restoration, and sustainable use of aquatic resources within the fishery in coastal fisheries or inland fisheries."

In the State of Sabah in Malaysia, Co-management/CBRM of the river fish population locally called "Tagal System" was initiated in 2000. A smart-partnership approach between the local communities and the State Government, the System aims to protect and restore the fishery resources in the river for sustainable benefit of the local communities. In 2004, the Department of Fisheries of Sabah zoned the Tagal sites to make the Tagal System more successful and sustainable. Since then, the CBRM/Tagal System was also applied to other areas such as rice-field water canals, brackishwater rivers, and coastal waters. Local business development like eco/agro-tourism was also promoted in some successful Tagal sites to generate additional incomes for the local communities which include sports fishing, fish feeding, fish body massage, and swimming with the fish. The CBRM/Tagal System then expand to the marine waters through the launching of Artificial Reefs in 2009 as well as CBRM/Tagal for sea cucumber in 2011 that aimed to protect and restore the population of sea cucumber in Sabah since sea cucumber is considered a potential agro-tourism product of the State of Sabah. The success of Tagal System could be seen in all rivers with Tagal sites that are clean with plenty of fish, and in the enhanced awareness, harmony, and cooperation that has been created among local communities and other stakeholders on fishery resources conservation. The successful results also created an opportunity for the adoption of the CBRM/Tagal System in other States of Malaysia for sustainable fisheries development of the country. CBRM is considered a mechanism for sustainable utilization of fishery resources in coastal and inland areas through appropriate resource management. Therefore, promotion of this mechanism in the AMSs should be intensified.

5.5 Ecosystem Approach to Fisheries Management

Fisheries has been playing an essential role in the development of national and local economies of developing countries. However, compared with the other sectors of the national food economy, development of the fisheries sector is not only poorly planned and regulated but is also inadequately funded and often neglected by all levels of the government. The little attention given to the fisheries sector caused considerable impacts on productivity, livelihood sustainability and vulnerability of the fishing communities, and the resilience of the overall fisheries systems.

Building on the FAO initiatives, the Ecosystem Approach to Fisheries Management (EAFM) was advocated in the Southeast Asian region to strike a balance among the diverse societal objectives by taking into account the knowledge and uncertainties of biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries (FAO, 2003). EAFM is essentially an integrated management strategy within ecologically defined boundaries, and the integrated systems approach promoted through the EAFM tie together integrated coastal management and ecosystem-level perspectives. The principles that underlie the EAFM (FAO, 2005) emphasize on the importance of collaborative and adaptive approaches, in simple terms, EAFM is an attempt to do fisheries management in an ecosystem context (Link, 2010).

EAFM is an adaptive management process in which stakeholders' participation and co-management approach play a central role. The process begins with a scoping phase, during which concerns over both fishing and nonfishing activities and social well-being are identified, along with the broad geographic area to be managed. Issues relevant to the EAFM plan are ecological in nature (*e.g.* effects of fishing on habitats and ecosystem resilience, and target and by-catch species); societal (*e.g.* related to livelihood options, health and safety, post-harvest and processing, and interactions with other sectors); and related to governance (*e.g.* institutional, consultation, and external drivers). Stakeholders, as well as management institutions across all sectors are engaged in all phases of the management cycle, including deciding on priority issues to be addressed and the goals and objectives of the EAFM plan.

Management institutions identify the management strategies and actions to be implemented, and recommend actions on how to enforce them, to meet the goals and objectives of the plan. An essential component of an EAFM is the identification of indicators to be used during the scientific assessment of the outcomes to make sure that the goals and objectives of the EAFM management plan are achieved, as well as in reviewing the effectiveness of the management actions. The results are then used to adapt and revise the EAFM management plan as necessary. The five steps (plus a pre-step for start-up tasks) that make up the EAFM planning process are shown in **Figure 76**. Step 1: Definition and scoping of the Fisheries Management Unit (FMU); Step 2: Identification and prioritization of the issues and goals; Step 3: Development of the EAFM plan; Step 4: Implementation of the EAFM plan; Step 5: Monitoring, Evaluation and Adaption. It should be noted that the EAFM planning process is dynamic rather than linear, often cyclic as it evolves, and is adaptive.

Figure 76. Five steps of EAFM

Source: *Pomeroy* et al., *2013; Staples* et al., *2014*

Many AMSs are now considering the adoption of EAFM which puts more emphasis on balancing the ecological and human well-being based on good governance. Training courses on the Essential Ecosystem Approach to Fisheries Management (E-EAFM) had been organized by SEAFDEC Training Department through the REBYC-II CTI Project since 2014 to promote the concept and principles of EAFM in the AMSs. Adoption of the EAFM concept has various benefits to the AMSs as fisheries officers would be capable of applying the approach for developing appropriate national fisheries management plans for their respective countries. The AMSs are now conducting many activities based on the EAFM concept.

In some AMSs, fisheries management plans were developed taking into consideration the concept and principles of EAFM. In the Philippines for example, the Samar Sea Fisheries Management Plan (SSFMP) was based on the EAFM concept, *i.e.* starting with the formation of a Technical Working Group (TWG), the key stakeholders were identified and then followed by collection of the data on human, ecological, and governance aspects. SSFMP cooperates with various sectors, including the NGOs, local government units (LGUs), universities, especially in collecting the necessary data to be used in strengthening the functions of the SSFMP.Moreover, EAFM training and workshops were also organized to improve the knowledge and skills of relevant stakeholders of the SSFMP on the EAFM and co-management, especially its socio-economic aspects. As a result, a socio-economic survey form and guide for trawl fishery and other fishing gears was developed and the survey was conducted in early 2015 covering 11 municipalities and cities along Samar Sea. The data was analyzed by the enumerators, officers, and fishers and the results were presented at the Writeshop on Data Analysis organized by BFAR and the necessary management actions were clarified. One of the current activities of the SSFMP is aimed at providing alternative livelihoods to relevant stakeholders on the use of gillnets, traps, and hook and line in three sites, namely: Calbayog, Catbalogan, and Daram, and six municipalities on trawls.

In Malaysia, an EAFM Steering Committee was established in 2013 and during its National EAFM Workshop, where the vision of the EAFM Steering Committee was developed and the roadmap for the implementation of EAFM in Malaysia was determined. This was followed by the conduct of EAFM training courses involving relevant stakeholders of the country's fisheries management program on the implementation of fisheries conservation zones. In November 2015, the Fisheries Resource Management Plan for Lawas in Sarawak was developed using the EAFM approach.

In Indonesia, the workshop to develop EAFM indicators was organized in 2010. Using the EAFM indicators, assessment of the performance of its Fisheries Management Plan was carried out. Moreover, Indonesia also developed an EAFM assessment plan for shark fisheries which was adopted in 2010-2011. Furthermore, capacity development on the EAFM has been promoted in many areas of the country.

The Governments of Cambodia, Lao PDR, and Myanmar have also been paying attention on the importance of EAFM by sending their respective fisheries officers to take part in the Regional EAFM Training Course and Training of Trainers on Essential Ecosystem Approach to Fisheries Management (TOT-E-EAFM) organized by SEAFDEC in 2015. SEAFDEC also supported the EAFM and TOT-EAFM on-site training in Lao PDR, Myanmar, and Cambodia starting August 2016. The Department of Fisheries of Viet Nam also started to enhance the capacity of its local fisheries officers by organizing EAFM training courses with the trainers who had been trained by SEAFDEC.

While many countries have already developed their respective fisheries management plans based on the EAFM concept, capacity building on EAFM had been provided to local people in respective countries using the EAFM materials. However, capacity building activities need to be intensified and continued for the effective implementation of EAFM in the Southeast Asian region. Meanwhile, Thailand already translated the EAFM materials into the Thai language for dissemination throughout the country while Myanmar is in the process of translating the materials into the Burmese language. These efforts should be supported and enhanced considering that the EAFM materials would be more useful if these are in the local languages of the countries.

5.6 Habitat Protection and Coastal Fishery Resource Enhancement

The coastal waters of Southeast Asia are blessed with fishery resources with high level of productivity because of rich ecosystems such as dense mangrove forests and sea grass beds sustained by rich effluence of nutrients from land, as well as extensive coral reefs with clean tropical sea environment. These areas are significant to a broad range of aquatic organisms, *e.g.* refuge during their life cycle from breeding, spawning, nursing, and growing; feeding zones of aquatic species that are economically important; and serve as important source of recruitment of a wide diversity of aquatic resources.

It is widely recognized that healthy aquatic environment is a prerequisite for sustainable fisheries production. Therefore, fisheries management in the Southeast Asian region should be directed towards realizing a good balance and relationship between human activities and coastal environment so that aquatic resources could be utilized in a sustainable manner. Specifically, fisheries management should aim to safeguard the health and reproductive capacity of fish stocks through sustainable protection and conservation of the aquatic resources that provide the foundations for profitable fishing industry and promote equitable sharing of benefits for the resource users. However, most of the important fishery resources in the region are believed to have declined due to many factors that include overfishing, illegal fishing, use of destructive fishing practices, and environmental degradation. Inshore, the massive clearance of mangrove forests for aquaculture, urbanization, industrialization, wood fuel, timber, and the like, has brought about large destruction of the breeding, nursery, and feeding areas of many aquatic species that might have been already destroyed and lost.

Accordingly, the June 2011 ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment" adopted the ASEAN Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 that include provisions encouraging the AMSs to "*Optimize the use of inshore waters through resources enhancement programs such as promoting the installation of artificial reefs and structures, encouraging coordinated and effective planning for coastal fisheries management programs, undertaking environmental impact assessment studies, restocking of commercially-important fish species, as appropriate, and give priority to human resources development for the implementation of such programs*" (Plan of Operation No. 27); and "*Recognizing the different management approaches that are required, sustainably manage major critical coastal habitats, such as mangroves, coral reefs, and sea grasses; and develop and disseminate information and guidance on appropriate tools and interventions*" (Plan of Operation No. 29).

5.6.1 Coastal Fishery Resource Enhancement Programs of the Southeast Asian Countries

Many Southeast Asian countries have been concerned with declining resources, and thus had mainstreamed coastal fishery resource enhancement programs in their respective national plans, policies, and legislations, with the purpose of addressing the degradation of fishery resources. As a result, various tools have been used to alleviate the declining resources, while means of enhancing the habitats and controlling the utilization of resources have been undertaken, *e.g.* deployment of artificial reefs (ARs), promotion of fishery *refugia* and marine protected areas (MPAs), use of fish aggregating devices (FADs), and installation of stationary fishing gears (SFGs). These are summarized in **Box 16**.

Box 16. Coastal fishery resource enhancement tools promoted by the Southeast Asian countries

Country	Habitat Rehabilitation and Artificial Reefs Installation	Management of Fisheries *Refugia*	Restocking, Stock Restoration, Rehabilitation
Brunei Darussalam	The Government through its Fisheries Department had developed and set up ARs since 1985 as means of promoting fishery resources enhancement using various types, *e.g.* used tires in 1985; ARs using redundant oil jackets in 1988, 1994, and 2010; and concrete and stainless steel prefabricated pyramidal structures in 2002. Used mainly for enhancing the coastal fishery resources, ARs also play a vital role in protecting the coastal fishing grounds by serving as barrier against illegal fishing gears. Moreover, AR sites are also being developed for eco-tourism activities (FRA-SEAFDEC, 2010).	In 2003, two MPAs were developed in Selirong Island and Pelong Rocks, which had been integrated with the Eighth National Development Plan of Brunei Darussalam (SEAFDEC, 2004; SEAFDEC 2005).	
Cambodia	The Fisheries Administration (FiA) divided the responsibilities of managing the fishing grounds and conservation areas within the Community Fisheries (CF) domain to be managed by community fishers. More than 350 conservation areas had been rehabilitated by the community fishers resulting in enhanced fish stocks and increased fish production through community participation. Mangrove reforestation is a routine activity in the conservation areas where community fishers follow the rules and regulations on mangrove reforestation as prescribed by FiA, while conservation areas had been rehabilitated and community fishers are also engaged in alternative livelihoods, *e.g.* tourism in the Tonle Sap Great Lake, upon thorough consultations among the members of the CF (Kawamura, *et al*., 2016). The Ministry of Environment and the Ministry of Agriculture, Forestry and Fisheries play significant roles in implementing the ARs program in collaboration with donors, *e.g.* the United Nations Environment Programme (UNEP), Danish International Development Agency (DANIDA), FAO, and the Department for International Development (DFID) of UK. The country's ARs program was initiated in 1991 using 300 units of concrete modules and base and log of trees installed in the Tonle Sap Great Lake at depths of less than 10 m, to provide habitats for aquatic species and improve fish stocks. Furthermore, 700 units were deployed in 1997 and 100 units more in 2002. The concrete ARs also serve as protection of the coastal areas and enhance the biodiversity (FRA-SEAFDEC, 2010). Installation of ARs in the lakes as means of protecting the fishing grounds from encroachment had been successfully carried out (Kawamura, *et al*., 2016).	In 1979, FiA established 13 protected areas called "fish sanctuaries" in freshwater zones especially in the Tonle Sap Great Lake. When the Fisheries Law was enforced in 1987, any form of fisheries activities were prohibited in the fish sanctuaries. In 1997, four national parks were established in coastal areas and part of the fifth park covering an area of 366,250 ha was considered as Protected Area (SEAFDEC, 2004; SEAFDEC, 2005). In 2004, Blood Cockle *Refugia* was established in Sihanoukville to enhance and protect the habitats of bivalves, blood cockles (*Anadara granosa*) such as mangroves and sea grass in natural sea beds with the country's Community Fisheries establishing the necessary self-regulatory measures, *i.e.* fishing rights and entry, fishing seasons and fishing hours, and harvestable size of blood cockles, through consultations with the stakeholders, *e.g.* local fishers, local officers, government staff, researchers, and relevant organizations and agencies (Kawamura, *et al*., 2016). In 2002, MPAs were established by the FiA with funding support from ICRAND project under UNEP, at the Koh Kong side of Sihanoukville where coral reefs are abundant (SEAFDEC, 2004; SEAFDEC, 2005).	
Indonesia	In 1998, the country's 15-year program (1998-2013) known as the Coral Reef Rehabilitation and Management Program (COREMAP) was launched for the protection, rehabilitation, and sustainable use of coral reefs and associated ecosystems through co-management. COREMAP covers 10 provinces, namely: Maluku, Irian Jaya, South Sulawesi, Southeast Sulawesi, North Sulawesi, East Nusa Tenggara, West Nusa Tenggara, Riau, North Sumatra, and West Sumatra. The major initiatives of COREMAP Phase 1 included public awareness campaigns, pilot community-based management, institutional development activities, and information and training network and development of Monitoring, Control and Surveillance (MCS) system (UP-MSI, ABC, ARCBC, DENR, ASEAN, 2002). Rehabilitation and conservation of the country's habitats are carried out through mangrove reforestation, coral transplantation, installation of fish apartments, and the like. Constructed from durable plastic materials that could last for more than 25 years, fish apartments are meant to support the aggregation of fish and serve as fish shelters. Fish apartments installed near fishing communities serve as refuge for fish stocks and prevent encroachment of the fishing areas by illegal fishers (Kawamura, *et al*., 2016). Three types of AR models are used in Indonesia, namely: cube shape model, dome model, and pyramid model. Installation of these ARs is meant to promote coral reef biodiversity and economic growth. In 1999, the Marine Habitat Enhancement Program at Minahasa of North Sulawesi implemented a Reef Ball Project in collaboration with the private sector, by deploying approximately 3000 reef balls at three main locations. It was also reported that used tires, out of commission steel structures, and old or confiscated pedicab units have been deployed to serve as ARs in the coastal waters of Indonesia (FRA-SEAFDEC, 2010).		Indonesia's stock enhancement activities include determining the bio-limnological characteristics of release sites, development of fisheries co-management approach, and making use of local wisdom or knowledge for the management of the sites. Fish stock enhancement and culture-based fisheries are options to optimize the utilization of inland waters for producing more fish, ensuring food security, creating additional income, and promoting human welfare. The concerned government agencies also support and take active part in the activities, as well as provide seeds of local fishes for restocking purposes, *i.e.* Research Institute for Inland Water Fisheries in Palembang; Research Institute for Stock Enhancement in Java; and the SEAFDEC Inland Fishery Resources Development and Management Department in Palembang (Kawamura, *et al*., 2016).

Box 16. Coastal fishery resource enhancement tools promoted by the Southeast Asian countries (Cont'd)

Country	Habitat Rehabilitation and Artificial Reefs Installation	Management of Fisheries *Refugia*	Restocking, Stock Restoration, Rehabilitation
Lao PDR	Being landlocked, the country emphasizes only on inland fisheries. Several government development programs have been oriented towards clarifying boundaries and thereby promoting enclosure of resources within fixed and legible territories. The Department of Livestock and Fisheries is responsible for the management of the country's natural aquatic resources. Between 1993 and 1999, the local government of Lao PDR endorsed the establishment of 68 Fish Conservation Zones as part of a community-based fisheries co-management initiative, all of which are situated in the mainstream Mekong River in Siphadone Wetlands near the border of Cambodia. Besides government's support, communities also received support from international non-governmental organizations, especially for the Lao Community Fisheries and Dolphin Protection Project, and Environment Protection and Community Development (Baird, 2006). In 2010, SEAFDEC started the resource enhancement program at Nam Houm Reservoir, where various activities were conducted during the five-year project period, *e.g.* compilation of fisheries information and data, promotion of sustainable fisheries and the concepts of community-based and co-management in inland fisheries, strengthening the critical habitats by installing 50 pieces of high effective fish shelters as protective measures of broodstocks from illegal fishers, prohibiting the use of certain fishing gears in conservation areas, transfer of technology on mobile hatcheries to fishers' groups in Nam Houm Reservoir for the breeding the common silver barb using hormones, and promotion of juvenile fish releasing techniques, among others (Kawamura, *et al*., 2016).		
Malaysia	The Malaysian Fisheries Act 1985 prohibits any fishing activities within the 0.5 nautical miles radius of artificial reef areas (Kawamura, *et al*., 2016). The general objective of Malaysia's ARs program is to create and enhance the fishery resources and stop trawlers from encroaching into the country's coastal areas (SEAFDEC, 2010). Rehabilitation of resources through establishment of ARs and coral replanting programs are among the tools adopted in Malaysia. Thus, FADs and ARs which have been found acceptable for fishery resources enhancement and management tools were installed in the country's waters. As a result, a total of 99 ARs have been deployed since 1975 and an additional of more than 200 ARs have been installed to mitigate the impacts and loss of habitats due to destruction and to enhance the marine resources (SEAFDEC, 2004; SEAFDEC, 2005). From 1987 to 1990, the Department of Fisheries Malaysia deployed 3 000 000 tires as artificial reefs, and from 1990 to 2004, pre-fabricated concrete and PVC reefs were deployed for the special purpose of serving as ARs for lobster and squid, and in 2000 reef ball ARs were deployed in Malaysian waters. The government pursues an extensive ARs program by conducting intensive research and development, and as a result, six innovative large-size ARs weighing 5-19 metric tons had been developed and deployed during 2006-2009, and had been dubbed as cube ARs, cuboids ARs, soft-bottom ARs, lobster ARs, recreation ARs, and tetrapod ARs.	MPAs were first established in Malaysia in 1983 and promoted as no-take zones. At present, a total of 40 marine parks have been gazetted. FAD sites have been developed at the same time with MPAs, and a total of 222 FAD sites were established utilizing a budget of Malaysian Ringgit (RM) 24 million or about US$560,000 (SEAFDEC, 2004). Meanwhile, special *refugia* for two economically important commodities such as shrimp and lobster had been established in Sarawak and Johor, respectively, following the concept of *refugia* similar to that in Sarawak, Malaysia, which is known as the "tagal system" for the seasonal conservation of the freshwater fish Malaysian red mahseer (*Tor tombroides*). The main objective of the special *refugia* is to address the country's declining production of penaeid shrimps and lobsters. Thus, activities had been initiated aiming to safeguard spawning aggregations, nursery grounds, and migration routes; protect and revive fish populations from being overfished; and increase and sustain catch and incomes of fishers and relevant stakeholders. In developing the aforementioned new concept of *refugia*, science-based information had been taken into consideration while agro-tourism aspects were explored so that local communities could generate additional incomes. However, the establishment of such *refugia* systems is constrained by various factors, *e.g.* inadequate support from local communities; pollution from terrestrial activities especially the sludge coming from crude palm oil milling factory that flows into the *refugia* area; local communities not empowered to stop encroachment by illegal fishers in *refugia* areas; migratory characteristics of target commodities makes it difficult to manage the fisheries; and in the case of eco-tourism activities, the target species become dependent on artificial diets provided by tourists instead of finding food by themselves from the natural environment (Kawamura, *et al*., 2016).	During 2010-2014, coral reef restoration activities had been carried out in the waters off Pahang and in Perhentian Island of Terengganu Province through coral replantation. Malaysia is reported to have about 1687 km^2 of coral reef areas with more than 540 species of hard corals, but only about 9% of the coral reef areas are protected under the country's MPA systems, while some of the coral reefs have been threatened by climate change, pollution, and illegal fishing among others, leading to massive coral bleaching and habitat loss. Based on the country's experience, site selection is crucial as the site should have moderate water current with unobtrusive sunlight, and should not be too near to adjacent natural reefs. Coral fragments used for transplantation must be larger than 10 cm, and the site should be maintained immediately after the corals had been transplanted. Some benefits of coral restoration include increased live coral cover, recovery of targeted coral reefs, increased biodiversity, reestablishment of ecological balance, and stabilizing the surrounding environment (Kawamura, *et al*., 2016).

Box 16. Coastal fishery resource enhancement tools promoted by the Southeast Asian countries (Cont'd)

Country	Habitat Rehabilitation and Artificial Reefs Installation	Management of Fisheries *Refugia*	Restocking, Stock Restoration, Rehabilitation
Myanmar	The Ministry of Livestock and Fisheries is responsible for the fisheries development of the country, and has established marine parks and marine reserves as well as fisheries protected areas under the country's Fisheries Law. Fishing in these protected areas is prohibited unless specifically licensed to operate. Although ARs deployment and coral planting have not yet been established in the country, the Department of Fisheries (DoF) of Myanmar is more concerned in increasing the number of marine parks and marine reserves or MPAs at places where corals are abundant to restore and enhance the marine aquatic resources (SEAFDEC, 2004; SEAFDEC, 2005). The DoF recognizes that ARs play important role in marine aquatic resources enhancement and intends to establish the country's ARs program but technology on development of ARs and financial support for such development would be required (FRA-SEAFDEC, 2010).		Inland fisheries management in Myanmar is divided into two categories, *i.e.* leasable fisheries and open fisheries. In leasable fisheries, fishing rights are granted to lease holders under a lease agreement subject to stipulations relating to the area, species, fishing implements, period, and fishing methods used. Those lease holders must take the responsibility of carrying out stock enhancement and conservation of fisheries habitats. It has been reported that there are 3729 leasable fisheries in Myanmar and culture-based system is applied in most of these leasable fisheries. Several activities had been carried out in leasable fisheries to conserve, rehabilitate, and maintain the fisheries habitats and fish stocks, and improve fish production from inland fisheries. Moreover, selective harvesting of stocks is also being promoted while means of protecting the inland fishery resources from illegal fishing activities are also being developed (Kawamura, *et al*., 2016).
Philippines	The Philippines started ARs installation in 1981 with 70 small-size ARs along the country's coasts. The Philippine Fisheries Code of 1998 provides specific management measures to conserve and manage the fishery resources of the country. ARs have been deployed by the Bureau of Fisheries and Aquatic Resources (BFAR) and technically supported the Local Government Units (LGUs). BFAR formed the SCUBA divers group to monitor, manage, and safeguard the coral reefs. Initially, the group implemented the Coral Garden and Reef Rehabilitation Project in Tangalan, Aklan in central Philippines (SEAFDEC, 2004).	There are over 500 MPAs around the Philippines that were established through local community initiatives, and are entirely locally-managed marine areas for artisanal (small-scale commercial) fishing activities (UP-MSI, ABC, ARCBC, DENR, ASEAN, 2002). Fisheries *refugia* have also been established in the Philippines, *e.g.* in Busuanga, Palawan and in Zamboanga Peninsula. Success of fisheries *refugia* depends on the actions at the local level with the intensity of support of the community which is dependent on the involvement of local stakeholders while science-based management measures are most crucial. Local knowledge and wisdom are also harnessed as these are critical for site selection and establishment of management measures. In addition, intensified information and communication also help in enhancing communities' acceptance of the fisheries *refugia* approaches. In the case of the *refugia* in Busuanga, Palawan, a model of fish egg dispersal and larval settling in Philippine waters was developed where the source and sink of fish eggs and larvae had been used in identifying the spawning and nursery *refugia*. For the *refugia* in Zamboanga Peninsula, concerns on the decreasing catch of sardines were addressed leading to the establishment of a management measure, *i.e.* enforcement of closed fishing season in the Peninsula's fishing ground. Subsequently, the catch of sardines in Zamboanga Peninsula has been increasing (Kawamura, *et al*., 2016).	Inland fishery resources in the Philippines comprise swamplands, lakes, rivers, and reservoirs that serve as host of some 340 species of freshwater fishes. The country's National Program on the Fisheries Enhancement of Inland Waters was launched covering 36 minor lakes and 320 small reservoirs in 16 regions in the Philippines for the purpose of increasing the country's fisheries production from inland fisheries. The Program is also intended to rehabilitate and/or restore the physical conditions of the country's minor lakes and reservoirs, enhance fisheries, and repopulate indigenous aquatic species in support of biodiversity conservation, poverty alleviation, and food sufficiency (Kawamura, *et al*., 2016).

Box 16. Coastal fishery resource enhancement tools promoted by the Southeast Asian countries (Cont'd)

Country	Habitat Rehabilitation and Artificial Reefs Installation	Management of Fisheries *Refugia*	Restocking, Stock Restoration, Rehabilitation
Singapore	The Primary Production Department (now the Agri-Food & Veterinary Authority) of Singapore launched a 10-year stocking program in 1986. Over 80 000 sea bass, 8 500 cherry snappers, and 630 000 banana shrimps were released in the country's rivers basically promoting restocking and game fishing. ARs were installed in mid1989 in the southern islands under the ASEAN-US Coastal Resources Management Project. In 2001, the National University of Singapore and Singapore Tourism Board conducted collaborative research on the use of ARs as part of eco-tourism activities. Nevertheless, MPAs have no place elsewhere in the country so these are not included in the national policies on coral reefs rehabilitation of government agencies responsible for this resource. FADs were however installed to serve as obstacles in waterways but consequently, there was a lack of interest in this aspect (SEAFDEC, 2004).		
Thailand	Since 1978, the Department of Fisheries (DOF) as the main agency responsible in governing the country's fishery resources had been installing ARs for resource rehabilitation, not only in the Gulf of Thailand but also in the Andaman Sea. The objectives of ARs are to rehabilitate coastal fishing grounds, develop and provide job opportunities, increase small-scale fishers' incomes, and promote conservation and management of coastal fisheries. From 1978 to 1986, DOF experimented on the substance, structure, and techniques for deploying ARs. As a result, the DOF established that the most suitable structure of ARs is the square concrete dice block with size 1.5 m×1.5 m×1.5 m as these could provide shelter for aquatic species as well as obstruct trawlers and push netters from entering the AR areas. From 1986 until the present, 280 sites had been installed with small ARs and 30 sites with large ARs during 1988-2006 with a funding of about one billion Baht or about US$40 million. A project on mass installation of ARs in the Southern of Gulf of Thailand which is under the Royal Initiation of Her Majesty the Queen, deployed artificial reefs in Pattani and Narathiwat Provinces from 2002 to 2015. The materials used for the construction of the ARs included used and out of commission vehicles such as goods train wagons and armored tanks, as well as concrete blocks and concrete pipes. The project has succeeded in elevating the standards of living of fishers and in restoring the natural wealth of the fishery resources. From 1985 to 2009, ARs were also deployed in 329 small sites (1-2 km^2 from the shoreline) in 18 provinces covering a total area of 493 km^2 with a budget of 827 million Baht or about US$25 million. ARs were also deployed in 33 large sites (20-30 km^2 from the shoreline) in 19 provinces covering an area of 1442 km^2 with 568 million Baht budget or about US$17 million (FRA-SEAFDEC, 2010). At present, local fishers can request installation of ARs from local authorities (Supongpan, 2006).	The Master Plan for Marine Fisheries Management of Thailand launched since 2009 served as guide for sustainable management of marine fisheries resources, and included a 10-year plan to "promote sustainable fisheries development based on the sufficient economy that places the people at the center." The DOF has the main responsibility of encouraging related agencies and stakeholders to be involved in the plan. Included in Strategy 4 on ecosystem and fishing ground rehabilitation to safeguard biodiversity and marine environmental quality and to demonstrate the importance of resource enhancement, are several guidelines that include: identification of natural habitats on which important fish stocks depend in certain parts of their lifecycle to ensure sizeable recruitment to fishable stocks; establishment of artificial reefs (ARs) and promotion of the use of living resources surrounding them under the management by community or fishermen organization; and promotion of sea ranching practices that do not jeopardize the marine ecosystem (DOF, 2008). Fisheries *refugia* has been established in the Gulf of Thailand for Indo-Pacific mackerel (*Rastrelliger brachysoma*) and other economically important species that face major stock reduction due to various factors, *i.e.* increasing demand for protein sources together with rapid development and improvement of fishing gear and fishing techniques, and illegal fishing among others. Enforcement of closed seasons and areas in some parts of the Gulf of Thailand for the Indo-Pacific mackerel and other economically important species has been carried out by related agencies. Monitoring changes in the status of target species and evaluating the fishing methods to develop appropriate measures that could be promoted and used for cancellations and revisions of the measures, are conducted from time to time based on the changes in the status of the fishery resources and effective management of the aquatic resources (Kawamura, *et al*., 2016).	The natural stock of giant clam (*Tridacna squamosa*) which has been declining in their natural distribution areas since 1993 necessitated the conduct of hatchery breeding and seed production activities in Thai waters mainly for conservation purposes. Restocking programs had been implemented in the country through the DOF, local administration organizations, provincial agencies, the Electricity Generating Authority of Thailand and other private sector, and government agencies. Results of the trial restoration of giant clam indicated a survival rate of 40% mainly influenced by various factors in the environment. Moreover, the new Management Strategies of Thailand adopted starting 2015 is an important tool that could be used to attain sustainable production from fisheries and maintain fish diversity, as well as means to enforce relevant laws and regulations to combat illegal fishing in the country (Kawamura, *et al*., 2016).

Box 16. Coastal fishery resource enhancement tools promoted by the Southeast Asian countries (Cont'd)			
Country	**Habitat Rehabilitation and Artificial Reefs Installation**	**Management of Fisheries *Refugia***	**Restocking, Stock Restoration, Rehabilitation**
Viet Nam		Development of the country's MPAs is governed by the Ministry of Science, Technology & Environment (MoSTE), Department of Fisheries Resources Protection, Ministry of Fisheries (MoFi), and Ministry of Forestry. Recently, the Government of Viet Nam authorized MoFi to develop a National Plan for Marine Protected Areas with marine components, particularly coral reefs and sea grass beds, including MPAs in the Spratly's archipelago. Although the plan is still pending government's approval, MoFi will be responsible for the MPAs with the objective of conserving mainly the coral reefs, sea grass beds, island ecosystems, and marine living resources (UP-MSI, ABC, ARCBC, DENR, ASEAN, 2002). As reported, there are 16 MPAs along the coastline of Viet Nam and 16 fisheries *refugia* were successfully established taking into account available scientific information and traditional knowledge of fishers compiled through consultations with local authorities. The objective of establishing fisheries *refugia* in Viet Nam is to protect spawning and nursing period of important aquatic species (Kawamura, *et al*., 2016). Monitoring of the country's MPAs is done once a year, the results of which are used as basis in formulating policies and regulations on the protection and development of the aquatic resources. Engagement of the stakeholders during the process of establishment the conservation zones helped in pooling the knowledge and experience of local stakeholders, *e.g.* officers, fishers, scientists, and government authorities. National activities on ARs are still to be implemented as ARs are not yet in place (SEAFDEC, 2004).	During 2012-2015, artificial breeding of abalone (*Haliotis diversicolor*) was carried out in Bach Long Vi, Viet Nam. This project was carried out to address the concern on degradation of the natural habitat and over-exploitation of this species of abalone (Kawamura, *et al*., 2016).

5.6.2 *Country Synthesis on Overview of Resources Enhancement*

The Workshop on Enhancing Coastal Resources: Artificial Reefs, Stationary Fishing Gear Design and Construction and Marine Protected Areas organized by SEAFDEC/TD in Samutprakan, Thailand in 2003, noted that the respective national legislations, policies, and plans including resource enhancement activities to promote conservation and management of marine resources of the Southeast Asian countries were in place. But this does not include Singapore because the country has no national policies or agencies managing coral reefs and reef resources. Moreover, most of the countries have deployed ARs in their respective waters, promoted the use of stationary fishing gears (SFGs), and established MPAs as approaches towards conservation and management of the coastal resources. Cambodia and Myanmar are currently promoting only MPAs but with the intention of expanding to other potential measures while Singapore is basically promoting only restocking to increase resident fish stocks and game fishing as well as ARs but not SFGs as these are considered obstacles in navigation pathways. Viet Nam is in the initial stage of deploying ARs.

The resource enhancement activities in most countries are generally focused on the following: mitigating the impacts and loss of habitats due to natural and man-made destructions; enhancing marine productivity and biodiversity of coastal resources; providing physical obstruction against invasion of trawlers into coastal areas; providing productive and alternative near shore fishing areas to small-scale fishers; and promoting sustainable livelihoods such as eco-tourism and small-scale selective fishing in the use of coastal marine resources.

5.6.3 Policy Recommendations and Strategic Plans for Fishery Resource Enhancement in the Southeast Asian Region

Considering that most of the fishery resources in the Southeast Asian waters are already in various levels of decline mainly due to illegal and unregulated fishing activities, and in an effort to address the concerns on resource degradation, SEAFDEC with funding support from the Japanese Trust Fund (JTF), carried out a five-year program "Promotion of Sustainable Aquaculture and Resource Enhancement in Southeast Asia" in 2010. Implemented in the Southeast Asian countries, the program was conceptualized based on two approaches, namely: improvement of critical habitats and nursing grounds of fishery resources; and direct enhancement of fishery resources through artificial propagation techniques. The project "Rehabilitation of Fisheries Resources and Habitats/Fishing Grounds through Resources Enhancement" was implemented by the SEAFDEC/TD to serve as immediate response to the concerns on the deteriorating coastal and inland ecosystems, and preventing further loss of habitats and eventual damage to the aquatic organisms. Simultaneously, the Philippine-based SEAFDEC/AQD carried out the project "Resource Enhancement of Internationally Threatened and Over-exploited Species in Southeast Asia through Stock Release" including the establishment of strategies of stock enhancement through sustainable, responsible, and environment-friendly approaches.

In order to identify the appropriate resource enhancement strategies that could serve as guide for the countries in the region in their efforts towards rehabilitating their respective fishery resources, SEAFDEC with support from the JTF organized the "Symposium on Strategy for Fisheries Resources Enhancement in the Southeast Asian Region" in Thailand on July 2015. Organized with two-pronged themes, namely: Fishery Resources Enhancement through Habitat Improvement and Management; and Fishery Resources Enhancement through Artificial Propagation and Stock Release, the Symposium compiled, consolidated, and exchanged necessary information and technologies based on the countries' initiatives to enhance the fishery resources that might have already been degraded and destroyed due to illegal and unregulated fishing practices (Kawamura, *et al*., 2016).

5.6.4 Way Forward

The Policy Recommendations and Strategic Plans for Fisheries Resources Enhancement in the Southeast Asian Region adopted during the July 2015 Symposium on Strategy for Fisheries Resources Enhancement in the Southeast Asian Region (***Appendix 1***), were used as basis for the development of activities under the project "Rehabilitation of Fisheries Resources and Habitat/Fishing Grounds for Resources Enhancement in Southeast Asia" from 2015 to 2019 supported by the JTF. The Project intends to identify the appropriate resource enhancement tools appropriate for the region as well as habitat conservation measures based on analysis and diagnosis of the effectiveness of the measures, and formulate strategies and guidelines for implementation in the Southeast Asian region. Capacity building on fisheries resource enhancement and habitat conservation measures would also be promoted in the AMSs. The Project also aims to strengthen the collaboration and cooperation among the SEAFDEC Member Countries for the promotion of sustainable fisheries resources enhancement in the Southeast Asian region to ensure the sustainability of such measures.

5.7 Challenges and Future Direction

Scientific evidences have demonstrated that several important fish stocks are already fully exploited and even over-exploited, and there are emerging requirements at the global level and from major importing countries for exporting countries including those in the Southeast Asian region to demonstrate that their fish and fishery products are derived from responsible practices. Therefore, measures assuring that fishing practices would not result in negative impacts to the ability of fishery resources to provide long-term contribution to food security need to be established and adopted.

It is well recognized that the availability of scientific information is crucial for sustainable management of fisheries, although the nature of fisheries in Southeast Asia which target multi-species of catch and the large number of small-scale fishers involved in the activities, make it difficult to obtain accurate information on fish catch. Consequently, improvement of data collection at national levels as well as for the regional compilation should be enhanced in order to come up with better picture of the status and trends of fisheries, as such available data and information could be used as basis for sustainable management of the fisheries. Development of appropriate indicators such as Catch Per Unit of Effort (CPUE), and management systems such as Total Allowable Catch (TAC) or Total Allowable Efforts (TAE) and their applicability to fisheries in the Southeast Asian region should also be explored. Promotion of other management approaches that are applicable for the Southeast Asian setting, especially the nature of the region's fisheries, particularly co-management and ecosystem approach to fisheries management, should be enhanced to boost the understanding and capacity of relevant officers of the AMSs on such management approaches.

While the Code of Conduct for Responsible Fisheries (CCRF) has been promoted as a global policy framework for sustainable and responsible fisheries management with the regionalized version being promoted in the Southeast Asian region through SEAFDEC efforts, international requirements emerged, particularly on the need to combat IUU fishing. Under the framework of the CCRF, the International Plan of Action to Prevent, Deter and Eliminate IUU Fishing was developed, with measures being delineated for coastal States, flag States, and port States to combat IUU fishing practices that undermine all efforts undertaken towards the sustainability of fisheries. Recently, more pressures from international and regional markets exacerbate the adoption of market-related measures by the Southeast Asian countries. These include several schemes for traceability of fish and fishery products including those issued by the private sector and groups of buyers. In 2010, the European Community started to put into force EC Regulation 1005/2008 requiring all fish and fishery products to be accompanied by a catch certificate in order to allow their entry into the Community. The U.S. also issued in 2015 the U.S. Presidential Task Force on Combating IUU Fishing and Seafood Fraud, and subsequently the new U.S. seafood traceability program to ensure that global seafood resources are sustainably managed and not fraudulently marketed.

In order to address such situation and the emerging requirements, the Southeast Asian region developed regional approaches to enhance the sustainable management of fisheries. The ASEAN Guidelines on Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain was developed and adopted by the AMSs through the AMAF Meeting in 2015, as a regional framework for combating IUU fishing. The ASEAN Guidelines would be supported by several tools developed at the regional level including the Regional Fishing Vessels Record or RFVR, the ASEAN Catch Documentation Scheme or ACDS, and the RPOA for Management of Fishing Capacity or RPOA-Capacity, among others. Future challenges that lay ahead would be addressed by strengthening the momentum of the aforementioned initiatives and enhancing the capacity of the countries in the implementation of such regional collaborative frameworks.

In 2016, the AMSs adopted the Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products. While it is encouraged that the Joint Declaration be implemented by the AMSs with support from donors and collaborating agencies, it is also necessary that collaboration between and among the AMSs need to be strengthened, *e.g.* through bi-lateral and multi-lateral cooperation. Important issues also arose during latest regional discussions including the possible development of the ASEAN Common Fisheries Policy. However, at this moment it is still unclear to what extent such common policy would focus and cover. Further discussion on this issue is therefore another important challenge that would pave the way towards the future of fisheries in the Southeast Asian region in the years to come.

6. AQUACULTURE DEVELOPMENT

6.1 Control and Prevention of Present and Emerging Transboundary Aquatic Animal Diseases

Shrimp aquaculture is a lucrative industry responsible for generating billions of US dollars in export income annually. In Southeast Asia, *Penaeus monodon* and *P. vannamei* are the major cultivated species with the latter species currently dominating the Asian and world market. Preceding 2000s, *P. monodon* was the dominant cultivated shrimp species in Asia. However, the scenario fairly changed around that year with the widespread adoption of domesticated and specific pathogen free (SPF) *P. vannamei*, which since then has become the principal choice for shrimp growers chiefly due to its success in avoiding problems concomitant to white spot disease outbreaks.

The intensification of shrimp cultivation in Southeast Asia to increase production has been impeded by pervasive episodes of epidemic diseases, which were inflicted not only by the white spot syndrome virus (WSSV) but also by other pathogenic shrimp viruses such as the yellow head virus (YHV), Taura syndrome virus (TSV), and infectious hypodermal and hematopoetic necrosis virus (IHHNV) among others (Flegel, 2012). Unwarranted occurrences of these viral diseases in cultivated shrimps have led to serious economic losses of about US$ 15 billion over the past 15 years, with approximately 80% of the losses occurring in Asia (FAO, 2014b). Irresponsible transfer of live shrimps, particularly the farmed stocks, allegedly carrying the pathogens, is the main culprit responsible for the rapid and widespread occurrences of disease outbreaks in hatcheries and grow-out ponds.

Since 2009, the emergence of a new disease, currently termed acute hepatopancreatic necrosis disease (AHPND), has stirred financial havocs among major shrimp producing countries in Southeast Asia, especially in Viet Nam, Malaysia, Thailand, and the Philippines. Aside from AHPND, farmers have been faced with urgent pressures ascribed to the emergence of newly emerging diseases like the hepatopancreatic microsporidiosis (HPM) and the covert mortality disease (CMD), among others (Thimatadee *et al*., 2016).

In 2012, members of the Governing Council of the Network of Aquaculture Centres in Asia-Pacific (NACA) recognized the need for Regional Consultations and Contingency Planning. Moreover, during the SEAFDEC Program Committee Meetings in 2012 and 2013, representatives from SEAFDEC Member Countries conveyed their concern regarding the outbreaks of AHPND and other transboundary diseases in the region and acknowledged the need for concerted regional effort to address the issue at hand. Hence, with assistance from Japan-ASEAN Integration Fund (JAIF), SEAFDEC and the Philippine Government convened the Regional Technical Consultation on Improvement of Aquatic Animal Health Management in Aquaculture in Southeast Asia on February 2016 in Makati, Philippines (also known as the ASEAN RTC on AHPND and other transboundary diseases). The consultation was aimed at addressing the pressing concern of the AMSs on the outbreaks of AHPND and other transboundary diseases of aquatic animals, particularly in penaeid shrimps, which is the leading food commodity export of the Southeast Asian region.

6.1.1 Status of AHPND

6.1.1.1 Current host and geographical distribution of AHPND

AHPND, recently identified as the most serious disease of cultured penaeid shrimps in the tropics, has been mainly implicated in mass mortalities of the whiteleg shrimp (*P. vannamei*) but has also been reported in tiger shrimp (*P. monodon*) and fleshy prawn (*P. chinensis*). The first outbreaks of AHPND began in China in 2009 and subsequently spread to Viet Nam (2010), Malaysia (2011), Thailand (2012), Mexico (2013), and most recently in 2015 in the Philippines (Tran *et al*. 2013; Joshi *et al*., 2014; Soto-Rodriguez *et al*., 2015; dela Peña *et al*., 2015). The disease was earlier known as early mortality syndrome (EMS) because mortality occurs in the early stages of culture, *i.e*. within 30-35 days after stocking the shrimp post larvae (PL) in culture ponds. However, the term EMS led to confusions as mortality during the early phase of shrimp culture could be due to several factors.

6.1.1.2 Current tests and diagnostic methods for AHPND

The group of *Dr. Lightner* at the Arizona State University in the USA documented for the first time in mid-2000s the histopathology of *P. monodon* and *P. vannamei* obtained from culture ponds with EMS in China and Viet Nam. In their report, massive rounding and sloughing of the hepatopancreatic tubule epithelial cells occur in the absence of any detectable causal pathogen which was then subsequently coined as acute hepatopancreatic necrotic syndrome or AHPNS (Lightner *et al*., 2012). The definition of AHPNS by *Dr. Lightner*'s group served as springboard for the widespread dissemination of relevant information on AHPNS in Southeast Asia through a disease card published online by NACA as agreed upon for adoption by a meeting of specialists in Bangkok, Thailand in 2012 (NACA, 2012). The NACA disease card contains vital information including the presumptive gross signs of AHPNS. However, the gross signs only constituted the presumptive diagnosis, hence, histological examination of at least 10 specimens for confirmation was necessary (NACA, 2012; NACA, 2014).

The causal agent of AHPND as identified by the group of *Dr. Lightner* in 2013 was the specific virulent strains of *V. parahaemolyticus* (VP-AHPND). Thus, the name of the disease was changed to acute hepatopancreatic necrosis disease (AHPND) after discovering that VP-AHPND colonizes the stomach of shrimp produced toxins responsible for the sloughing of hepatopancreatic tubule epithelial cells of the hepatopancreas. Bioassay using bacteria isolated from ponds with AHPND outbreak was employed to satisfy Koch's postulates. This was successfully achieved through immersion challenge using VP-AHPND bacteria grown in broth culture, which subsequently induced 100% mortality in shrimps coupled with the expressions of typical pathognomic histology of AHPND. In addition, the cell-free broth obtained from VP-AHPND cultures was found to induce massive sloughing of the hepatopancreatic tubule cells even in the absence of bacterial cells (Tran *et al*., 2013). Fortunately, all isolates tested lacked the pathogenicity island related to human infection, hence, negative for human pathogen markers *tdh* and *trh* (Nishibuchi *et al*., 1985; Nishibuchi *et al*., 1989).

VP-AHPND isolates subjected to sequence analysis of total DNA extracts revealed that they possess a unique plasmid which contains an operon coding for homologs of *Photorhabdus* insect-related (Pir) binary toxin, Pir A and Pir B, which are key elements in the induction of AHPND (Tinwongger *et al*., 2014). Moreover, the examined VP-AHPND isolates possess a unique plasmid known as pVPA3-1 that contains insecticidal related genes PirA and PirB (Han *et al*., 2015). The detection of these two potent toxin genes in VP-AHPND isolates propelled the construction of primers for the PCR method of detecting AHPND. Preliminary PCR methods were uploaded by *Dr. Flegel*'s group at the NACA website in December 2013 and updated in 2014 (Flegel and Lo, 2014). False-positive PCR results have arisen using the AP2 primer set, perhaps due to mutation of plasmids lacking the toxin gene. However, Sirikharin *et al*. (2015) documented that the AP3 method exhibited excellent sensitivity and specificity as evidenced by nil false positive or false negative test results conducted on bacterial isolates verified as AHPND or non-AHPND by bioassays with shrimp. Such detection methods are single step PCR that require enrichment especially for samples containing VP-AHPND whose quantity is below the threshold limit of detection or at the early stage of infection. In February 2015, *Dr. Flegel*'s group published at NACA website an AP4 nested PCR method suitable for the archived DNA extracts and for tissues or environmental samples preserved in lysis buffer or alcohol. AP4 nested PCR method gave 100% positive and negative predictive values for the same V-AHPND isolates used in validating the AP3 PCR method but with notably 100 times higher detection sensitivity (Sritunyaluchsana *et al*., 2015). Recently, a loop-mediated isothermal amplification (LAMP) method that uses two sets of primers (LAMP-A2 and LAMP-A3) has been developed and validated for use to specifically identify VP-AHPND strains (Kongrueng *et al*., 2014). Aside from the fact that LAMP assay for detecting AHPND related bacteria can significantly reduce time, ease and cost of detection, LAMP method proved to be superior to the PCR method in detecting AHPND.

6.1.2 Other Emerging Transboundary Diseases of Penaeid Shrimps

The shrimp industry in the Southeast Asian region is also currently being confronted with other emerging diseases that include the hepatopancreatic microsporidiosis (HPM) and hepatopancreatic haplosporidiosis (HPH), as well as the covert mortality disease (CMD) among others. Caused by *Enterocytozoon hepatopenei* (EHP), HPM infects both *P. monodon* and *P. vannamei* (Thitamadee *et al*., 2016). EHP is transmitted directly from shrimp to shrimp by cannibalism and cohabitation and could be detected using light microscopy (100× objective lens). However, the characteristic spores are very small and sometimes present only in small numbers even in heavily infected samples. Molecular techniques such as nested PCR, *in situ* hybridization, LAMP, and real-time PCR are currently available for EHP detection in penaeid shrimps. In Thailand, most of its imported specific pathogen free (SPF) stocks of *P. vannamei* that are negative for EHP often become test-positive in recipient maturation and hatchery facilities. This observation could be attributed to poor biosecurity like use of live animals (*e.g.* polychaetes and clams) as feed for the broodstock shrimp and use of post-larvae (PL) derived from government approved, imported SPF broodstock for rearing up to broodstock size in local shrimp ponds (Thitamadee *et al*., 2016). To avoid EHP contamination in rearing facilities, the use of wild or captured live animals as feeds for the broodstock should be avoided. If not feasible, feeds should be frozen before use, pasteurized (heating at 70°C for 10 min), or gamma irradiated (Thitamadee *et al*., 2016). Just like AHPND, it is necessary that polychaetes should be tested for the presence of any shrimp pathogens, and concomitantly reared in biosecure environments.

Serious outbreak of HPH in cultivated *P. vannamei* in Indonesia occurred between 2007 and 2009 (Utari *et al*., 2012). Based on histological examination, the causative agent morphologically resembles the previously reported unnamed haplosporidian in Central America. Sequence analysis of the small sub-unit ribosomal RNA indicated that the two isolates are closely related with 96% sequence identity. Since 2010, further disease outbreaks in broodstock and post-larvae (PL) by histology and PCR methods had not been recorded so far in Indonesia. Fortunately, there have been no reports of HPH outbreak in other Southeast Asian countries. HPH, just like EHP, is not included in the OIE list of reportable diseases (Thitamadee *et al*., 2016).

The cause of CMD is a virus known as covert mortality nodavirus (CMNV). When infected with CMD, shrimps die at the bottom of the pond making fish farmers unaware of the mortality. CMD has been implicated in mass mortalities of shrimp in China since 2009, around the time when AHPND emerged, but unlike AHPND, mortality was continuous rather than abrupt and peaked later than AHPND at around 60-80 days with cumulative mortalities peaking up to 80% (Zhang *et al*., 2014). Histologically, shrimp with CMD exhibits enlarged nuclei in the hepatopancreas with coagulate muscle necrosis associated with gross signs of muscle whitening. To date, the prevalence of CMNV positive shrimp samples detected using nested RT-PCR in Thailand is apparently high (Thitamadee *et al*., 2016).

6.1.3 Issues and Concerns

Transboundary diseases, including AHPND, encompass concerns concomitant to economic, trade, and food security for a considerable number of countries. The rapid spread of pathogens to other countries may inadvertently reach epidemic proportions thereby requiring pragmatic control strategies, including exclusion, through cooperation between and among several countries. Issues covered here chiefly include the priority issues identified during the ASEAN RTC on AHPND and other transboundary diseases for improved aquatic animal health management in Southeast Asia. These priority issues shall serve as impetus for developing policy recommendations aimed at controlling and preventing the further spread of AHPND and other emerging transboundary diseases of penaeid shrimps in the region.

6.1.3.1 Strategies for disease prevention, control, and biosecurity

Considering that an important component of effective disease prevention and control is the development of appropriate diagnostic techniques, researches on AHPND chiefly focused on the pathology and etiology of the disease. Disease prevention could be achieved through implementation of good hygiene to limit the transmission pathway of the pathogens. In general, various approaches including the use of potential bacteriophages, suitable water quality, and adherence to appropriate stocking density could prevent unwarranted outbreaks of AHPND in culture ponds. In addition, aside from the quantity and quality of feed given to shrimps and quality of seeds used, an important element that may curb if not eradicate the occurrence of AHPND in culture ponds is strict adherence to biosecurity measures.

As pointed out by *Dr. Flegel* during the Fourteenth Meeting of the Advisory Group on Aquatic Animal Health (AGM 14) in November 2015 in Bangkok, Thailand, careful attention should be made on the need to test wild caught *P. monodon* breeders for presence of major pathogens prior to using these in hatcheries. Moreover, examination of post-larvae for overall health quality through microscopic detection for any abnormality and presence of pathogens, and molecular detection by PCR, of major viral pathogens should be carried out. However, these practices seemed to have stopped with the widespread use of *P. vannamei* in shrimp culture. The widespread use of live polychaetes as broodstock feed has become popular among shrimp hatchery operators because of higher nauplii yields but unfortunately it put the entire industry at risk for the spread of any transboundary pathogens. Thus, when *V. parahaemolyticus* acquired the pVA1 AHPND plasmid from China in 2009, possibly through the exportation of live polychaetes as broodstock feed, there were no preventive measures in place geared at aborting if not controlling its rapid spread in China and subsequently to other major shrimp-producing countries in Southeast Asia. Since eradication of VP-AHPND strains in culture ponds is unfeasible, measures that prevent their translocation to new geographical regions should always be looked into considering the fact that they can easily establish themselves in local environments thereby posing tremendous biosecurity threats.

Current aquaculture practices promote the proliferation of microbial communities that most often than not, include a large proportion of opportunistic pathogens not only including VP-AHPND strains but also other pathogenic *Vibrio* spp. It is therefore imperative to focus efforts on aspects that cover ecological approaches to control AHPND. It is prudent not only to look at the causal agent per se but also on the microbial community of the animal's rearing environment as a whole (Pakingking *et al*., 2015). Pond bottom management including disinfection of the pond soil and water will not warrant the eradication of VP-AHPND vectors but may reduce the epidemic spread of AHPND. *Dr. Loc Tran* from Nong Lam University in Viet Nam reported his success with the use of the tilapia "green water" system. This system involves the installation of floating net-cages stocked with tilapia in the shrimp pond or alternately with tilapia from one pond and shrimp in another pond, but with water cycling from the tilapia pond to the shrimp pond and back (Tran *et al*., 2014). In Negros Occidental, Philippines, some shrimp growers recently experienced successful shrimp production runs using the tilapia green water system. Considering that acquisition of VP-AHPND by shrimps from their rearing environment is highly feasible as supported by scientific data showing that VP-AHPND bacteria could be detected in shrimp water and pond sediments, strict adherence to proper pond preparation before stocking and pond management during culture must be conscientiously practiced.

The use of PCR methods to detect the presence of VP-AHPND in shrimps and live feeds such as polychaetes and bivalves should be an integral component of good shrimp aquaculture practices (Thitamadee *et al*., 2016). As such, shrimp growers should submit samples of shrimp post-larvae for the presence of AHPND bacteria by PCR before purchase and/or before stocking to grow-out ponds. Likewise, careful testing of live feeds given to SPF broodstock is necessary to check for VP-AHPND. Thus, AHPND-positive batches of shrimp and live feeds should not be used and must be disinfected and discarded properly. In Thailand, some farmers claimed successes in evading AHPND by culturing their post-larvae in nursery ponds for the first month or so under stringent controlled biosecure conditions. When shrimps reach the desirable size (larger PL size), the shrimps are already competent enough or less vulnerable to AHPND before their eventual release to grow-out ponds (Thitamadee *et al*., 2016). Furthermore, the installation of central drain system in culture ponds has been recently practiced by some shrimp growers to minimize the accumulation of excessive organic loads in the pond sediments arising from shrimp wastes and uneaten feeds. Hence, overfeeding should be avoided and removal of sediments as often as possible should be done as uneaten pellets could serve as substrate to the VP-AHPND bacteria.

The group of *Dr. Hirono* from Tokyo University of Marine Science and Technology is currently developing some practical prevention methods against AHPND, and generated some promising results so far, on the potential use of formalin to kill VP-AHPND as vaccine immunogen in shrimp against AHPND. However, *Dr. Hirono* pointed out that its application in small shrimps appeared to be difficult. Some encouraging data on the application of nano-bubble technology that could inactivate VP-AHPND bacteria present in shrimp rearing water and use of IgY as additive in shrimp feeds have also been recently documented by his group (Hirono, 2016). All generated data are however still under experimental stage in the laboratory and rigorous amounts of field studies are necessary to verify the practical application of these methods in the actual scenario.

In some countries that experience the impact of AHPND in their shrimp culture industry, the excessive use of antibiotics for therapeutic or prophylactic purposes has been reported. Recalling that the indiscriminate use of antibiotics to treat luminescent vibriosis in the 1980s consequently led to the collapse of the shrimp industry in Southeast Asia, this should serve as perpetual reminder for shrimp farmers to strictly adhere to the apposite use of antibiotics in aquaculture. This is to hinder similar catastrophic disease episodes inflicted by pathogenic vibrios in the 1980s to happen again. Misuse of antibiotics does not only devastate microbially mature shrimp cultivation systems but has been proven ineffective in treating diseases inflicted by vibrios such as *V. harveyi* and its closely related bacteria such as *V. parahaemolyticus* which is the causal agent of APHND. The application of phages as potential prophylactic and therapeutic methods for AHPND in shrimp culture has been recently identified as an alternative approach to prevent and control the proliferation of bacterial pathogens in shrimp farming. For example, treatment of *P. vannamei* larvae suffering from vibriosis caused by *V. parahaemolyticus* with selected phages has been reported to significantly reduce shrimp mortality (Lomeli-Ortega and Martinez-Diaz, 2014).

The use of specific pathogen free (SPF) stocks would be an effective approach to prevent viral infections and outbreaks in biosecure rearing systems. SPF shrimps for pond cultivation are the resultant populace derived from wild parents and produced by extensive quarantine procedures. However, the SPF condition of the shrimp is not heritable as what chiefly separates between the host and target pathogens is the physical environment that is free of pathogens. Thus, once shrimps are removed from the SPF production facilities, they are subject to a greater risk of infection unless they are reared in a well-established facility with history of disease surveillance and practicing biosecurity protocols. As pointed out earlier, the causal agent of AHPND is a free-living bacterium that can persevere with brackish and marine waters as well as in sediments for a long time even in the absence of carriers. Hence, emphasis on good pond management that promotes the proliferation of indigenous heterotrophic bacteria with probiotic potential that could regulate optimum water quality and population of VP-AHPND bacteria and other pathogenic vibrios in the shrimp gut and its rearing environments ought to be the first consideration in hand prior to the stocking of SPF shrimps in cultivation ponds. Additionally, concerns on inbreeding are another equally important issue confronting the shrimp industry in Southeast Asia that should be accordingly addressed (Moss *et al*., 2005). Pertaining to this concern, researches focusing on the impacts of inbreeding and consequential effects on shrimp's genetic erosion and concomitant vulnerability to diseases should be pursued. However, careful planning is necessary for selective breeding programs, which is expensive and enormous amount of investments will be required for their successful implementation and sustainable operation.

6.1.4 Challenges and Future Direction

The unprecedented outbreaks of AHPND in major shrimp-producing countries demonstrate the need for international cooperation and collaborative research among relevant institutions to curb emerging disease problems ascribed to the uncontrolled transboundary movement of live penaeid shrimp broodstock or their offspring and other living aquatic organisms from an AHPND-infected area to an unaffected aquaculture facility. Considering the intermittent occurrence of AHPND in some countries in the region, NACA, the Office International de Epizooties or World Organization for Animal Health (OIE), Food and Agriculture Organization of the United Nations (FAO), and SEAFDEC pooled their efforts to aggressively and effectively disseminate the information to these vulnerable countries in order to avoid the massive widespread of AHPND in the Southeast Asian region. For its part, NACA published an AHPND Disease Card in 2012 (updated in 2014) and routinely provides new information on AHPND on its website (*www.enaca.org*). Since NACA listed AHPND as reportable shrimp disease, focal points of the NACA member countries are obliged to report any occurrence of AHPND in its Quarterly Aquatic Animal Disease Reporting System. Another important development is the inclusion of AHPND in the listing of diseases notifiable to the OIE. Accordingly, since 1 January 2016, OIE member countries have been obliged to report to the OIE the presence or absence of this disease in their respective countries, mainly to support member countries' efforts in preventing transboundary spread and unwarranted outbreaks of this devastating disease through transparent and consistent reporting. Moreover, FAO also initiated various similar projects to disseminate information on AHPND.

In order to obtain better understanding of the etiology of the disease and identify a number of risk management measures and key areas for future research, the project TCP/VIE/3304 *Emergency Assistance to Control the Spread of an Unknown Disease Affecting Shrimps in Viet Nam* was conducted in Viet Nam in 2013 (*http://www.fao.org/docrep/018/i3422e/i3422e00.htm*). A sequel to this was the recent implementation of an inter-regional TCP project: TCP/INT/3502 *Reducing and Managing the Risk of AHPND of Cultured Shrimp* aimed at providing a platform to improve understanding of the disease through the lens of governments, scientists, and producers, and collectively generate practical management and control measures. Relative to this, are back-to-back inter-regional meetings in Panama City, *e.g.* International Technical Seminar/Workshop on *EMS/AHPND: Government, Scientists, and Farmer Responses* on 22-24 June 2015, and the First Inter-regional Workshop on EMS/AHPND Risk Management and Risk Reduction Strategies at National and Regional Levels on 25-27 June 2015 (Reantaso, 2016). By and large, despite these regional and international actions that have been undertaken so far, aggressive and continual efforts should be concerted and pursued to spur and heighten awareness among shrimp growers and pertinent stakeholders so that inadvertent transboundary movement of persistent and newly emerging shrimp pathogens in the region could be sustainably controlled and prevented.

It is recognized that the riskiest activity for geographical spread of VH-AHPND strains and other transboundary pathogens is the uncontrolled movement of live shrimp breeders or their offspring from a pathogen-contaminated area to an unaffected aquaculture area. Of unequivocally risky practice is the uncontrolled movement of live aquatic animals such as polychaetes intended for use as feeds for shrimp broodstock from pathogen-contaminated areas to unaffected areas dedicated for shrimp cultivation (Thitamadee *et al*., 2016). A plausible constraint that may hinder the effective disruption of translocation of these shrimp pathogens is the illegal importation of pathogen-carrying shrimps or their offspring and other live aquatic organisms used as broodstock feeds. Thus, development of a harmonized *Regional Guidelines on Health Management and Good Practice* applicable to all Southeast Asian countries is urgently needed to sensibly prevent and control further inadvertent outbreaks of AHPND and other emerging transboundary diseases of penaeid shrimps. Moreover, once established, a more systematic reporting system (*i.e*. early warning and subsequent monitoring) to relevant agencies or competent authorities at the countries, regional, or international level should be instituted. As such, there is a need to immediately develop emergency preparedness and contingency plans by competent authorities of concerned countries, especially in cases of the inevitable emergence of a novel and dreadful disease. More importantly, attention and guidance should be provided to farmers who are into small-scale shrimp culture as they represent a weak link in the system posing high risk for diseases.

Recognizing the importance of detecting transboundary pathogens of penaeid shrimps in broodstock and their offspring, and importantly in live aquatic organisms like polychaetes and clams which are used as feeds, detection methods should be adherent to gold standards such as those indicated in the OIE guidelines, and whenever possible should be harmonized in the region. The scarcity, availability, and capacity of some laboratories, either public or private sector, equipped with level II (parasitology, histopathology, bacteriology, and mycology) and level III (immunology and molecular techniques) facilities in some developing countries in the region is another constraint that should be tackled accordingly (Lavilla-Pitogo *et al*., 2011). In addition, rigid trainings pertinent to aquatic animal health should be strengthened among aquatic animal health personnel since an inadequate level of aquatic animal health expertise in Southeast Asia still remains. Thus, strong partnership among relevant government agencies, various international organizations, and the academia should be intensified to fill the gap. As part of capacity building program, knowledge and skills on aquatic animal health management in general could be substantiated by bringing the training module on-site in order to consequently foster greater and active participation of local staff (Lavilla-Pitogo *et al*., 2011).

It is increasingly evident that development of production systems based on cultivation of SPF stocks in a biosecure environment will be vital to ensure constant supply of SPF stocks. Thus, development of such system in major shrimp producing countries in the Southeast Asian region will be necessary in order to be assured of reliable and sustainable production with a minimal impact on the environment (Thitamadee *et al*., 2016). This goal is not impossible as the pool of knowledge on aquatic animal diseases, environmental microbiology, ecology, and biochemical engineering among others has already been generated including the ongoing researches that are optimistically sufficient to drive the establishment of a prototype SPF breeding facility (Flegel and Lo, 2014). Additionally, governmental support programs at the national and regional levels will be necessary to assist farmers in capital investments once a successful prototype SPF breeding facility for shrimps and other living aquatic organisms used as feeds is established.

More importantly, the government and private sectors at national and regional levels, should work together to generate sufficient funds and resources for the conduct of research and development programs. Hence, researches relating to the diverse aspects of fish health management including immunology and pathogenesis of infectious diseases of different etiologies and novel methods for disease prevention and therapy are respectively carried out and generated (Hong *et al*., 2015; Thitamadee *et al*., 2016). Finally, in order to prevent illegal transboundary movement of living aquatic animals including shrimp broodstock or their offspring for cultivation as well as polychaetes used as broodstock feeds, countries in the region should work in concert to harmonize national legislations and regulations related to aquatic animal health management. These could include legislations for the transboundary movement of live aquatic animals in order that unwarranted disease outbreaks and concomitant economic losses are rationally precluded during the course of shrimp cultivation.

6.2 Overcoming the Fish Meal Dependence in Aquaculture

In recent years, the inclusion level of fish meal in commercial aquafeed formulations had decreased but in terms of quantity, fish meal usage actually increased due to increased production of aquaculture feeds in the Southeast Asian region. Fish meal or fish by-catch is a major source of protein in aquaculture feeds and its widespread use puts pressure on wild fisheries, an important source of food for the human population. The aquaculture industry's dependence on fish meal has long been recognized and the use of alternative protein sources as substitute for fish meal was the theme of the consultative meeting of representatives from the AMSs in Myanmar in 2014 (Catacutan *et al*., 2015).

Protein source in aquaculture feed is expensive because of its bulk in the feed formulae. For decades, researches on suitable alternative protein sources to overcome the dependence on fish meal had been conducted by many research agencies including the SEAFDEC Aquaculture Department (SEAFDEC/AQD). Nutrient levels in materials with potential as protein sources in aquafeed were analyzed and tested for acceptability or suitability in popular species for culture. These resources mostly come from plants, some from processing by-products, and few from unconventional sources. At SEAFDEC/AQD, the materials had been processed for testing in diets of culture species such as sea bass, abalone, milkfish, catfish, grouper, snapper, and shrimps.

6.2.1 Status on Use of Aquaculture Feeds

The level of use of alternative protein sources in aquaculture feeds is not of the same intensity in every AMS. Some countries are moderate to heavy users of aquaculture feeds, reflective of the level of their respective aquaculture operations. However, other countries use very minimal volumes of aquaculture feeds or none at all because their aquaculture operation is dependent on available fish by-catch coming from either fresh or marine waters.

Countries which are low to moderate users of aquaculture feeds have shown trends towards increasing their aquaculture production. Some countries are catching up to increase production from aquaculture by engaging the private sector and their governments to build bigger capacity aquafeed mills, modify tax on importation of materials such as fish meal, and train farmers on using aquafeed. Increase in aquaculture production is also triggered by the increasing human population and consequently demand for fish protein which can be supplied through aquaculture. Importation of aquaculture feed or feed ingredients has also increased in countries with common borders. Thus, it is clear that the demand for aquaculture feeds would continue to increase in the future.

6.2.1.1 Feed utilization of aquaculture species

Some aquaculture species are common to all AMSs, and classification of these species according to feeding habits will be helpful in obtaining information on the extent of fish meal use in aquafeed. These species vary in their dietary requirements for protein and subsequently the optimum dietary level contribution from fish meal. The species could be classified as herbivores (*e.g.* milkfish, carps, and barbs), carnivores (catfish, snakehead, sea bass, grouper, and black tiger shrimp), and omnivores (*Pangasius* and tilapia).

In most AMSs, farmed freshwater species generally consume less formulated feeds as such species are mostly low-value with culture systems that usually depend on fish by-catch or on natural food available in culture facilities during rainy months. For countries with access to sea water, there is an immense use of commercial feeds where high value species, such as sea bass and grouper, are cultured for export or for local consumption. Since this system of culture is expanding in the region, fish meal usage would surely continue to increase.

6.2.2 Research Efforts to Overcome Fish Meal Dependence in Aquaculture

Research and development efforts on fish meal and fish oil substitution in aquafeed with locally available ingredients are ongoing and being done by most AMSs. Agencies or entities engaged in this activity are their respective Departments of Fisheries, universities, and the private sector. For example in Thailand, a major aquaculture producing country, its Department of Fisheries oversees the production of commercial aquafeed for eight species. Also, there is an ongoing involvement by the Government, feed millers, and fish farmers to ensure the sustainable development and use of alternative dietary ingredients in aquafeed.

In Indonesia, production of local fish meal is high but only 5% of the total production goes to aquafeed and the rest is exported. Thus, the cost of commercial feed has increased because 70% of feed components is imported, the price of which continues to increase every year. Efforts towards reduction of fish meal in commercial diets have been done particularly for freshwater species where 5-11% is fish meal compared with that in marine fish species (> 30%) and shrimp (20-30%). Soybean meal is highly utilized to replace fish meal in commercial feed production but this is entirely imported as local soybean is used for processing *tempeh* and *tofu*. The use of soybean in commercial feed for low-value species like carp, tilapia, catfish, *Pangasius*, and milkfish would not be competitive in terms of price. Hence, local ingredients like copra or palm cake meal, rice bran, and tapioca are utilized in farm-made feeds in areas where commercial feeds are not available. Local products from animal sources such as shrimp head meal, blood meal, golden snail, and vermi meal have been evaluated and could be used at 8-30% in diets of groupers. Plant ingredients containing > 20% protein (copra cake meal, rubber seed meal, *Leucaena* leaf meal, and aquatic weed meal) have been extensively evaluated and could be used at levels ranging from 10% to 60% depending on the species. Anti-nutrient substances limit the use of these plant sources and bio-processing using proper organisms is being developed to improve quality.

Extensive research to replace fish meal in aquafeed formulation has been conducted in Malaysia. Alternative sources used by commercial feed millers or at the farm include soybeans, canola, wheat gluten, pea, agricultural derived products and by-products, and also waste of agro-processing industries (bone meal, blood meal, poultry meal by-product, oilseed meal, cereals, and cereal by-products). However, research findings and current status of utilization of some materials such as microalgae, single cell proteins from microbial fermentation of waste materials, ento-protein from insect-based sources, and distillers dried grain soluble (DDGS) in commercial aquafeed have not been made known to the public. Replacement of fish meal in diets of omnivorous freshwater species to sustain fish production had been successful in the region, and the DOF of many countries had been promoting the farming and consumption of fish species such as tilapia, catfish, and grass carp.

Soybean is the most commonly used plant protein in commercial feeds in Viet Nam. Replacement of fish meal by soybean meal had been studied, and results indicated that such replacement in catfish diet could be 80%, for snakehead and knife fish diet at 30%, and pompano diet at 50%. In 2013, the country recorded high importation of plant sources (canola meal, corn gluten, palm seed meal, rice bran, peanut meal, cotton seed meal, and sunflower seed meal) but these might not have been all used in manufacturing aquafeed. In Singapore, research results conducted by a government agency showed that the residual fibrous part of soybean or okara mixed with minced fish trimmings could be used to supplement commercial feeds for red snapper.

Aquaculture in Cambodia and Lao PDR relies on available low value fish by-catch as feeds, but farmers have begun to import commercial feeds mostly for the hatchery operations because of increasing aquaculture activity. In Myanmar, the volume of export of fish meal to six countries decreased in 2013-2014 compared with that in 2010-2011. This is indicative of the increasing use of this commodity in the country where aquaculture is practiced in freshwater, brackishwater, and coastal areas. For freshwater species, the aquaculture feeds are made from locally-available agricultural by-products, *e.g.* rice bran, boiled broken rice, and oilseed cakes but feeds for tiger shrimp and sea bass are imported. The country also produced soybean meal but the quality has to be improved. Marine feed ingredients are also available such as shrimp shell and head meal, as well as dried fish powder which could be used as attractants.

6.2.3 Fish Meal Substitution in Diets of Aquaculture Species

Results of nutritional studies on alternative protein sources have been published for many aquaculture species. In the last few years, the research efforts of SEAFDEC/AQD focused on diets of milkfish, abalone, and grouper. Soybean meal is the most popular or successful plant protein source to substitute fish meal in diets of almost all aquaculture species. This plant source and its derived products such as soy protein concentrate are utilized by milkfish at 40% of the diet at a lowest fish meal level of 15% with no negative effects on growth and survival (Coloso, unpublished). Since soy bean meal is an imported product, other cheaper sources were tried such as the DDGS to replace a portion of soybean meal in feed formulations for milkfish fingerlings (Mamauag *et al*., 2017). Milkfish digest the protein in formulations with DDGS at 91%, and at 45% DDGS dietary inclusion, and the growth performance parameters and intestinal morphology are not affected. Currently, formulation with DDGS is being tested in the grow-out feed of milkfish in sea cages. For other species such as grouper, *Epinephelus fuscoguttatus*, a carnivore, feed efficiency and growth increased in fingerlings when fed diet with the hydrolysate from milkfish offal at 10-15% (Mamauag and Ragaza, 2016).

For the tropical abalone, *Haliotis asinina*, diet development studies conducted in land-based tanks, showed that with a good binder the marine sources of protein in formulations could be decreased with a significant increase in shell length and weight gain showing potential to shorten the culture period (Bautista-Teruel *et al*., 2016). Currently being evaluated are enriched seaweeds (*Ulva lactuca* and *Gracilaria bailinae*) as feed ingredients in the tropical abalone diet.

6.2.4 Issues, Challenges and Constraints

Various issues and challenges and constraints have been raised on the use of alternative sources to replace fish meal in the diet of aquaculture species classified under omnivores, carnivores, and herbivores species (refer to ***Appendix 2***), the vital one is information on suitable alternative sources for specific species and their availability. For alternative sources of plant origin, information on anti-nutrient factors, nutrient information and quality are crucial to their utilization. Soybean is the most common plant protein used to replace fish meal in aquafeed formulations, but due to its increasing cost as dictated by the market, local sources have been identified but production volume is limited. Furthermore, information is scant with regards to the digestibility, amino acid profile, and dietary inclusion level (suggested level) of plant protein sources with potential for use in aquafeed. Research results on alternative protein sources in aquafeed are not available to interested stakeholders.

6.2.5 Future Directions and Policy Recommendations

Strong collaboration is encouraged among AMSs in exchanging research information or joint research work between institutions with appropriate facilities and expertise. This is also true between local agencies especially with the agriculture sector for the mass production of identified plant protein sources suitable for aquafeed production and also among R&D institutions, the private sector, the academe, and donor agencies.

The policies recommended for AMSs on overcoming the dependence on fish meal by development and use of alternative dietary ingredients in aquaculture feed are shown in **Box 17**.

Box 17. Recommended policies on the use of alternative dietary ingredients in aquaculture feed

- Establish a national aquafeed quality control to ensure high compliance of feed milling companies to fisheries regulations and acts.
- Establish a focal agency of ASEAN Programs for this purpose. SEAFDEC/AQD could be given the role of focal agency and as such should work closely with ASEAN Member States, research institutions, academe, industry, and international organizations.
- Create an ASEAN Forum or network and include all stakeholders.
- Formulate the National Action Plan.
- Enhance awareness on the importance of reducing dependence of aquaculture on feed and ingredients of marine origin.

6.3 Production and Dissemination of Good Quality Seedstock

The world's total farmed food fish production in 2012 was approximately 66.6 million metric tons, of which 88.4% came from Asia (FAO, 2014a). China contributed 61.7% to the 88.4%, followed by Southeast Asia with 26.2% and the rest from Central and Western Asia. Farmed aquatic commodities include high volume of low value aquaculture species like tilapia, carps, as well as Clariid and Pangasiid catfishes that are easily traded. Freshwater fish species are easily produced for they have been successfully bred in captivity and farmed historically long enough in that their husbandry protocols are already well established and optimized. On the other hand, marine fishes especially those requiring years to mature and are often hormonally induced to breed, need extensive hatchery and nursery facilities and technical skills for seedstock production before these could be farmed in ponds or cages. Brackishwater and/or marine invertebrates like mud crabs, shrimps, and shellfishes are among the commercially valuable species from marine aquaculture. Mariculture necessitates higher investment inputs from feeds to technical farm operations and maintenance, hence marine fish products are inevitably sold at higher market prices.

With regards to farmed aquatic plants, Indonesia, Philippines and Malaysia are recognized as among the major producers with an estimated combined production of 8.6 million metric tons or 36.0% of the total world production of aquatic plants mainly comprising seaweeds (FAO, 2014a).

For both inland and mariculture systems, farming methods have progressively evolved and many have resorted to intensification to achieve higher outputs. This has led to problems such as poor quality broodstock and seedstock, deterioration of culture environments as well as the proliferation of aquatic fish disease-causing agents that pose challenges in sustainable aquaculture production in the Southeast Asian region. Such issues continue to occur despite the initiatives to: a) find solutions to nutrition, water quality, and health management concerns; b) develop sustainable intensive husbandry methods; and c) adopt genetic programs to produce genetically enhanced, quality seedstock that are on-grown to maximize farm yields for a short rearing period. Nonetheless, such concerns are gradually being addressed through policies as well as practical techniques and/or scientific interventions to enable the production of food fish that will not only support food security but also promote economic growth. Motivation to improve economic growth through fish production and trade is seen as an offshoot of the ASEAN integration where each Southeast Asian country must be ready to compete foremost against other regional market forces and ultimately contribute to global fish production.

6.3.1 Why Good Quality Seedstock?

Although aquaculture yields from the Southeast Asian countries are still high, a slight decline in the annual production was noted in recent years. This has clearly been due to the adverse impacts of climate change and natural calamities on farmed fish stocks with the assumption that farmed stocks are well managed. If farms are poorly managed more so for intensively farmed species, problems such as disease outbreaks would inevitably affect operations adversely. Examples of such aquaculture species are the penaeid shrimps that have been highly susceptible to pathogens, *e.g.* white spot syndrome virus (WSSV) and the bacteria that cause acute hepato-pancreatic necrosis syndrome or early mortality syndrome (EMS). These pathogens have caused massive shrimp die-offs thus affecting shrimp production. In this instance as an immediate solution, the tiger shrimp industry has shifted to the culture of the whiteleg shrimp *Litopenaeus vannamei*, a more resilient species although genomics applications have now found a way of understanding the mechanism behind WSSV and EMS in tiger shrimps and are starting to provide solutions to the same. Given the option to produce and/or procure better seedstock of the desired species that are genetically fit or ideally superior, fast-growing, pathogen-free, stress resilient, and well-nourished, their survival and yield in the grow-out farms can at least be sustained and at best, be improved. Apart from the use of good quality seedstock, fish farm operators can invest on a breeding, hatchery, nursery and/or grow-out facility that is provided with optimal rearing conditions from quality rearing water to nutritionally complete and cost-effective diets to ensure a profitable and sustainable yield. These genetic and environmental factors influence growth and survival in farmed aquatic species. Knowledge of how each factor affects their economically important traits can definitely help one define, develop, and adopt technical measures especially starting from broodstock management to production of quality seedstock. With the fact that environmental manipulation can be done with more ease, on the whole, quality seedstock production (either through traditional methods or advance genetic improvement schemes) must be given due attention and the benefits of using genetically enhanced seeds should be highlighted.

6.3.2 Status of Seed Production in Southeast Asia

For many farmed species, particularly those with life cycles that have been successfully closed or completed in captivity, seedstock can be obtained from hatcheries aside from wild sources. ***Appendix 3*** summarizes the sources of seedstock for commercially farmed aquatic species in each AMS. While most of the species in Southeast Asia that are commercially produced in large volumes are introduced, *e.g.* Nile or red tilapias and the African catfish to name a few, some indigenous species such as carps and Pangasiid catfishes have been successfully domesticated and artificially propagated after years of research. For some, larval rearing in the hatchery remains to be a limiting factor due to various reasons that may range from diseases, low survival, occurrence of abnormalities due to inbreeding depression or nutritional deficiencies, poor water quality, or simply unsustainable larval food production. In a complete hatchery (or a hatchery that is engaged in all phases of seedstock production from selecting and maintaining broodstock to larval rearing), when the cause of poor growth and survival of seedstock can be addressed by genetic intervention, it means that the hatchery has successfully adopted a scheme that considers the use of genetically variable, fit and preferably known unrelated spawners for producing quality seedstock. For species produced from medium-scale and/or large-scale aquaculture operations, quality seed production is assured as well if genetic improvement schemes apart from biosecurity measures are incorporated in the program. ***Appendix 4*** summarizes conventional, advance and/or marker-aided genetic methods that have been developed in Southeast Asia or otherwise, for the production of quality seedstock of major Southeast Asian aquaculture species. Since many countries in Southeast Asia are developing countries, most genetic improvement programs are focused on low-value species that have short generation intervals such as the tilapias. Carps have likewise been the subject of full-blown genetic improvement programs. The development of improved tilapia and carp strains has employed mostly combined selection methods based on genetic programs supported by either government funds or international grants (*e.g.* for the development of GIFT and GIFT-derived strains). Local public initiatives on other species (abalone, mangrove crab, and milkfish) are currently being undertaken and the approaches start with genetic profiling of aquaculture stocks using DNA markers, with the ultimate aim of using genetic diversity information as basis for marker-aided broodstock management and selection. Other studies use genomics to investigate genes that are linked to growth and other economically important traits such as disease resistance (especially in penaeid shrimps). With the development and use of advance equipment and molecular biology methods (*e.g.* next generation sequencing) for genomic studies, the outcome of aquaculture genetic improvement programs may soon be achieved in a shorter period as compared to when conventional or traditional selection is used.

6.3.3 Issues and Concerns

Increase in fish production from aquaculture would be difficult to attain if the industry continues to use slow growing, poorly adapted, and inadequately surviving seedstock that comes mostly from multiple and pooled sources as is the case with species that are produced by small-scale hatcheries. The challenge is not only with the fact that enough seedstock are pooled and on-grown but on how to maintain the genetic integrity and quality of such stocks. For some species, *e.g.* milkfish and groupers disseminated in Indonesia, seedstock production remains sustainable in view of government-initiated efforts to organize the industry into a network composed of complete hatcheries (breeding centers), meaning hatcheries that maintain broodstock for seedstock production and basic hatcheries that simply obtain eggs from the breeding centers (Sugama *et al*., 2016). This system has been adopted in milkfish seedstock production, which enables Indonesia to export seedstock to other milkfish producing countries like the Philippines and Taiwan. The same approach is being used for grouper seed production. If the Southeast Asian countries can adopt a similar scheme in the production of other economically valuable aquaculture species then the problem of inadequate seedstock can be partly addressed. Aside from inadequate seedstock, another issue that has plagued the aquaculture industry is the production of healthy or disease resistant stocks and prevention of the spread of infected seedstock through importation and/or local stock transfers. This has been a major concern particularly in species that are susceptible to viruses that can be spread by way of seedstock movement. Examples of disease-prone stocks include penaied shrimps and some high-value marine fishes that suffer mortalities brought about by deadly viruses. Solutions to such problems sometimes start in the production of specific pathogen-free seedstock and/or the prevention of stock infection and vertical transmission of the disease by injecting potential broodstock with species-specific vaccines. Early detection using molecular tools likewise help screen infected seedstock. Guidelines and/or criteria for evaluating good quality seedstock prior to being sold locally and exported or post-procurement and importation, as the case may be, often include the need for pathogen screening as part of quarantine procedures.

Other issues that have to be continually looked into with regard to seedstock production would be on how to maintain the genetic quality of the stocks being produced apart from other technical concerns which can be addressed through research and development. ***Appendix 5*** contains a summary of the constraints in the seed production industry in the Southeast Asian region.

6.3.4 Challenges and Future Direction

Challenges in the production and dissemination of quality aquaculture seedstock remain to be both technical and non-technical in nature. As previously emphasized, most of the issues that may be complicated to address is on how to technically produce healthy seedstock as the Southeast Asian aquaculture is constantly being challenged by having to intensively produce commodities in the grow-out phase. The approaches being pursued are being addressed by advanced techniques in PCR-assisted disease diagnosis apart from the development of schemes to produce disease and/or stress resistant stocks using genomic information. With molecular tools that can be employed to survey and collect highly genetically variable broodstock from the wild, continuously monitor the genetic integrity of hatchery broodstock (including changes in successive generations of the same), address aquatic health management problems, and enhance genetic enhancement schemes in the production of quality aquaculture seedstock, the industry as a whole can look forward to benefitting from quicker R&D solutions to problems on aquatic seed production. As for the non-technical challenges, perhaps additional enabling laws and or current policies particularly on the adoption and implementation of good aquaculture practices should be promoted and strictly observed especially in many developing countries where the seedstock industry is composed mostly of small-scale hatcheries. Collective efforts, not only from the hatchery industry sector but from all the stakeholders, should be pooled to help the aquaculture industry achieve its production targets.

6.4. Producing Safe and Quality Aquaculture Products

The use of antibiotics and other chemicals in aquaculture is widely practiced to help meet the increasing demand for fish food from aquaculture. These antibiotics and chemicals appear to be part of material inputs during rearing, mostly from feed ingredients and as therapeutants for prevention or treatment of diseases. Thus, cultured shrimps and fish in various stages from hatcheries to grow-out ponds are exposed to chemicals. Consequently, with the ever-growing demand for food safety, fish farmers are faced with the challenge of producing safe food from farm to fork. Government regulations are becoming stricter on the uncontrolled use of chemicals due to their adverse effects on human health and the environment, and the development of pathogen resistant bacteria. Many chemicals have already been banned and the use of some is being regulated. The spectrum of allowable chemicals for aquaculture is becoming narrower, with the trend towards the use of environment-friendly mitigating agents geared to a more responsible approach to aquaculture.

6.4.1 Current Status

Concerns for safe, effective, and minimal use of chemicals in aquaculture in order to protect human health and the environment are reflected in the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). In 2000, a comprehensive report on use of chemicals in Asia with emphasis on various aquaculture systems, species, and country regulations regarding distribution and use was made available after the Experts Meeting on the Use of Chemicals in Aquaculture in Asia at SEAFDEC/AQD in 1996 (Arthur *et al*., 2000). Since then sustained efforts were made to update the general information based on chemical usage in aquaculture in Asia and understand the realities and uncertainties in the regulatory frameworks governing the use of chemicals to ensure food safety and minimal impacts on public health and the environment. Many countries are now imposing strict food safety requirements, among which, monitoring of the maximum residue levels and banned chemicals on imported aquaculture products, would likely pose significant difficulties to countries exporting aquaculture commodities in the future.

A series of regional workshops on Harmonization of Guidelines for the Use of Chemicals in Aquaculture and Measures to Eliminate the Use of Harmful Chemicals was organized by Malaysia in 2009, 2010, and 2012, and participated by representatives from the AMSs. The ASEAN Guidelines for the Use of Chemicals in Aquaculture and Measures to Eliminate the Use of Harmful Chemicals was published in 2013. Developed to help national regulators and stakeholders in managing the diverse use of chemicals in aquaculture, this set of Guidelines was so designed that it can be implemented within the specific policy and legal framework of each AMS. It outlines the rules and responsibilities of the competent authority or national regulators, the manufacturers and traders of chemicals, and the aquaculturists in each AMS regarding the safe methods of manufacturing, procurement, use, and disposal of chemicals to ensure food safety, and protection of public health and the environment. It also outlines the channels of communication of the competent authorities with the national stakeholders, other ASEAN competent authorities and relevant organizations about the use of chemicals and current laws and regulations regarding chemicals in aquaculture as well as the manner of monitoring the progress of the competent authorities in the implementation of the Guidelines. The set of Guidelines also presents a list of commonly used chemicals and drugs in aquaculture among the AMSs which have been deliberated on and agreed upon during the regional workshops. SEAFDEC supports and promotes the adoption of the Guidelines among its Member Countries and compliments this with the guidelines on the use of antibiotics and other chemical inputs based on scientific information gathered from projects funded by the Government of Japan Trust Fund and other relevant SEAFDEC studies.

Due to the growing awareness on issues on food safety of aquaculture products, SEAFDEC considered it an urgent matter to help establish, support, and promote regional guidelines on the right usage of antibiotics and other chemical inputs that will allow farmers to increase production of safe aquaculture products. The findings from SEAFDEC/AQD research and the outcome of the harmonization of guidelines on the use of chemicals in aquaculture were consolidated in a SEAFDEC/AQD publication "Important Findings and Recommendations on Chemical Use in Aquaculture in Southeast" (Coloso *et al*., 2015). Also included in this monograph is technical information on three important chemicals, namely: ethoxyquin, organotin compounds and melamine, the residues in aquaculture products which threaten the food safety of aquaculture commodities.

SEAFDEC/AQD conducted studies to determine the withdrawal or depletion periods of antibiotics on different fish species cultured in the tropics. Although the mechanisms of accumulation and withdrawal of antibiotics and chemicals have already been well studied in developed countries, these data were generated using their species and under conditions that are different from the conditions prevalent in the Southeast Asian region. Thus, studies were conducted to estimate the depletion of two types of antibiotics, oxytetracycline (OTC) and oxolinic acid (OXA) on four fish species, namely: milkfish (*Chanos chanos*), hybrid red tilapia (*Oreochromis mossambicus-hornorum* x *O. niloticus*), mangrove red snapper (*Lutjanus argentimaculatus*), and orange spotted grouper (*Epinephelus coioides*).

In line with the promotion of food safety awareness in the Southeast Asian region, another SEAFDEC/AQD study surveyed the levels of antibiotics and pesticide residues in aquaculture products from culture systems such as ponds and cages or pens from the three major islands of the Philippines (Luzon, Visayas, and Mindanao). Samples were obtained from the markets or from fish farms and transported to SEAFDEC/AQD Tigbauan Main Station in Iloilo, Philippines where the samples were analyzed for the presence of organochlorine pesticide (OCP), OTC, and OXA antibiotic residues. Some samples still contain residues of these antibiotics and the banned OCP. For instance, in a specific *Macrobrachium* sample from Luzon, higher level than the Permissible Exposure Limits (PEL) and Maximum Residue Levels (MRL) of Endrin and its metabolite, and Endosulfan I were detected, indicative that the banned OCPs are still being used presumably in agriculture operations and that they enter the culture system through water run-offs.

Ethoxyquin is a chemical added to aquafeed to prevent oxidation or rancidity of fats, and is known to be one of the best feed antioxidants but is also responsible for a wide range of health related problems in dogs, as well as in humans. Tolerance level in uncooked muscle meat of animals is 0.5 ppm. However, Japan lowered the residual limit in shrimp to 0.01 ppm in 2012, and this caused alarm and financial losses to farmers from countries that export shrimp to Japan. In 2014, Japan formally increased the allowable limit from 0.01 ppm to 0.2 ppm in crustaceans. Although it is a twenty-fold increase in the allowable level, it is still lower than acceptable tolerance level of 0.5 ppm. Nevertheless, this brought some relief to shrimp exporting countries like Viet Nam, India, and Philippines.

Organotin compounds, like tributyl or triphenyl derivatives of tetravalent tin, have been extensively used as algicides and molluscicides in anti-fouling products. In the Philippines and other Southeast Asian countries, triphenyltin (brand names Aquatin, Brestan, or Telostan) has long been used as molluscicide in brackishwater earthen ponds to control the population of pond snails in milkfish culture. The use of organotins has been restricted in many countries, including the Philippines because of their effects on aquatic organisms and persistence in the environment. They render the soil sterile, considerably non-biodegradable, bioaccumulate in fish and snails, and are hazardous to humans. The concept of integrated pest management, the use of metaldehyde and tobacco dust, and lime treatment are just some ways to control the population of snails. Although organotins are banned in the Philippines, illegal importation has continued because its usage is allowed and continues to be practiced in neighboring countries. A uniform implementation of the ban in Southeast Asian countries will be helpful in limiting the use of this chemical in aquaculture.

Melamine is an adulterant that can be added to feed ingredients for aquafeeds to artificially inflate the apparent protein content. Together with cyanuric acid, it has been found that crystals formed from melamine and cyanuric acid can cause kidney damage in mammals, fish, and shrimp. If in doubt of the source and quality of feed ingredients and aquafeeds, samples should be submitted for melamine and cyanuric acid analysis. Their presence in feed ingredients and aquafeeds are biomarkers for contamination, adulteration, or intentional addition to increase crude protein levels. The United Nations' Codex Alimentarius Commission has set the maximum amount of 1.0 mg/kg melamine in powdered infant formula and 2.5 mg/kg in other foods and animal feed. While not legally binding, the recommended levels can serve as basis for banning the importation of products with excessive levels of melamine.

Along with the research activities to promote awareness of food safety of aquaculture products, SEAFDEC/AQD organized the International Training Course on Food Safety and the International Workshop on Food Safety of Aquaculture Products in Southeast Asia in May 2013 and November 2013, respectively. In the workshop, the status of food safety and traceability of aquaculture products were presented by the SEAFDEC Member Countries. In general, the countries are heading towards farm certification and implementation of protocols that would prevent the occurrence of food safety hazards in farm level, specifically, the considerations addressed in Good Aquaculture Practices (GAP). Each country identified their responsible authority in monitoring and regulating the food safety of aquaculture products. The training and workshop aimed to disseminate and exchange information in order to promote and encourage regional initiatives in ensuring the food safety of aquaculture products in the ASEAN region. Both the international training course and workshop were financially supported by JTF of the Government of Japan.

6.4.2 Issues, Challenges, and Constraints

The concept of food safety of aquaculture products should always start at the farm level. However, there seems to be a low awareness on this aspect on the part of marginal fish farmers who have lesser access to information, especially on the proper handling of chemicals, appropriate administration of antibiotics, and the hazards that these chemicals and drugs can bring to humans, animals, and the environment.

Due to the increasing demand of consumers for safe aquaculture products, stricter government laws implementing food safety requirements will be a challenge to fish farmers. Farm certification may become mandatory from being recommendatory. Preventing the occurrence of food safety hazards at the farm level is by far, a better tool to produce safe aquaculture commodities than removing the hazards in post-harvest operations. The implementation of GAP can be a tool to address the concerns on food safety, however, this can put heavy strain on the part of fish farmers and may be dealt with non-compliance and even rejection by farmers if they are not appropriately prepared and informed.

The adoption and implementation of harmonized guidelines on the use of chemicals for aquaculture in AMSs would require a massive effort on the part of each government and the competent authorities. Monitoring agencies of each country should be more vigilant and play a greater role in the implementation of the guidelines. More specifically, banned and regulated chemicals should be properly monitored.

6.4.3 Future Direction

Problems on antibiotic residues and evaluation of their withdrawal or depletion period on other tropical aquaculture species and monitoring of chemical contaminants either introduced during culture or inherently present in the culture environment are just some of the science-based future studies for consideration. Adhering to the principles of GAP should be promoted and recommended to all aquaculture operations, especially to small-scale and medium-scale aquaculture facilities. Governments should render assistance, especially to marginal fish farmers relevant to food safety and the ASEAN GAP. Information dissemination on food safety on farm level should be intensified.

Worthy of consideration also is the record of updated inventory of the amount of chemicals being used by each AMS, their application and assessment of the effect on the target objective of usage and the side effect to humans and the environment. Each AMS should have already adopted the ASEAN Guidelines for the Use of Chemicals in Aquaculture and Measures to Eliminate the Use of Harmful Chemicals (ASEAN, 2013). Nonetheless, competent authorities should be well-equipped with laboratory facilities and police powers for proper implementation.

6.5 Addressing Concerns Due to Intensification of Aquaculture and Climate Change

As the biggest producer of fisheries products both from capture and aquaculture, Asia has been considered the birthplace of aquaculture (FAO, 2016b; FAO, 2016c; Tacon *et al*., 1995). From 1950 to 2014 (**Figure 77**), Asia provided an average of 83% to the total world aquaculture production, with Southeast Asia contributing 9-31% to Asia's total aquaculture production (**Figure 78**). Indonesia and the Philippines contributed the most at 23-63% and 10-45% of the total, respectively (**Figure 79**). With the increasing demand for fish and fishery products and the dwindling supply of wild aquatic resources, aquaculture, considered a reliable solution to food security problems, is being intensified to compensate for the declining fisheries production. Aquaculture intensification has already caused aquaculture production to overtake the contribution of capture fisheries to the total world production at 51% in 2013 (FAO, 2016b).

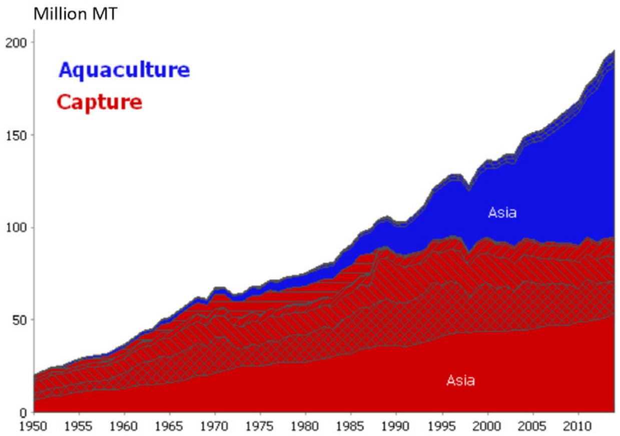


Figure 77. Total world capture (red) and aquaculture (blue) production from 1950 to 2014 by quantity; shaded areas with different patterns represent different continents and plain area represents Asia

Source: *FAO Database 2016*

However, as aquaculture production intensifies, a number of problems have been linked with it. The phenomenal growth of aquaculture in the recent years has caused modification, destruction or complete loss of habitat; unregulated collection of wild broodstock and seeds; translocation or introduction of exotic species; loss of biodiversity; introduction of antibiotics and chemicals to the environment; discharge of aquaculture wastewater, thus coastal pollution; salinization of soil and water; and dependence on fishmeal and fish oil as aquaculture feed ingredients, to name a few (Beveridge *et al*., 1994; Chua *et al*., 1989; Iwama, 1991; Naylor *et al*., 2000; Primavera, 2006). Thus, efforts have been done to balance the need to increase production and minimize the impacts of aquaculture on the environment.

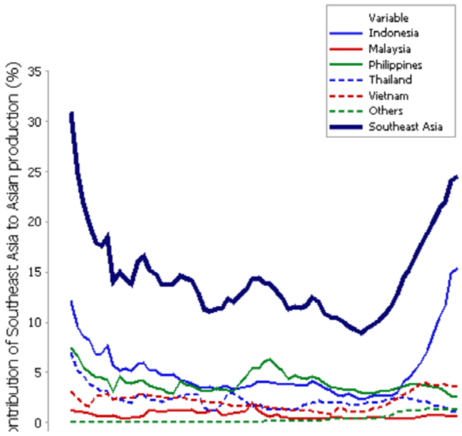


Figure 78. Contribution of Southeast Asian countries to aquaculture production in Asia, and top aquaculture producing Southeast Asian countries (1950-2014)

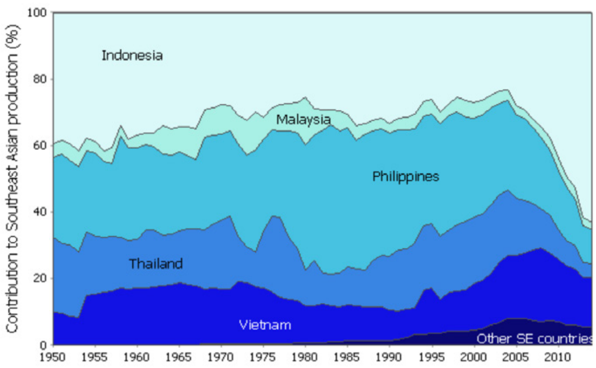


Figure 79. Contribution of Indonesia, Malaysia, Philippines, Thailand, Viet Nam and other Southeast Asian countries (Brunei Darussalam, Cambodia, Lao PDR, Myanmar, Singapore, and Timor-Leste) to aquaculture production in Southeast Asia from 1950 to 2014

Source: *FAO Database 2016*

Aside from aquaculture, the natural environment has also been greatly affected by extreme weather conditions brought about by climate change. Scientific evidence of the warming climate system is unequivocal and compelling. Extreme events, like numbers of recorded high temperature, numbers of intense rainfall, strengths of typhoons and storms, and the like, have been increasing since the 1950s (IPCC, 2007). Southeast Asia is not spared

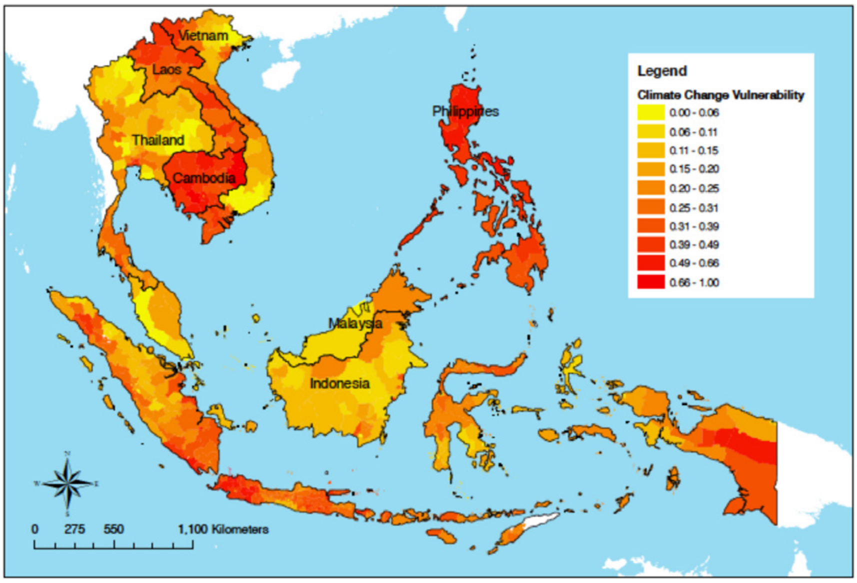


Figure 80. Climate change vulnerability map of Southeast Asia

Source: *Yusuf and Francisco, 2009*

from these impacts of climate change and of the countries in the region, the Philippines is the most vulnerable to the global changes (**Figure 80**) brought about by the changing climate (Yusuf and Francisco, 2009). The impacts of aquaculture coupled with extreme changes in climate could cause irreversible damage to the environment. Different sectors of the society have concerted their efforts to help mitigate the impacts of the fast changing climate.

6.5.1 Current Status of the Environment

In 2013, aquaculture became the major source of fisheries products after it has overtaken production from capture fisheries. Despite its own share of the problems that need to be addressed, the most important of which is its impact on the environment, the important role of aquaculture in food production provides a strong and credible argument for its continued implementation. Aquaculture continues to provide valuable food supply and economic support for many countries, especially in the Southeast Asian region. To limit the potential negative environmental impacts of aquaculture effluents, studies are conducted while policies and laws are formulated. There is also a joint effort of the scientific community, academe, policy makers, farm owners, and government authorities to come up with approaches that might help reduce production of aquaculture wastes or mitigate its impact. The specific strategy for mitigating the negative effects of aquaculture will depend on local conditions. Among the basics are choosing a location with high flushing rates and deep water, and using dry, easily digested feeds that will help reduce the potential negative impacts (Iwama, 1991). Tacon and Forster (2003) have suggested approaches for aquaculture farmers to follow to protect the environment (**Box 18**).

Box 18. Suggestions for aquaculture farmers to protect the environment

- treating farm effluents prior to discharge
- limiting the concentration of specific dissolved or suspended inorganic and organic materials and/or nutrients contained within the effluent discharged from the farm
- establishing maximum permissible amounts of specific nutrients (such as total nitrogen or phosphorus) that the farm is able to discharge over a fixed period of time
- limiting the total number of licenses that can be issued and/or size of farm, depending upon the vicinity of other farming operations and the assimilative environmental carrying capacity of the receiving aquatic ecosystem
- limiting or fixing the total quantity of feed the farm is able to use over a fixed period of time
- fixing maximum permissible specific nutrient levels within the compound feeds to be used to rear the species in question
- banning the use of specific potentially high-risk feed items such as fresh/trash fish and invertebrates and certain chemicals and antibiotics
- prescribing minimum feed performance criteria
- requiring the (i) use of specific Codes of Conduct, including appropriate Best Management Practices (BMPs) for farm operations; (ii) development of suitable farmor pond sediment management strategies for the storage and disposal of sediments; and/or (iii) implementation of an environmental monitoring program

At present, most fish farmers on one hand do not follow the said approaches but if implemented, only some of the approaches are followed, and as a result, the environment continues to suffer. On the other hand, the worsening climate has added its toll to the already suffering environment. Global sea level rose by about 17 cm in the last century with the rate in the last decade nearly doubled that of the last century (**Figure 81**) (Church and White, 2006). In 2008, extreme sea levels were high along the coasts of Southeast Asian countries, and low at most of the islands in the tropics (Peterson and Baringer, 2009). The global surface of the Earth, as shown by temperature reconstructions, has warmed since 1880. Most of this

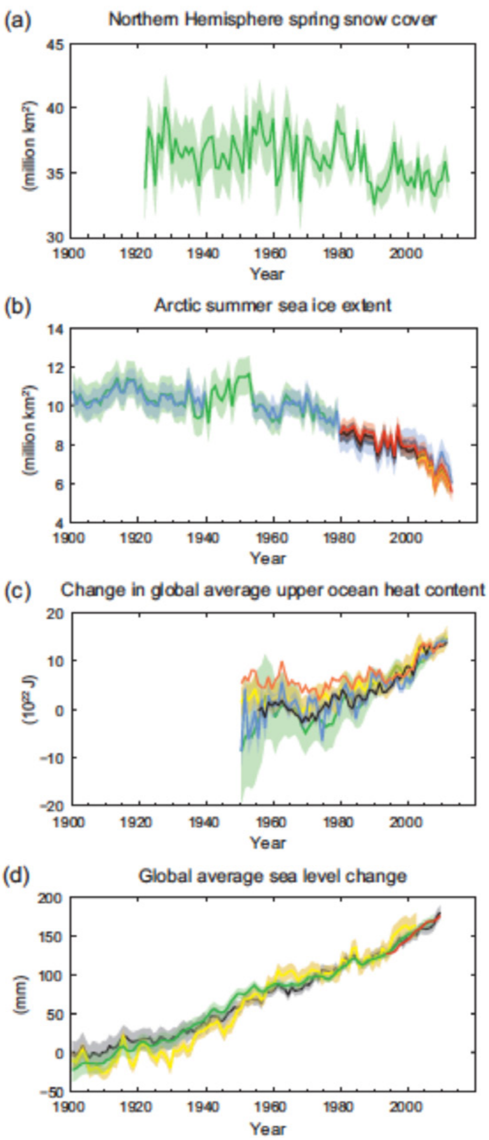


Figure 81. Observed indicators of a changing global climate from 1900-2012:
(a) Northern Hemisphere average snow cover for spring (March-April);
(b) Arctic average sea ice for summer (July-September);
(c) change in global average upper ocean heat content; and
(d) global average sea level change

Source: *IPCC, 2013*

warming has occurred since the 1970s with all 10 of the warmest years occurring in the past 12 years (Peterson and Baringer, 2009). In turn, the oceans have absorbed much of this increasing heat, warming the top 700 m by 0.302°F (~0.17°C) since 1969 (Levitus *et al*., 2009). Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades with the snow melting earlier. Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30% resulting from increasing carbon dioxide (CO_2) emission into the atmosphere and hence more are being absorbed by the oceans. The amount of CO_2 absorbed by the upper layer of the oceans is increasing by about 2 billion metric tons per year (Sabine *et al*., 2004). In 2008, the most extreme land precipitation events have greatly affected Japan and the Southeast Asian countries. Regional *La Niña* impacts included above-average rainfall across much of the Maritime Continent (*e.g.*, Indonesia, Philippines, Malaysia, and Borneo) extending to northernmost portions of Australia (Peterson and Baringer, 2009). The impacts of climate change in forms of different weather disturbances are not limited only to a few places but everywhere. The daunting reality is that through the years these disturbances intensify causing excessive casualties to the natural environment.

6.5.2 Issues and Constraints

6.5.2.1 Intensification of aquaculture

Modification, destruction, or complete loss of habitat: Among the coastal ecosystems, mangroves are the most greatly affected by aquaculture since most aquaculture ponds were constructed in mangrove areas. Southeast Asia has the widest and the most diverse mangroves in the world but between 1980 and 2005 it suffered a decline of 26.46% (Spalding *et al*., 2010). Most of these losses were due to conversion into milkfish and shrimp ponds (Naylor *et al*., 2000), resulting in loss of goods and ecosystem services generated by mangroves—plant and wood products, provision of nursery habitat, coastal protection, flood control, sediment trapping, and water treatment (Bandaranayake, 1998; Ewel *et al*., 1998; Macnae, 1968). Aside from losing these goods and services, converting mangroves into aquaculture ponds transforms an open access fisheries with multiple users to a privatized farm resource of few wealthy individual investors and business enterprises.

Loss of biodiversity: The impacts of aquaculture on biodiversity are rarely positive, sometimes neutral, but usually negative to some degree (Beveridge *et al*., 1994). Loss of biodiversity is one of the consequences of habitat modification or its complete destruction to give way to aquaculture ponds. Globally, mangrove biodiversity is highest in the Indo-Malay Philippine Archipelago, with 36-46 of the 70 known mangrove species occurring in this region. However, the region has one of the highest rates of mangrove area loss at an estimated 30% reduction in mangrove area since 1980 (Polidoro *et al*., 2010). Although mangrove species diversity may be low, faunal, microbial, and other associated species diversity can be high (Alongi, 2009). Thus, losing mangroves means losing a highly complex system that serves as nursery or permanent residence for a range of organisms, both from the terrestrial and the aquatic environments (Alongi, 2002; Macnae, 1968). Unregulated collection of broodstock and wild seeds for use in aquaculture facilities also threatens the wild population. The same may happen to fish species harvested for use in fish meal and fish oil production. Regardless of purpose, indiscriminate harvesting of wild stocks has negative impact on biodiversity.

Discharge of aquaculture wastewater and introduction of antibiotics and chemicals to the environment: Aquaculture has heightened public concerns about pollution, water quality degradation, health, and other violations of the public trust (Costa-Pierce, 1996). Aquaculture wastewater outputs and loads vary widely, depending upon the species cultured, farming system, and aquatic environment employed (Tacon and Forster, 2003). Aquaculture wastes are mostly derived from excess feeds and fecal matter. Continuous discharge of wastewater without treatment may result in a chain of undesirable events, *e.g.* serious oxygen deficit caused by the decomposition of organic substances, sedimentation, eutrophication or algal bloom caused by the accumulation of organic nutrients like nitrogen and phosphorus, changes in energy and nutrient fluxes, changes in pelagic and benthic biomass and community structure and fish stocks, low productivity, sometimes disease outbreaks. Moreover, the inadequate handling of wastewater has serious consequences on human health, the environment, and economic development (Cao *et al*., 2007). Aside from wastewater, aquaculture also introduces various chemicals to the environment in the form of therapeutants, disinfectants, water or soil treatment compounds, algicides and pesticides, fertilizers, and feed additives. Too much use of these chemicals can result in toxicity to non-target populations, human consumers and wild biota, and the accumulation of their residues (Primavera, 2006). Antibiotics (tetracycline, oxytetracycline, oxolinic acid, furazolidone and chloramphenicol) are also used excessively and may lead to the development of resistant bacterial populations (Hoa *et al*., 2011; Tendencia and de la Peña, 2001).

6.5.2.2 Climate change

Solar irradiance: Studies have shown that solar variability has played a role in past climate changes. A decrease in solar activity is thought to have triggered the Little Ice Age between approximately 1650 and 1850, when Greenland was largely cut off by ice from 1410 to the 1720s while glaciers advanced in the Alps. Since the sun is the fundamental source of energy that drives our climate system, it is just reasonable to assume that changes in its energy output would cause the climate to change. However, the current global warming could not be explained by changes in energy from the sun. Since 1750, the average amount of energy coming from the sun either remained constant or increased slightly. If warming was caused by the sun, the atmosphere is expected to be warmer in all layers. However, a cooler upper atmosphere and a warmer surface lower atmosphere were observed. Greenhouse gases are the ones trapping heat in the lower atmosphere making it warmer than the upper atmosphere (IPCC, 2007).

Greenhouse effect: Most climate scientists agree that the main cause of the current global warming trend is human expansion of the "greenhouse effect," as human activities are changing the natural greenhouse. Over the last century, burning of fossil fuels like coal and oil has increased the concentration of atmospheric CO_2. Clearing of land for agriculture, industry, and other human activities have also increased the concentrations of greenhouse gases. Industrial activities that our modern civilization depends upon have raised the atmospheric CO_2 levels from 280 ppm to 400 ppm in the last 150 years. Among the consequences of changing the natural atmospheric greenhouse include warming of the earth, warming of the oceans, melting of glaciers, increased sea level, and increased evaporation and precipitation (IPCC, 2007; NASA, 2016).

6.5.3 Outlook and Future Perspective

Habitat rehabilitation or restoration: In the case of aquaculture, habitat rehabilitation or restoration is more focused on mangroves which suffered most because of pond construction. In the review paper of Ellison (2000), he cited that although most of the objectives of restoration projects were for forest products, coastal protection and stabilization, two Southeast Asian countries set their goals for maintenance or sustainability of fisheries (Malaysia) and provision of habitat for wildlife (Viet Nam). Rehabilitating nursery habitats is also effective in restoring populations of naturally occurring species and considered as one of the approaches in enhancing fisheries (Welcomme and Bartley, 1998). This has been observed in mud crabs, *Scylla* spp. in the reforested mangroves in Kalibo, Aklan, Philippines (Walton *et al*., 2007) and mangrove recolonized in an abandoned pond in Dumangas, Iloilo, Philippines (Lebata-Ramos, unpublished data).

Stock enhancement: Stock enhancement using individuals reared in aquaculture facilities is becoming a popular method of supplementing depleted stocks (Bert *et al*., 2003). Bell *et al*. (2006) discussed two of the most successful stock enhancement initiatives—the augmentation of scallop fishery in Hokkaido, Japan causing a four-fold increase in annual harvest. Success in stock enhancement depends on setting the management goals and identifying the right species for release. It can be a very effective tool if accompanied with habitat restoration because it will be of no effect in situations where recruitment is limited due to lack of sufficient nursery areas (Bell *et al*., 2006). Although stock enhancement activity may change the status quo of the ecosystem, given the substantial damage these ecosystems have suffered due to anthropogenic activities and the depletion of fishery resources due to overfishing, the impact of adding juveniles aimed at improving production of target species should not be a cause of great concern, provided that this activity is conducted responsibly and that this will not cause further degradation to the ecosystem and its diversity (Lebata, 2006).

Aquasilviculture: Mangroves and aquaculture are not necessarily incompatible (Primavera, 2006). Marginal coastal sites such as denuded and overexploited mangrove areas and unproductive or abandoned fishponds can be made productive and economically profitable through aquasilviculture. The integration of aquaculture with silviculture, known as aquasilviculture refers to the harmonious co-existence of aquaculture species and mangrove trees (de la Cruz, 1995). This mangrove-friendly aquaculture technology had been applied in shrimp ponds (Primavera *et al*., 2007) and mud crab pen culture (Primavera *et al*., 2010; Triño and Rodriguez, 2002) in the Philippines; shrimp-mangrove farms in Viet Nam (Binh *et al*., 1997); and milkfish pond culture, milkfish and shrimp polyculture (Fitzgerald and Savitri, 2002), and shrimp pond culture (Shimoda *et al*., 2006) in Indonesia. Using the concept of mangrove resource rehabilitation and livelihood provision, the Philippine Bureau of Fisheries and Aquatic Resources recently implemented the National Aquasilviculture Program to help address climate change, food security, and poverty among municipal or artisanal coastal fisherfolks (Dieta and Dieta, 2015). Aside from integrating aquaculture into the mangroves, aquaculture species (*i.e.* seaweeds, mussels, oysters, and fish) are also being reared in mangrove waterways.

Integrated aquaculture: The concept and practice of integrated aquaculture is well-known in inland environments in Asia, but much less reported in the marine environment. In the recent years, the idea of integrated aquaculture has been often considered a mitigation approach against the excess nutrients and organic matters generated by intensive aquaculture activities particularly in marine waters. Integrated marine aquaculture can cover a diverse range of co-culture and farming practices, including integrated multi-trophic aquaculture (IMTA) and aquasilviculture. IMTA explicitly incorporates species from different trophic positions or nutritional levels in the same system for bioremediation and economic returns (Soto, 2009). Integration can be directly beneficial to farmers either through additional valuable products, improving water quality, preventing diseases, habitat conservation, or increasing allowed production volumes through waste reduction (Troell, 2009). Neori *et al*. (2004), for example, reported that annually, a 1-ha land-based integrated sea bream–shellfish–seaweed farm can produce 25 metric tons of fish, 50 metric tons of bivalves, and 30 metric tons fresh weight of seaweeds or 55 metric tons of sea bream or 92 metric tons of salmon, with 385 or 500 metric tons fresh weight of seaweed, respectively, without pollution. In coastal fishing communities in Guimaras, Philippines, SEAFDEC/AQD has successfully introduced the concept of IMTA through the combined pen culture of milkfish *Chanos chanos*, with sandfish *Holothuria scabra*, and seaweeds *Kappaphycus* sp. Funded by Japan International Research Center for Agricultural Sciences (JIRCAS), the project aimed to demonstrate the potential of IMTA in mitigating the impacts of excess nutrients from uneaten milkfish feeds and milkfish feces while obtaining additional income from other non-fed species.

Modern integrated systems are bound to play a major role in the sustainable expansion of world aquaculture. IMTA seems to be the direction of aquaculture in order to make it economically and environmentally sustainable.

Proper feeding management: Most aquaculture wastes are usually dietary in origin. Aquaculture feeds and feeding regimes can play a major role in determining the quality and potential environmental impact of fish and crustacean farm effluents (Tacon and Forster, 2003). Optimized local feed management together with further development of fish feed in terms of increased digestibility of feed components will lead to greater profitability to the farmer and also minimize aquaculture wastes (Kolsäter, 1995). Boyd (2003) suggested the Best Management Practices (BMPs) that pertain to feeding management (**Box 19**).

Box 19. Suggested Best Management Practices (BMPs) pertaining to feed management

- use fertilizers only as needed to maintain phytoplankton blooms
- use high quality, water stable feeds that contain only the required amount of nitrogen and phosphorus than necessary
- apply feeds conservatively to avoid overfeeding and to assure that as much of the feed is consumed as possible

Feeding may also be improved through the use of automatic feeder and by employing compensatory feeding. Feeding regimes may be manipulated in such a way that feed inputs to the environment may be minimized without sacrificing production.

Climate change adaptation and mitigation: The fast changing climate is inevitable and to survive this irreversible condition, adaptation and mitigation measures have been formulated. Adaptations are adjustments in natural or human systems in response to climatic changes (IPCC, 2007). It involves adjusting to actual or expected future climate. The goal is to reduce our vulnerability to the harmful effects of climate change like sea-level encroachment, more intense extreme weather events or food insecurity. It also encompasses making the most of any potential beneficial opportunities associated with climate change (NASA, 2016). Adaptation measures are needed to protect livelihoods and food security in many developing countries that are expected to be the most vulnerable, even under moderate climate change and the impacts of the change are likely to be lower the sooner the mitigation activities begin. The overall challenge of climate policies is to find the efficient mix of adaptation and mitigation solutions that will limit the overall impacts of climate change. Adaptation is necessary to limit potential risks of the unavoidable residual climate change now and in the coming decades. Examples of this adaptation measures are shown in **Box 20** (IPCC, 2007; NASA, 2016; Tubiello, 2012).

Box 20. Examples of adaptation measures on climate change

- expanding rainwater harvesting, storage and conservation techniques and water reuse and desalination
- adjusting cropping periods both for agriculture and aquaculture and shifting to species or areas more productive under new climatic conditions or developing culture techniques for new species which are more resilient to climate change
- relocating residents from storm and surge-prone areas to safer locations
- designing standards and planning for roads, rails, and other infrastructure to cope with warming
- using renewable sources and reducing dependence on single source of energy

On the other hand, mitigation is reducing climate change by reducing the flow of heat-trapping greenhouse gases into the atmosphere, either by reducing the sources of these gases or enhancing the "sinks" that accumulate and store these gases. The goal of mitigation is to avoid dangerous human interference with the climate system, and stabilize greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner (NASA, 2016). Mitigation actions involve direct reduction of anthropogenic emissions or enhancement of carbon sinks that are necessary for limiting long-term climate damage.

The benefits of adaptation choices will be realized almost immediately but will matter most under moderate climate change. However, benefits of mitigation may only be realized decades from now.

6.5.4 Way Forward

Aquaculture may be the ultimate solution to the problem of reduced fisheries production. However, in view of irresponsible practices by many, aquaculture has negatively affected the environment. To compensate the diminishing fisheries production and meet the demands for fisheries products as human population continues to grow, aquaculture must be redesigned to minimize its impact on the environment and make it more environment-friendly and at the same time economically sustainable. Scientific studies on how aquaculture destroyed habitats, polluted the waters, threatened non-target species, and a long list of others; and how aquaculture should be done to make it sustainable and environment-friendly are readily accessible. But despite the easy access to such information, aquaculture continues to degrade the environment. Scientific findings should be properly and widely disseminated to fish farmers, hatchery operators, feed suppliers, policy makers, and government agencies to make them understand that protecting the environment is not the task of just one person but should be a joint effort of everyone producing from it, using it, and living in it. Science should be strongly supported by policies that are strictly implemented in order to achieve the goal of having a better and cleaner environment in the future.

While climate change is a global issue, it is strongly felt on a local scale. In areas where the environments are badly damaged, the impacts of climate change may be greatly experienced. When Typhoon Haiyan hit the Philippines, storm surges caused heavy casualties and damages in communities where mangrove areas have been converted to ponds or other uses. As anthropogenic activities continue to destroy the environment and as weather disturbances worsen, the impacts of climate change on the society become more catastrophic. Adaption and mitigation measures are in place but the capacity to adapt and mitigate is dependent on socio-economic and environmental circumstances and the availability of information and technology. In the absence of national or international climate policy directions, cities and local communities around the world have been focusing on solving their own climate problems. They are building flood defenses, planning for heat waves and higher temperatures, installing water-permeable pavements to better deal with floods and storm water, and improving water storage and use. Moreover, efforts are also into managing the increasingly extreme disasters we are seeing and their associated risks, protecting coastlines and dealing with sea-level encroachment, managing land and forests, dealing with and planning for reduced water availability, developing resilient crop varieties, and protecting energy and public infrastructure (NASA, 2016). Unfortunately, those with the least resources are the most vulnerable to, and the least able to adapt to, climate change. As such, it is important to protect and rehabilitate the environment as a mitigation measure to the fast changing climate. In the end, it is still the condition of the environment that defines the condition of the earth.

7. VULNERABILITY OF FISHERIES TO CLIMATE CHANGE AND NATURAL DISASTERS

The annual cycles of the monsoon is key to both terrestrial and marine natural resources productivity in Southeast Asia. The seasonal monsoon and related variations in the climate, hydrological, and oceanographic patterns are important for the life-cycle of aquatic resources. However, climate variability and climate change combined with unusual and unpredictable seasonal weather patterns are increasingly affecting the livelihoods of people dependent on fisheries and aquatic resources. This should be seen in the perspective of, as emphasized in the SEASOFIA issued in 2012 (SEAFDEC, 2012b), capture fisheries and aquaculture which are among the most important livelihood sources available to coastal communities. The same goes for communities living in the watersheds and floodplains of the region with its abundance and diversity in fisheries and other aquatic resources and plants.

The sustainability of these resources continues to be subject to various threats and pressures and important habitats and biodiversity are threatened by environmental degradation and destructive fishing. Overfishing in the region is a problem leading to the reduced availability of fishery products. Erosion is also a serious problem and the construction of dams and roads, for example, in and around watersheds, is impacting the connectivity of river floodplain systems, affecting the migration and spawning of many fish species. As a result, the livelihoods of many inland and coastal communities are threatened.

Adding to the threats from environmental degradation and overexploitation, smaller villages in coastal and inland areas throughout the region are facing increased hardships due to the impact of natural hazards such as storms, tornados, floods, drought, and so on. Lessons learned from disasters and efforts to adapt to climate variability should be incorporated into plans to, given the specific geographical location, integrate fisheries management into habitat management, and coastal and inland resources management. This could include safety and rescue at sea, records of available vessels to be kept, efforts to ensure connectivity and migration paths, and many more. This should also include efforts to build resilience, incorporate local knowledge in adaptation plans, and to restore important and protective coastal and inland features, wetlands, and habitats throughout the Southeast Asian region.

The situation, with the need to reverse environmental degradation and to implement climate related mitigation measures, is very much the same as that explained in SEAFDEC (2012b). In this connection, the argument on climate related concerns builds upon and summarizes the earlier text with emphasis given on environmental degradation, overexploitation, and impacts of climate variability and climate change, as seen in combination and in many cases considered as climate change impacts that add as "stressor" to existing problems.

It is important and urgent to integrate fisheries management into marine and terrestrial spatial planning and subsequent resource exploitation with the objective of ensuring sustainable utilization of important resources, protecting vulnerable areas and species, and thereby mitigating the impacts of climate variability and climate change while promoting adaptation at community level. In particular, strategies and interventions to mitigate the effects of climate change to the fisheries industry should be established. Environment friendly strategies to lessen the sectors' impacts on the environment should also be developed, which pertains to the efforts to reduce the carbon footprint of fisheries. These efforts should be taken with serious deliberation considering that many people in the Southeast Asian region are increasingly dependent, directly or indirectly, on the fishery resources as proven in the per capita consumption that reached a new all-time high (FAO, 2010).

7.1 Vulnerability of Coastal and Inland Communities and Impacts on Important Habitats

The Southeast Asian region has been considered as one of the areas where rural or coastal people are most vulnerable to environmental variations caused by climate change (and environmental degradation) because of its long coastlines, extensive floodplains, and dependence on seasonal monsoon patterns that trigger the productivity and availability of fisheries and other aquatic resources as the main source of sustenance for many coastal dwellers and inland communities (IPCC, 2007 as cited by Santos *et al*., 2011). The vulnerability of people and habitats should not only be viewed from the perspective of the normal fluctuations in the common seasonal monsoon variability with shorter or longer wet or dry seasons but also, and increasingly so in the perspective of longer term climate change that may threaten to further expose the already vulnerable coastal and inland fishing communities by more persistent changes in the monsoon pattern. It is widely recognized that the effects of climate change include seasonal monsoon or rainfall variations, increased and stronger incidence of storms and typhoons, changes in the patterns and peaks in dry and wet season fluctuations, increased land-based run-offs, and rise in sea-surface and shallow lake temperature. The effects highly influence the productivity of the coastal and inland habitats and the availability of fishery and aquatic resources.

In coral reef ecosystem, sea surface temperature rise is the main factor which has the most direct adverse effect as manifested in massive coral bleaching that started in 1998 and followed by subsequent similar events throughout the region up to the present. Similarly, climate-related effects on mangroves will be highly manifested due to sea level rise as well as the frequency and intensity of strong surges. Sea level rise will have direct impact on these habitats and will dictate mangrove landward migration (Gilman *et al*., 2007). In addition, the clearance of mangroves for urban and industrial development, shrimp farming and other uses, leaves coastal villages more exposed to natural hazards and climate change and may even result in them being forced to leave. Furthermore, the filling up of wetlands and floodplains increases the vulnerability to seasonal floods leaving inland communities more exposed while prolonged periods of drought affects the availability of aquatic resources thus increasing hardship. Likewise, sea grass beds are affected by sea surface temperature rise particularly impinging plant growth and other physiological functions. Distribution pattern of aquatic species would most likely shift due to variations in temperature and sea-depth, and there are already reports on changes in migration pattern.

7.2 Impacts of Climate Variability and Climate Change on Capture Fisheries

Climate variability and climate change are modifying the distribution, migration pattern, and productivity of marine and freshwater aquatic species and already affecting biological processes and altering food webs (FAO, 2009a). The adaptive capacity of the environment is highly affected by changes in water temperature. Changes in habitat temperature greatly affect their growth rate, metabolism, reproduction seasonality and efficacy, susceptibility to diseases and toxins, and their spatial distribution (Lehody, 1997 as cited in Santos *et al*., 2011). Fish may tend to move to cooler and tolerable waters thus changing their migratory patterns and known availability. Variability in the rain and dry season monsoon pattern has implications on the migration and spawning of fish in inland water bodies and it is generally understood that a “good” flood season is combined with an abundance of fishery resources.

Changes in the distribution through migration (either spawning and/or feeding) of stocks will ultimately affect the availability of aquatic resources at certain place and time. Other profound effect to stocks is the availability of food (as would be the case in inland waters during a prolonged dry season) as a result of climate variability and in the longer term more permanently by climate change. The changes in global climatic patterns and season, will affect fish recruitment and population. The warming of river basins and estuarine waters could affect yields from fisheries either positively or negatively depending on the resulting dissolved oxygen concentrations and aquatic productivity. It is likely that species distribution will occur according to the adaptability of the species involved.

7.3 Impacts of Climate Change on Aquaculture Development

The range of threats and impacts indicated above are, given the specific location (*e.g.* inland, coastal), also to be considered with regards to aquaculture development – albeit due to its very nature more site, or pond specific. In particular, changes in water temperature could influence the growth rate of stocks and metabolism by prolonging the period of culture and increasing production inputs as well as the selection of species to be cultured. The variability of weather conditions, prolonged hot conditions and drought, intense and stronger storm surges are just but a few factors that would most likely influence options for aquaculture. A rising water temperature and adverse rainfall patterns will affect the physical, chemical, and biological quality of the water such as the dissolved oxygen, salinity, pH, nutrients, and plankton dynamics. As such, greater impact will be experienced for those activities in the open environment like floating net cages in lakes and estuaries as well as in the open sea. In addition, the frequent change in water parameter is likely to create increased turbulence hence higher cost to install or maintain infrastructures to hold the fish.

7.4 Adaptation and Mitigation Strategies to Balance the Impacts of Climate Variability and Climate Change

A reversal of present trends of coastal and inland environmental degradation is an important element in efforts to reduce the effects of natural hazards and to mitigate the effects of climate variability and climate change. In the process of rehabilitating important habitats (such as mangroves and flooded forests) and geographical coastal and inland features (such as sandy beaches, mudflats, dunes, floodplains, and other wetlands), efforts should be done to restore protective features and at the same time to maintain critical areas for aquatic resources and fish species during their life cycle. Plans to integrate fisheries management into habitat management should also strive to include schemes to protect against natural hazards appropriate for the specific geographical situation.

Works to mitigate the effects caused by natural hazards should not only be viewed from the perspective of common seasonal monsoon variability in Southeast Asia but also, and increasingly so, in the perspective of longer term climate change that may threaten further the already vulnerable coastal and inland fishing communities. Through the fragmentation of fishing communities, traditional knowledge on how to "live with the sea" or "how to live with the floods" and how to manage and maintain coastal habitats is rapidly being lost. Similar processes of marginalization in inland fishing communities, including encroachment into wetlands and floodplains also need to be considered in order to reverse the trend.

SEAFDEC in cooperation with collaborating agencies has been implementing programs related to adaptation and mitigation of the effects of climate change in the Southeast Asian region. In order to assess the individual country's efforts specifically focusing on the emerging regional policy issues related to climate change, SEAFDEC in close collaboration with the AMSs through the ASEAN Fisheries Consultation Forum (AFCF) has identified actions to be implemented that are aimed at mitigating the impacts of climate change. It is emphasized that development of mitigation strategies should at all time be integrated in every fishery related programs and frameworks. Building upon local knowledge and traditional practices, the use of participatory approaches in vulnerability assessment of climate change impacts on coastal and inland communities form as basis for the formulation of local adaptation strategies.

In efforts to build adaptive capacity and to mitigate climate related impacts, it is important to highlight that existing programs and actions being implemented and are of importance to improve fisheries management and the well-being of people involved in fisheries and fisheries related activities (coastal/inland fisheries, commercial fishing, processing and post-harvest), are also relevant in terms of responses from the sector to climate change and local variations in monsoon and hydrology patterns. Indeed, good habitat and fisheries management will build the resilience and robustness of the aquatic systems, making them less vulnerable to climate change stresses.

Furthermore, there is a need to develop reporting methods and indicators, on how actions taken can contribute to building up of adaptive capacity to mitigate the effects caused by climate change. In addition, awareness programs on the short-term and long-term effects of climate change to the environment should also be taken into consideration, and efforts should be solicited to mitigate such effects. Programs for livelihood diversification to lessen dependence on current income sources among fisherfolk should also be considered. Provision of other means of income among artisanal or subsistence fisherfolk gives them opportunities and lessen their dependence on fishing, thus, also lessens their vulnerability to environmental changes. Risk reduction among fishers working in harsh offshore conditions as well as among small-scale fisherfolk in coastal and inland waters is crucial. Likewise, governments should exert efforts to strengthen adaptive measures and provide tools for safety at sea to people engaged in fisheries related activities. Ideally, wide range, reliable, accessible, and up to date meteorological services should be in place in the Southeast Asian region.

In aquaculture, research and development initiatives should similarly be geared to respond to the impact of climate change and the need to build mitigation strategies for people engaged in inland and coastal aquaculture as suitable, given the geographical location of the region. Researches should continue to be equipped towards culture stocks and strain development focusing on stocks with wider tolerance to environmental changes including alternative feed sources to lessen dependence on fishmeal. To lessen the impact of climate change on aquaculture activities, countries should develop and implement appropriate action plans that integrate climate change mitigation strategies into aquaculture development plans.

7.5 Reducing Carbon Footprints from Fisheries and Aquaculture

The global consensus and concern that dependence on fossil fuels and non-renewable energy sources should be significantly reduced in the coming decades focus in tapping alternative and renewable energy sources. In addition, global targets for the reduction of the emission of greenhouse gases should be established. Through SEAFDEC and collaborating organizations, the fisheries and aquaculture sectors could continue to strengthen their efforts to reduce carbon footprints and to mitigate environmental impacts which contribute to climate change. It is well recognized that reducing fossil fuel dependence in fishing operations would entail several measures that include the development and promotion of cost effective technologies, backed up by appropriate policy structures for the management of energy use in fisheries in the region. In addition, fuel and energy source alternatives should be identified, while R&D on environment-friendly and efficient capture technologies should be pursued (SEAFDEC/TD, 2011). Projects have already been initiated in the Southeast Asian region concerning measures to reduce the fossil energy dependence in capture fisheries. Involvement of and awareness raising in the private sector should continue to be enhanced with the objective of reducing the use of fossil fuels while relevant programs should be promoted in collaboration with other institutions including the academe, NGOs, and research institutions, in developing advocacies relative to minimizing the contribution of fisheries to climate change. Energy saving programs would have the added benefit in reducing fuel costs for people engaged in fisheries and fish processing.

8. FISHERFOLKS AND WORKERS IN FISHING ACTIVITIES

8.1 Labor in the Southeast Asia Fishing Industry

The FAO statistics indicated that Asia contributed the largest number of fishers and fish farmers compared to other regions of the world, where 87% of the total people are employed in the sector (FAO, 2016a). Such number comprises those engaged in different fishery sub-sectors, either part-time or full time, and regardless of their scales of engagement. Recognizing the importance of fishers and workers in fisheries sectors, the Southeast Asian countries have been confronted with pressing concerns on the need to combat IUU fishing associated with labor-related issues, as well as on the status of people engaged in fishing and related activities in the region.

The increasing demand of workers in the fisheries sectors to serve the expansion of intra-regional and international trade of countries in Southeast Asia, results not only in large numbers of migrant workers getting onboard to seek work opportunities in other countries but also large groups of workforce moving from one country to another. Receiving countries therefore need to take serious attention in addressing the issues and concerns in fisheries labor, especially the allegations that these workers receive low wages, their social security is either non-existent or inadequate, unskilled in relation to fishing operations, received inadequate training before working onboard fishing vessels, not aware of the requirements for safety at sea, possess fake or no legal documents, subjected to forced labor, child labor, human trafficking, experience poor working conditions and unfair treatment by employers, and that some fishing vessels do not comply with sea safety requirements (SEAFDEC, 2016e).

Several countries in the region therefore have revised their respective legal frameworks particularly those that are relevant to labor aspects in fisheries (SEAFDEC, 2016e). As an example, vessel owners and skippers in the Philippines are required to provide a guarantee that all crew members are to be treated in accordance with Philippine labor laws, before a fishing license is issued for a vessel. In Indonesia, a special Sub Directorate of Fisheries Labour and Manning a Fishing Vessel was established within the Directorate of Fishing Vessel and Fishing Gears under the Directorate General of Capture Fisheries of the Ministry of Marine Affairs and Fisheries. In Thailand, the Royal Ordinance on Fisheries of 2015 includes labor aspects (Art 11), and the Department of Fisheries (DOF) in cooperation with the Department of Labour Protection and Welfare (DLPW) and the International Labour Organization (ILO) had developed a set of four Good Labour Practice (GLP) Guidelines which are pending endorsement by the Government.

Considering that issues on migrant labors and workers are regional in nature and could not be solved by a particular country alone, close communication and cooperation among countries are therefore required taking into consideration the existing "ASEAN Declaration on the Protection and Promotion of the Rights of Migrant Workers" (ASEAN, 2007). In particular, during the regional consultation organized by SEAFDEC in 2016, it was agreed that the roles and obligations of the "Receiving State" and the "Sending State" should be strengthened, and that establishment and enforcement of Memorandum of Understanding (MoU) between sending and receiving countries should be promoted (SEAFDEC, 2016e). Moreover, receiving countries should consider developing standard employment contracts and other protection measures, and support the workers through the conduct of specific pre-departure training programs (occupation, language, culture), especially those who intend to work in the fisheries sector while sending countries should provide specific pre-departure training program (occupation, language, culture) for workers who intend to seek employment in the fisheries sector based on the MoU. The Philippines, Indonesia, and Viet Nam actively promote and provide opportunities to fishery labor, and continue to enhance the capacity of their national fishing crew before they go abroad to work in the fisheries sector. Furthermore, countries should also ensure that crew members receive decent working conditions abroad.

Issue on gender also has a very close linkage with the fisheries sector of the region, considering that women provide labor not only before or during fishing activities but also after. The role of women is not only limited to small-scale but also in industrial fisheries as well as in aquaculture, particularly at the processing and marketing stages, as well as in financial management. It is therefore necessary that women should be empowered to be involved in decision-making processes, and the roles of women in fisheries should be emphasized and well recognized. Furthermore, in order that the issue on gender is appropriately addressed in the region, such issue should also be mainstreamed in fisheries and aquaculture development projects at all stages, from planning, implementation, and evaluation, as well as in national fisheries development strategies as appropriate and applicable for the respective countries.

8.2 Safety at Sea, Working Condition, and Safety Onboard Fishing Vessels

In Southeast Asia, the number of registered fishing boats as of 2014 was reported to be approximately 800,000 (SEAFDEC, 2016a), comprising non-powered boats, outboard powered boats, and inboard powered boats; and operating either in the inland, coastal, or marine areas.

Specifically for marine fisheries, the number of fishing boats was reported to be more than 115,000 (SEAFDEC, 2016a). In nine ASEAN Member States (except Lao PDR), the types and sizes of fishing boats could be very much different among the countries, while the fishing boats operate either within or outside the EEZs of respective countries. With the main fishing grounds in the Indian Ocean, South China Sea, Gulf of Thailand, Sulu Sea, and Sulawesi Sea, sea and weather conditions are usually not very harsh, except during the monsoon season.

Considering the differences in nature and characteristics of fishing activities as well as in the design of boats among the countries, issues on safety of fishing crew and working conditions need to specifically focus on particular types of fishing boats and corresponding countries that engage in the activities. As an example, the operation of gillnet uses small-size fishing boat with few fishers involved, the fishing gears and devices used are simple, and the operation is undertaken near shore. In the contrary, for purse seine operations, fishing boats are huge with gear that comprise large net with sophisticated devices, large number of fishers are involved, work could be very tiring, and operations are carried out far away from the shore.

On working and living conditions including safety of fishing crew onboard the fishing vessels, most countries claim that their fishing boats provide decent working conditions to the crew. However, the level of standard among the countries could be greatly different. For example, fishing boats of Brunei Darussalam are small in number but most are large in size and manned by migrant crew members. As shown in **Figure 82**, in commercial fishing boats of Thailand, 84% of crew members are migrant workers coming from Myanmar, Cambodia, and Lao PDR, while in Malaysian commercial fishing boats, 82% of crew members are migrants from Thailand and Viet Nam (SEAFDEC, 2016e).

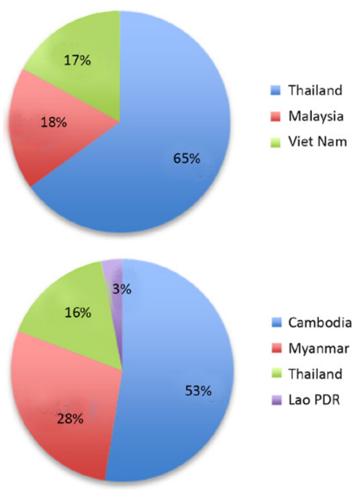


Figure 82. Nationalities of crew in Malaysian and Thai commercial fishing boats

Source: *SEAFDEC, 2016e*

From the scenario on migrant workers in Malaysian and Thai fishing boats, it could be noted that Thai and Vietnamese fishers prefer not to work in fishing boats of their own countries, but prefer to work in other countries, particularly in Malaysian fishing boats perhaps due to better working conditions and wages. While Thailand claims shortage of Thai crew to work onboard Thai fishing boats, large numbers of workers from Cambodia and Myanmar prefer to work in Thai fishing boats than in their respective countries. Migration of fishing crew could therefore be one of the indicators for evaluating the working condition and standards onboard fishing vessels among the five Southeast Asian countries, *i.e.* from Malaysia, Thailand, Viet Nam, Cambodia, and Myanmar.

For countries like the Philippines, Indonesia, Singapore, and Brunei Darussalam, the issues could be in terms of safety during the fishing operations, and safety of the fishing boats. Nevertheless, the issue on safety of fishing boats should be considered a priority as this has linkage with relevant laws, regulations, and management of the respective countries, as well as with relevant international conventions, of which some provisions are applicable to the Southeast Asian countries. Some provisions of the international convention are however, of very high standard and nearly impossible for the countries in the region to adopt. Majority of fishing boats in the Southeast Asian region are small boats, and the countries have their respective regulations in relation to safety standards of fishing boats, which could differ from one country to another but are practical enough for their specificity and use. Therefore achieving standards at international level may not be possible, taking into consideration the scale of fishing boats, the status of countries, as well as the nature of boats and fishing activities. The important question is therefore on what should be the appropriate safety standards, and what factors should be considered in establishing the relevant regulations on safety standards.

Furthermore, it should be noted that at this moment, there is no regulation that ensures appropriate standard for the Southeast Asian region with respect to the working conditions onboard fishing boats. Developed countries such as those in the EU or Japan, and others have much better working condition standards compared with those in the Southeast Asian region but the "Safety Guide for Small Fishing Boats" developed by FAO could be adopted. However, considering that such FAO guide may not be fully suitable for small-size fishing boats in the Southeast region in several aspects, in 2003, SEAFDEC addressed this issue by organizing several fora to raise the issues on safety of small fishing boats in the region, and came up with regional guidelines that take into consideration the specificity of the countries in the region.

Specifically, SEAFDEC conducted the "Regional Workshop on Safety at Sea for Small Fishing Boats" in December 2003 to raise the issue on boat design and construction, equipment and its correct usage, search and rescue operations, occupational health, and safety awareness including the avoidance of dangerous fishing practices (SEAFDEC, 2003b). Subsequently, the second and third Workshops that addressed issue on safety at sea for small fishing boats were organized in April 2010 and December 2011, respectively; while the Regional Training Workshop on Optimizing Energy and Safety at Sea for Small-scale Fishing Vessels was also organized in February 2013 to enhance the capacity of AMSs towards effective enforcement and management of safety measures by relevant authorities and stakeholders.

In 2005, FAO, ILO, and the International Maritime Organisation (IMO) developed the "Code of Safety for Fishermen and Fishing Vessels," "Part A" of which provides information that promote the need to ensure safety and health of crew members onboard fishing vessels, while "Part B" provides information on the design, construction, and equipment of fishing vessels with a view to promoting the safety of fishing vessels as well as safety and health of the crew. The "Voluntary Guidelines for the Design and Construction and Equipment of Small Fishing Vessels" and the "Safety Recommendations for Decked Fishing Vessels of Less Than 12 Meters in Length and Undecked Fishing Vessels" was subsequently approved to support the implementation of the Code by competent authorities. In connection to such developments, and to support AMSs in the implementation of the guidelines particularly to help competent authorities in formulating their own legislation and regulations or other measures for the safety of fishing vessels, SEAFDEC facilitated the translation of the Safety Recommendations into AMSs' national languages, namely: Thai, Khmer, Vietnamese, and Burmese.

In 2007, ILO also established the "Convention Concerning Work in the Fishing Sector" or Convention C-188 (ILO, 2007a), with recommendations concerning work in the fishing sector or Recommendations R-199 (ILO, 2007b). The ILO convention is very useful to ensure that fishers have decent conditions of work onboard fishing vessels with regards to minimum requirements for work onboard; conditions of service; accommodation and food; occupational safety and health protection; and medical care and social security. Although ILO's Convention No. 188 has been referred to by several countries, some articles in this convention seem not suitable and not practical for application by fishing boats in the Southeast Asian region.

The Convention for the Safety of Life at Sea or SOLAS (IMO, 1974), which is an important international treaty concerning the safety of merchant ships, could not be applied to fishing boats in the Southeast Asian region. However, the Torremolinos International Convention for the Safety of Fishing Vessels (IMO, 1977) which was replaced by the Torremolinos Protocol (IMO, 1993), contains safety requirements for the construction and equipment of new, decked, seagoing fishing vessels 24 meters in length and over, including those vessels that also process their catch. Nevertheless, neither the Torremolinos Convention nor its Protocol had been entered into force. Considering that construction of fishing boats in this region have been undertaken mostly in the traditional way of the respective countries, more than 80% of these boats could not be renovated to meet the requirements of the Convention. Nonetheless, the traditional design of fishing boats could also have their advantages and disadvantages, *e.g.* Philippine outrigger fishing boats have very good stability but inconvenient for living. Therefore, standards must be considered for fishing boats type by type. The location of fishing operation, condition of the sea, communication method between ship to shore and ship to ship, are also important factors that should be considered and adjusted to improve the status of fishing boats, especially those in the Southeast Asian region.

Taking into consideration therefore the provisions in Convention C-188, Recommendation R-199, as well as relevant guidelines developed by organizations such as FAO, IMO, ILO, areas that should be considered in improving the working and living conditions and safety of fishing boats in the Southeast Asian region, could include:

1. Seaworthiness - boat design and construction
2. Pattern of working - fishing gears and operations, working hour, time of operation
3. Efficiency of crew - knowledge, experience, and responsibility of crew
4. Condition of equipment and gears
5. Fishing boat accommodation
6. Fishing boat hygiene and food
7. Supporting exercise

On the standard of fishing boats, issue on "seaworthiness" is among the primary concerns, as either small or big vessels have their own property to withstand harsh sea conditions. Although there are several guidelines on boat design and construction, none of these could be applicable for fishing boats in the Southeast Asian region.

Recently, issues on working and living conditions onboard fishing boats and safety at sea are among the important factors that affect trading of fish and fishery products coming from the Southeast Asian countries. As an example, the Philippines was issued a yellow card from EU in 2014 that necessitated the improvement of the country's laws in relation to working conditions and safety at sea, some of the criteria imposed by EU before Philippines could export its fish and fishery products to the EU. After taking action to address such issues, the yellow card was lifted after few years. Nevertheless, the Philippines continued to improve the working and living conditions onboard its fishing boats by establishing in May 2016 the Rules and Regulation Governing the Working and Living Conditions of Fishers Onboard Fishing Vessels Engaged in Commercial Fishing Operations (Department Order No. 156-Series of 2016). Thailand also got a yellow card from the EU in 2014, and one of the actions undertaken by the country is to improve its national law concerning working and living conditions, and safety at sea of fishing boats. Thailand was also ranked in 2015 with "Tier 3" by the US State Department's Trafficking in Persons (TIP) Annual Report which rated the country with the worst human-trafficking records. After several improvements of its national laws and regulations, Thailand's status was upgraded in mid 2016 to the "Tier 2 Watch List."

Future challenges of the Southeast Asian region would therefore be on whether the countries could accommodate the requirements stipulated in relevant international convention and recommendations in their respective legal frameworks, and actively undertake measures to upgrade or enhance the level of working and living conditions, and safety onboard fishing boats in the future. Close cooperation among countries and thorough understanding of the issues and emerging requirements are among the most important requirements that need to be pursued.

9. COMPETITION ON USE OF WATER RESOURCES WITH OTHER SECTORS

Increasing demand for food, water, and energy, owing to the increasing global population and consumption pattern, makes services from aquatic ecosystems either inland or marine, more in demand while aquatic resources undergo more stress from competition and over-utilization. Under such a situation coupled with anticipated impacts of climate change which could be more prominent in the future, the fisheries sector is likely to face higher competition with other sectors sharing the limited water resources.

For inland capture fisheries, the most obvious competition could be seen from the alterations of inland aquatic habitats for urbanization and industrialization purposes. With increasing human population, large areas of floodplains are converted into housing areas, resulting in the shrinkage and disconnectedness of aquatic habitats, exacerbated by road constructions without sufficient underway, threatening the sustainability of inland aquatic biodiversity and the fishery resources. Urbanization and industrialization also create higher demand for water resources for household consumption and at the same time generate large amounts of wastes that pollute and contaminate the natural bodies of water if not properly disposed of or treated.

As the main priority food producing sector of the Southeast Asian region, agriculture is also the highest water-consuming sector. With human population that continues to increase together with food security requirements, greater demand for water is created to boost production through agricultural intensification. Higher inputs are used by farmers, particularly chemicals in fertilizers and pesticides, to produce higher yields and increase profits. Agricultural intensification also creates impacts on the natural bodies of water, *e.g.* discharge of excess nutrients and chemicals that leads to contamination and eutrophication of the aquatic habitats resulting in degradation of aquatic habitats and resources. Development of irrigation systems to support agricultural intensification also affects the fisheries sector as the natural aquatic habitats and water resources are altered in the process. The anticipated impacts of climate change (*e.g.* longer drought during dry season, heavier rains and floods during rainy season) also have their repercussions on the availability of water supply for irrigation purposes and fishery activities in the future.

To enhance the effective utilization of land and water resources, integrated agriculture-aquaculture could be considered as an option which could also mitigate the conflict between the fisheries and agriculture sectors, *e.g.* fish culture in rice fields (rice-cum-fish) with reduced or restricted use of pesticides and weedicides in rice cultivation and where fish is stocked to gain yield from both rice and fish, integrated fish farming that could make use of wastes from livestock and poultry for primary production of herbivorous fish. Fish from integrated aquaculture, although considered as secondary or complementary production, could contribute to production of nutritionally balanced food for the people.

Along with urbanization, industrialization, and agricultural intensification, cross-river obstacles are also being constructed in several Southeast Asian countries for development purposes, *e.g.* to increase domestic water supply, improve irrigation systems, and enhance hydropower generation. Construction and operation of dams not only create disconnectivity of aquatic habitats but also require sufficient level of water supply to sustain their functions resulting in diversion of water from adjacent catchments creating alterations of the habitats in natural water bodies. While it is well recognized that construction of cross-river obstacles would result in drastic impacts on aquatic biodiversity, fishery resources, and livelihood of people that are dependent on these resources, such impacts are hard to quantify compared with the benefits that could be gained from other sectors, *e.g.* hydropower generation, crop production, among others. Although mitigating measures have been explored for immediate application, *e.g.* construction of fishways to facilitate upstream-downstream migration of fish, in several countries such measure is not part of the requirements for cross-river construction while the design and operation of dams and fishways has not been properly taken into consideration as part of the requirements in fisheries planning.

Sand and gravel mining from sandy rivers is another activity that has been undertaken in relation to industrialization. In the Mekong River Basin, sand and gravel mining is carried out for construction purposes (concrete) and for landfills (railways, motorways, land reclamation in flooded areas, and offshore reclamation). Although there is no clear evidence on the morphological changes and environmental impacts of such activity in the Mekong River, faster erosion of the river banks could be observed. Nevertheless, it is also difficult to distinguish whether such change is caused by natural morphological phenomena of the river as a result of climate change or triggered by dredging, thus further study needs to be undertaken on this aspect.

Aquatic habitats also serve as tourist attractions, *e.g.* large inland reservoirs, rivers and their tributary landscapes, coastal seascapes, mangrove forests, coral reefs, whale and dolphin watching sites, and so on. Recreational fishing is an opportunity for indigenous communities to enhance their incomes and their active involvement in the management and conservation of their traditional livelihoods. While tourism activities could bring incomes and economic development opportunities to communities, the activities could also create impacts on the fisheries sector, *e.g.* changes in aquatic habitats from construction of tourism facilities, pollution caused by tourists, among others. Tourism activities should therefore be promoted in an environment-friendly manner, *e.g.* eco-tourism, in order to minimize its impacts on the habitats and aquatic resources.

In addressing concerns on the deterioration of aquatic habitats and fishery resources, initiatives had been undertaken to secure important aquatic habitats, although some could also affect the fisheries sector. Specifically in marine areas, establishment of Marine Protected Areas (MPAs) is one of the classic examples as this concept restricts human activities in such areas. While MPAs could be considered effective tool to maintain fish populations, MPAs in most cases also comprise no-take zones where fishing activities are prohibited. One of the approaches to mitigate such conflicts is the establishment of fisheries *refugia*, where fisheries objectives of protecting the critical life cycle, *e.g.* spawning, nursing, broodstock aggregation, and migratory routes of species targeted for management, could be integrated with establishment of protected areas for conservation purposes.

Petroleum extraction is another important economic activity that utilizes non-living resources from the ocean. Brunei Darussalam, Malaysia, Indonesia, Thailand, and Myanmar are countries that have rich hydrocarbon resources, with several offshore oil rigs and platforms constructed and operated. Construction of such platforms is beneficial to the countries but could conflict with the activities of their respective fisheries sectors. Fishers are prohibited from fishing near these platforms giving them less catch, although such areas could also be considered as a kind of *refugia*, where fishes are protected, thus, rehabilitation of the resources could naturally occur resulting in long-term benefit to the fisheries sector. While the importance of petroleum industry is necessary for energy security and economic development for countries in the region, their oil rig operations also come with associated risks, *e.g.* leakage or oil spills that would impact on the marine environment including aquatic species and habitats, as well as on human health.

Other sectors that share the aquatic resources worth mentioning here include those related to large-scale coastal constructions, *e.g.* land reclamation and construction of deep-sea ports that alter coastal morphological characteristics; water transportation, navigation and trade; communication systems using submarine cables; as well as those related to national security in transboundary areas of countries in the region.

Recommendations

Considering that several sectors share the water resources and conflict across sectors is anticipated to be more severe in the near future, it is necessary for the fisheries sector to come up with realistic data and information on the benefits that could be gained from using the aquatic habitats and water resources to sustain food security and livelihood of people. Such information would facilitate discussions and decision-making on the need to maximize the benefits gained from the water resources by people in the Southeast Asian region as a whole. With the benefits either direct or indirect that could be gained, the practical methodologies for valuation of aquatic ecosystem services should be explored and developed. Furthermore, awareness on the importance of aquatic resources for sustaining people's food security and livelihood should also be enhanced in order that interest in fisheries would be taken into consideration in decision-making and trading-offs for the sustainability of the fisheries sector in the future.

PART III
Outlook of Fisheries and Aquaculture for the Southeast Asian Region

1. GROWING DEMAND FOR FISH AND FISHERY PRODUCTS

In the Southeast Asian region, fisheries form an integral part of people's livelihood, providing significant contribution to food security, nutritional requirements, sustained incomes, and improved socio-economics of people. Considering that several Southeast Asian countries are major fish exporting nations, the contribution of Southeast Asian fisheries to food security is not only limited for people within the region but also all over the world. With anticipated increase in the world's human population from 7.3 billion in 2014 to 8.1 billion by 2030 and 9.6 billion by 2050 (**Table 65**), the world food-producing sector including fisheries would therefore be faced with stronger challenge to secure the availability of food and nutrition for the growing demand from such increasing population.

In order to ensure the sustainable development of fisheries in the Southeast Asian region for the benefit of future generations, the FAO Code of Conduct for Responsible Fisheries serves as broad fisheries development framework, while the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region (adopted in 2001) and the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 (adopted in 2011) would also continue to provide guidance on priority actions for enhancing the contribution of fisheries to food security of peoples in the region. Furthermore, the Strategic Plan of Action on ASEAN Cooperation in Fisheries (2016-2020), which was developed taking into consideration the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 and recently endorsed by the ASEAN-SEAFDEC Member Countries during the Thirty-eighth Meeting of the ASEAN Ministers on Agriculture and Forestry, also serves as guide for actions to be implemented by the AMSs towards sustainability of the fisheries sector in the near future.

2. ISSUES AND CHALLENGES TOWARDS SUSTAINABLE UTILIZATION OF FISHERY RESOURCES

Under the Convention on Biological Diversity (CBD), the Strategic Plan for Biodiversity 2011-2020 developed during the Tenth Meeting of the Conference of the Parties on 18-29 October 2010 in Aichi Prefecture, Japan, includes the Aichi Biodiversity Target Number 6, which states that "*By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so*

Table 65. Projected population, fish production, per capita production, and GDP of the Southeast Asian countries

Countries	Population (million)			Fish production (2014) (thousand metric ton)	Average. per capita fish consumption (2013) (kg/person/yr)[3]	GDP (2014)[5]
	2014[1]	2030[2]	2050[2]			
Brunei Darussalam	0.4	0.5	0.6	3.9	47.0	36,607
Cambodia	15.2	18.9	22.5	745.0	41.4	1,081
Indonesia	252.2	295.5	322.2	20,601.0	31.8	3,534
Lao PDR	6.8	8.5	10.2	151.0	19.8	1,693
Malaysia	30.2	36.1	40.7	1,988.0	54.0	10,803
Myanmar	51.5	60.2	63.6	5,040.0	60.7	1,221
Philippines	99.9	123.6	148.3	4,681.0	30.2	2,865
Singapore	5.5	6.4	6.7	6.7	46.9	56,319
Thailand	68.6	68.3	62.4	2,667.0	26.1	5,445
Viet Nam	90.7	105.2	112.8	6,333.0	34.8	2,053
Southeast Asia	**621.0**	**723.2**	**790.0**	**42,217.0**	**35.1[4]**	**3,867**
World	**7,300[3]**	**8,084**	**9,587**	**195,700.0**	**19.7**	**77,609[4]**

Source:
[1] ASEAN Statistical Year Book 2015
[2] World Population Prospects: The 2015 Revision, Key Findings and Advance Tables
[3] FAO Yearbook 2014
[4] Calculated based on per capita fish consumption in 2013 and population in 2014
[5] International Monetary Fund Database Website

that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits."

The importance of fisheries and "life below the water" was also reflected among world leaders in developing the targets to "end poverty, protect the planet, and ensure prosperity for all." To provide a platform for common efforts among governments, civil society and the private sector to meet these ambitions, the Sustainable Development Goals (SDGs) were adopted by the United Nations Sustainable Development Summit 2015 on 25-27 September 2015. The SDGs are made up of 17 goals together with sub-sets of 169 targets. In terms of fisheries and aquatic environmental protection, the SDG Goal Number 14 should be specifically highlighted as it indicates an ambition to: "*conserve and sustainably use the oceans, seas and marine resources*." The SDG goals have specific targets to be achieved over the next 15 years (by 2030).

The Aichi Biodiversity Target Number 6 and the Sustainable Development Goal Number 14 should therefore be taken into consideration in undertaking activities towards sustainable development of fisheries in the Southeast Asian region.

2.1 Marine Capture Fisheries

Based on the trend in fisheries production, where several major species being harvested are fully- or over-exploited, and with deteriorating aquatic habitats caused by habitat destruction and marine pollution, it is likely that production from capture fisheries of the Southeast Asian region will not increase much further in the near future. In this connection and considering the anticipated increasing demand for fish despite limited fishery resources, promotion of responsible practices on sustainable utilization of resources should be continued in the Southeast Asian region. Appropriate management approaches that are appropriate for small-scale fisheries that had been introduced through the past decades, particularly the co-management concept, should be promoted further for adoption by the countries as appropriate, taking into consideration the availability of their respective supportive legal frameworks. During the past few years, the concept of Ecosystem Approach to Fisheries Management or EAFM has been promoted for equitable management that balances ecological well-being and societal benefits to ensure long-term sustainable use of the fishery resources. Thus, the EAFM concept could be one of the methods beneficial for the region, considering the nature of the region's fisheries which is multispecies and involves a wide range of stakeholders across the sector.

Conservation and rehabilitation of important aquatic habitats, particularly the fragile habitats that are critical to life stages of aquatic species such as coral reefs, sea grass beds, and mangrove forests, restoration of deteriorated inland habitats and rebuilding stocks of aquatic species are some of the approaches that had been put into practice by several countries in the region with a view of enhancing the fisheries production. Nevertheless, to ensure effective implementation of such approaches, regional guidelines on best practices are necessary with clear objectives, based on results of feasibility studies, and with involvement of relevant stakeholders in the planning and management as well as in monitoring and evaluation. Furthermore, the concept on fisheries *refugia* that had been introduced in the region could be promoted further to complement the existing conservation and management measures by integrating the fisheries objectives of protecting the critical life cycles of aquatic species, *e.g.* spawning, nursing, broodstock aggregation, as well as maintaining the migratory routes of species targeted for management, with consideration also on the establishment of fisheries *refugia* for management of transboundary species that move across the EEZs of more than one country.

2.2.2 Combating IUU Fishing

Illegal, Unreported and Unregulated (IUU) fishing which has been identified as one of the causes of the declining fishery resources, can take place in all aspects of capture fisheries and in all bodies of water. Initiatives to conserve and manage fish stocks have been undermined by IUU fishing, the result of which could lead to total collapse of capture fisheries, seriously hampering all attempts to rebuild the stocks that may have already been overfished. International society during the past decade had enforced stringent requirements for combating IUU fishing and enhancing traceability of fish from capture fisheries, *e.g.* the European Council (EC) Regulation 1005/2008 Establishing a Community System to Prevent, Deter and Eliminate IUU Fishing (entered into force on 1 January 2010); the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (entered into force on 5 June 2016); US Presidential Taskforce on Combating Illegal, Unreported and Unregulated (IUU) Fishing and Seafood Fraud.

Recognizing the threats from declining fishery resources and taking heed of the international requirements for combating IUU fishing, several countries in the region had issued regulations to limit their fishing activities. These include:

- o Controlling overfishing activities by:
  - Improving vessel registration and licensing systems
  - Applying Vessels Monitoring System (VMS)
  - Prohibiting foreign vessels from operating in national waters (*e.g.* Indonesia, Malaysia)
  - Strengthening MCS and preventing poaching
- o Regulating fish landings at ports by:
  - Enhancing inspections at landing sites or ports through the implementation of the Port State Measures Agreement
  - Prohibiting the landing of catch from vessels (*e.g.* Indonesia, Malaysia) in other country's ports
- o Controlling fish and fishery products along the supply chain through the implementation of traceability system, *e.g.* catch to be accompanied with required documents along the supply chain

The ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain which was adopted by the Senior Officials Meeting of the ASEAN Ministers on Agriculture and Forestry (AMAF) in 2015, could serve as a regional framework for the development of corresponding measures to combat IUU fishing by the respective countries in the region, as well as for the establishment of regional cooperation and collaboration in combating IUU fishing. In any case, it is anticipated that more stringent requirements for ensuring the sustainable utilization of resources and combating IUU fishing could be encountered by the Southeast Asian countries in the near future.

Besides the requirements for combating IUU fishing, the fisheries sector of the region is also being challenged by the need to implement existing standards and instruments developed by various organizations such as the International Labour Organization (ILO) and the International Maritime Organization (IMO), particularly the ILO Promotional Framework for Occupational Safety and Health Convention 2006 (No. 187), and the ILO Work in Fishing Convention 2007 (No. 188). In responding to such requirements, the AMSs supported the development of the "ASEAN Guidelines on Implementation of Labor Standards for the Fisheries Sector" to secure the rights and decent working conditions of people engaged in the fisheries sector including migrant workers in the spirit of the ASEAN Community integration. Furthermore, modification of existing vessels or adoption of "new designs of fishing vessels" could be options for enhancing compliance with relevant provisions in the abovementioned Conventions, and reducing requirements for workers onboard fishing vessels in the future.

In compliance with the emerging requirements for sustainable utilization of fishery resources and combating IUU fishing, the Southeast Asian countries adopted a "Joint Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fisheries Products" in 2016 to promote the pertinent activities as shown in **Box 21**.

Box 21. Joint Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fisheries Products

- Strengthening Monitoring, Control and Surveillance (MCS) programs under national laws and regulations for combating IUU fishing
- Intensifying capacity building and awareness-raising programs, including information, education, and communication campaigns
- Enhancing traceability of fish and fishery products from capture fisheries through the implementation of the "ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain" and the "ASEAN Catch Documentation Scheme for Marine Capture Fisheries"
- Enhancing traceability of aquaculture products, through the implementation of all ASEAN Good Aquaculture Practices (GAPs) with certification scheme based on regulations of respective countries
- Managing fishing capacity with a view to balancing the fishing efforts with the declining status of the fishery resources in the Southeast Asian region, and establishing conservation measures based on scientific evidence
- Promoting the implementation of port State measures
- Enhancing regional cooperation in managing transboundary fishery resources
- Regulating the quality and safety of ASEAN fish and fishery products all throughout the supply chain
- Addressing issues on labor (safe, legal, and equitable practices) in the fisheries sector
- Enhancing close collaboration between the AMSs and relevant RFMOs in combating IUU fishing
- Undertaking collective efforts in developing preventive and supportive measures to strengthen rehabilitation of resources and recovery of fish stocks to mitigate the impacts of IUU fishing

For the implementation of these required actions, respective Southeast Asian countries should ensure the availability of supportive legal and institutional frameworks as well as human and financial resources. Furthermore, building the awareness of key stakeholders along the fishery supply chain should also be enhanced to facilitate the implementation of such actions, *e.g.* required traceability system.

The ASEAN Catch Documentation Scheme (ACDS) is one of the management tools meant to improve and strengthen fisheries management in the region, in order to support intra-regional and international trade of fish and fishery products. The development of the ACDS took into consideration the requirements of RFMOs, the EU, and the U.S. Presidential Task Force as well as the systems that are already in place in the respective AMSs in order that the ASEAN fish and fishery products would be acceptable by major importing markets. Although the ACDS is still in its finalization process for pilot-testing in selected AMSs, its implementation by the AMSs as envisioned, is not only intended to enhance intra-regional trade but also to improve national traceability of fish and fishery products in the future.

With regards to the Port State Measures Agreement (PSMA) which has been ratified by 25 States (including three Southeast Asian countries, namely: Indonesia, Myanmar, and Thailand) and entered into force on 5 June 2016, several Southeast Asian countries have already established their respective national systems and designated ports as well as the required legal frameworks to support the implementation of the PSMA. However, awareness-raising is still necessary to provide deeper understanding on the implications of the entry into force of the PSMA, including institutional responsibilities relevant to the respective laws and regulations of the countries. Furthermore, capacity building activities should also be promoted to ensure effective implementation of the PSMA. Through such processes, the capability of the countries in enforcing control over foreign-flagged vessels would be enhanced, as well as in obtaining information on source of origins of fish and fishery products, and preventing the importation of fish and fishery products from IUU fishing activities in the future.

In 2016, the ASEAN Regional Plan of Action for the Management of Fishing Capacity (RPOA-Capacity) was endorsed by the Thirty-eighth Meeting of the ASEAN Ministers on Agriculture and Forestry (38th AMAF). Implementation of the RPOA-Capacity, including development of respective National Plans of Action for Management of Fishing Capacity by respective AMSs is encouraged to strike a balance between fishing efforts and the available fishery resources. While close collaboration at regional, sub-regional or bilateral levels is necessary for ensuring effective fisheries management of transboundary fishery resources, the AMAF at its Thirty-eighth Meeting had encouraged the AMSs to consider developing the "Common ASEAN Fisheries Policy" to strengthen their collective efforts in attaining sustainable and responsible fisheries, and food security towards the unification of ASEAN Community. This is one of the biggest challenges for the Southeast Asian fisheries, which needs to be explored in the near future.

While it is well recognized that effective management is a key towards sustainable utilization of the fishery resources, improved data and information on status and trends of fishery resources is one of the prerequisites for science-based management, as well as in the implementation of the RPOA-Capacity or NPOA-Capacity taking into consideration the available fishery resources. Based on the progress of the compilation of available fisheries statistics from the Southeast Asian countries, it appears that several countries still have limited capacity to come up with timely and reliable fishery statistics with details necessary for determining the actual status and trends of the fishery resources. The region is therefore faced with strong need not only to improve collection and compilation of data and information on fishery resources, *e.g.* data on production that could be used for stock assessment and development of appropriate indicators appropriate for fisheries in the region (*e.g.* CPUE), but also to be able to implement management measures based on such data and information.

2.2 Inland Capture Fisheries

The inland capture fisheries sub-sector is important not only for its contribution to food security, particularly for rural areas, but also for providing steady contribution of around 7-8% of the region's total fisheries production. Nevertheless, the sub-sector has been confronted with the deterioration of inland aquatic habitats caused by alterations of floodplains for urbanization and conversion to agriculture areas, constructions of cross-river obstacles, *e.g.* dams for hydropower and irrigation purposes, roads, and pollution among others. Considering that inland water resources are being utilized by multiple resource users, competition for such utilization by several sub-sectors would be more severe in the future. Respective countries in the region should therefore enhance cross-sectoral coordination in order to maximize the benefits that could be obtained from inland water resources, and at the same time, ensure that relevant aquatic habitats would continue to provide its contribution to increased fisheries production for people's sustained livelihoods and to the aquatic resources' nourished biodiversity.

This sub-sector has also been confronted with concerns on availability of data and information, considering that the sub-sector comprises large portion of small-scales fisheries, most of which are part-time or subsistence fishers, with its catch and production that are diverse and multispecies, and a large portion of which is used for household consumption without being appropriately recorded. As a result, inland fisheries production is underestimated and underrepresented in most of national statistics or other records, which leads to the inadequate attention given to the inland fisheries sector. It is therefore necessary to improve data collection in order that the importance of inland capture fisheries is beefed up, and the information compiled provides sufficient justification for balancing and trading-off between resource conservation and development projects.

Although it could be viewed that management of inland fishery resources is mostly a national issue under the respective countries, regional management framework is necessary in some cases, particularly in transboundary inland bodies of water, *e.g.* Mekong River Basin (transboundary for Thailand, Cambodia, and Viet Nam).

2.3 Aquaculture

Based on statistical reports, the trend of aquaculture production has been drastically increasing over the past 10 years with the improvements in aquaculture technologies. Production from the aquaculture sub-sector is seen to be a key contributor to meeting the increasing demand for fish and fishery products in the future. While efforts have been exerted by many Southeast Asian countries to intensify aquaculture operations and increase production with a view to meeting food security requirements, such operations have also been seen to compete with the utilization of captured fish as ingredient for aquaculture feeds and for human consumption. Technologies for the substitution of fish-based ingredients in aquaculture feeds have been explored by relevant national and regional agencies, and works have continued with particular focus on the use of locally available ingredients in feed formulations. Sharing of information on this aspect is necessary, in order that utilization of the fishery resources in the Southeast Asian region could be optimized for sustaining the food security and livelihoods of its people.

While some aquaculture operations over the past decades had been developed towards intensification requiring high production inputs, *e.g.* seedstocks, feeds, chemicals, and therapeutants, that results in increased aquaculture yield, among others, the aquaculture industry had been confronted with continuing concerns on transboundary diseases that hinder its sustainable development. While the countries in the region have been seriously working to establish effective approaches to prevent and/or control further incidence of aquatic animal diseases, emerging diseases have continued to occur during the past few years, *e.g.* the AHPND or EMS that resulted in drastic reduction of aquaculture production from major exporting countries of the Southeast Asian region. Considering the transboundary nature of these diseases that could easily spread from one place to another or even across the country or region, establishment and strengthening of surveillance measures through regional collaborative mechanism are crucial to alert the countries of any disease occurrence and enable them to adopt and adapt appropriate preventive and management measures in a timely manner.

Responsible aquaculture practices should also be promoted by countries in the region, along with the available regional guidelines, *e.g.* the ASEAN Good Aquaculture Practice (GAqP), ASEAN Shrimp GAP, the ASEAN Guidelines for the Use of Chemicals in Aquaculture and Measures to Eliminate the Use of Harmful Chemicals. Furthermore, as adopted by the Thirty-eighth AMAF in 2016, the Regional Guidelines on Traceability System for Aquaculture Products in the ASEAN Region could be used by the Southeast Asian countries in verifying the safety and quality of their products, and ensuring that such products are farmed in compliance with national or international management requirements, and meeting with the national security and public safety objectives.

2.4 Cross-cutting Issues

2.4.1 Fish Utilization and Trade

In order to enhance the contribution of capture fisheries to food security, there is a need for improved utilization of the catch, *e.g.* management of low-value fish or by-catch, and improved post-harvest handling to minimize losses and maximize utilization and economic returns. These efforts would help in increasing the portion of fisheries production meant for human consumption in the future.

Issues on safety and quality of fish and fishery products are also equally crucial that need to be addressed appropriately. While several emerging standards and requirements that ensure the safety and quality of fish and fishery products are in place, particularly those intended for export, the region should also consider developing the ASEAN standards in line with relevant regional and international instruments such as the Rules of Procedure of the Codex Alimentarius Commission and the Agreement on the Application of Sanitary and Phytosanitary Measures or SPS Agreement. The respective countries should also continue to establish their respective national systems and build up their capacity in conducting analysis for chemical and drug residues as well as biotoxin substances in fish and fishery products to ensure that these fish products whether meant for export or domestic consumption, meet the quality and safety requirements.

2.4.2 International Fisheries-related Issues

The region's fisheries sector has been bearing the brunt from the listing of several commercially-exploited aquatic species into the CITES Appendices, *e.g.* basking shark, great white shark, whale shark, humphead wrasse, European eel, oceanic whitetip shark, porbeagle shark, manta rays, and three species of hammerhead sharks. During the CoP17-CITES in 2016, additional species have been approved for listing, *e.g.* silky shark, thresher shark, devil rays, and clarion angelfish. In the future, other aquatic species could be proposed for listing in the CITES Appendices, *e.g.* Asian eels, sea cucumbers, and corals. It is therefore necessary to improve data collection on various commercially-exploited species in the region, to provide justifications for discussion at relevant international fora, *e.g.* CoP-CITES as and when necessary. Although mechanisms had been established to develop a common and coordinated position among the AMSs on the listings of commercially-exploited aquatic species, such mechanisms should be strengthened, particularly by seeking high-level endorsement of the said positions to be reflected by the respective countries during the CoP-CITES, as well as other relevant international and regional fora in the future.

2.4.3 Small-scale Fisheries

The Southeast Asian fisheries either in coastal or inland areas, which comprise very large numbers of small-scale fishers, provide significant contribution to food security and livelihood of people. Thus, adoption of the "Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication" or the "VGSSF Guidelines" could be very relevant to the region. The VGSSF was conceived based on the vision of eradicating hunger and promoting sustainable development as outlined in new FAO strategic framework. Such vision could be achieved through the promotion of human rights-based approach by empowering small-scale fishing communities including the men and women populations, to participate in decision-making processes and to assume responsibilities for sustainable use of the fishery resources. Nevertheless, application of the SSF Guidelines at the regional level needs to be designed to cater to the needs of small-scale fisheries in the Southeast Asian region.

2.4.4 Climate Change

Climate change is another important global issue that has created impacts on the fisheries sector either capture fisheries or aquaculture. For marine capture fisheries, the sub-sector is affected by rising sea temperature, sea-level rise as well as ocean acidification, with anticipated changes in recruitment, physiology, population dynamics, and ecology of various aquatic species and their ecosystems. Furthermore, more drastic weather conditions have also occurred, *e.g.* more intense storms that result in severe calamities to fishing communities along the coastal areas. Moreover, drastic changes in seasonal patterns have also been observed in inland areas during the past few years, *e.g.* longer or shorter rainy season and drought period, resulting in alterations in inland water bodies that affect inland capture fisheries. Measures to enhance the awareness of people that could be impacted by climate change and variability as well as mitigation approaches are therefore necessary and should be developed.

In the case of aquaculture, the major impacts could be from the changes in water regimes (caused by climate variability) resulting in shortage or excessive water runoff impacting inland aquaculture, as well as fluctuation of water salinity for brackishwater aquaculture. As it could also be presumed that cultured species are easily impacted by changes in water temperature, thus, research studies aimed to explore appropriate species that could adapt with anticipated changing temperatures should be carried out. Furthermore, efforts on low carbon development in the Southeast Asian region should also be explored and promoted, by minimizing the contribution of the fisheries sector (capture and culture) to greenhouse gas emission, with emphasis in proportioning energy efficiency and utilizing alternative energy sources wherever possible and appropriate.

PART IV
Appendices

APPENDIX 1. Policy Recommendations and Strategic Plans for Fishery Resources Enhancement in the Southeast Asian Region

I. Fishery Resources Enhancement through Habitat Improvement and Management		
Issues and Challenges	**Recommendations**	**Strategic Plans**
Artificial reefs management	▪ Best practices on installation of artificial reefs (ARs) should be promoted to ensure the protection of aquatic species during their life cycle and allowing them to reach optimum size. ▪ Planning and deployment of ARs should be undertaken, taking into consideration the following: • Clear purpose of ARs, *e.g.* resource enhancement; • Results from relevant feasibility studies, including cost-benefit analysis, socio-economic analysis, financial analysis, among others; • Involvement of researchers, policy makers, fishing communities, local government units, and other stakeholders in the planning process; • Results of site suitability evaluation, *e.g.* existing corals and fishes, seabed conditions, oceanographic conditions, and water circulation patterns; • Choice of AR design/s that should suit seabed conditions and purpose; and • Certainty that installed ARs do not pollute the marine environment. ▪ ARs should be regularly monitored (over time and seasonally) using appropriate parameters, *e.g.* conditions of ARs, primary productivity, abundance, and diversity of aquatic species (fish, macro benthos, etc.). The impacts of ARs on environmental conditions, *e.g.* water current, turbidity, and sedimentation among others should also be monitored. ▪ Regular monitoring and evaluation of the effectiveness of AR programs should be conducted (for short, medium, and long-term) by comparing various indicators before and after or within and outside ARs. Correlation of the abundance of species inhabiting the ARs and other environmental factors, *e.g.* bottom condition and water current and condition should also be established. ▪ Cost-benefit analysis of AR deployment programs should be conducted, taking into consideration the resources, environmental, and socio-economic benefits that could be gained from the programs. Data to be collected could include investment costs (ARs construction and deployment), fisheries production by fishing gear and fishers' incomes before and after ARs deployment, and other ecosystem services.	▪ Developing regional guidelines on best practices for installation of the artificial reefs (ARs)
	▪ Implementation of AR programs should be integrated with other fisheries management measures to ensure that resources are utilized in sustainable manner, *e.g.* fishing regulations that include among others, prohibition of encroachment of commercial fishing activities, and establishment of conservation and fishing zones. Stakeholders' consultations on the management of ARs should be conducted to elaborate responsibility of stakeholders and fishers in the management plan.	▪ Integrating fisheries management measures and principles in AR management programs
	▪ AR programs could be implemented in the coastal and offshore areas (if necessary) to ensure that the life cycle of both of demersal and pelagic species is sustained. ▪ A list of expertise on ARs and available resources should be compiled for reference and usage by the countries.	▪ Integrating ARs in policies and plans for coastal and offshore fishery resources conservation, management, and development
Integrating fisheries and habitat management	▪ Fisheries *refugia* could be implemented to complement the existing conservation and management measures, by integrating it with the fisheries objectives of protecting critical life cycle, *e.g.* spawning, nursing, broodstock aggregation, and migratory routes of species targeted for management.	▪ Promoting the establishment of fisheries *refugia* as a tool for integrating fisheries and habitat management

I. Fishery Resources Enhancement through Habitat Improvement and Management (Cont'd)		
Issues and Challenges	**Recommendations**	**Strategic Plans**
Integrating fisheries and habitat management *(Cont'd)*	▪ Selection of sites for fisheries refugia should be based on scientific information and local knowledge especially in identifying the areas that are natural habitats for critical stages of the life cycle of species targeted for management, *e.g.* spawning, nursery grounds, broodstock aggregation, and migratory routes. The area of the fisheries refugia should be manageable by concerned stakeholders. ▪ Regulations on fishing activities in the refugia (*e.g.* restriction of harvestable size, fishing seasons, and fishing gears and methods) should be enforced taking into account the up-to-date scientific data (*e.g.* spawning season, size at maturity, larval study), which should be relevant and correspond to the activities of host communities.	▪ Conducting scientific research programs and stakeholders consultation to support the identification of suitable sites and establishment of fisheries refugia for target species, and coming up with scientific evidence that harmonize with local knowledge to serve as basis for developing appropriate management measures
	▪ Community participation should be optimized for the establishment and management of fisheries refugia (*e.g.* identification of suitable sites, establishment and implementation of management measures including MCS) and collaboration with relevant government agencies at local and national levels should be strengthened so that the fisheries refugia could be as self-sustaining as possible.	▪ Ensuring the sustained participation of key stakeholders in the planning, sites selection and development of management measures for fisheries refugia.
	▪ Sub-regional cooperation should be strengthened for the establishment of fisheries refugia for management of transboundary species (*e.g.* Indo-pacific mackerels) that move across the EEZs of more than one country.	▪ Enhancing regional and sub-regional collaboration for the establishment of fisheries refugia system for transboundary fish stocks management
Degradation of habitats in the Southeast Asian region	▪ Fish habitat restoration priorities in different water resources in the region should be reviewed.	▪ Making habitat restoration a priority at national levels
	▪ Effectiveness of habitat restorations and resource enhancement in inland water resources such as lakes should be determined through the following methodologies: • Conduct of baseline studies • Harmonization of legal and juridical mandates of authorized agencies, including local governments responsible for water resources • Pooling of government funds and resources • Mobilization of local communities and/or other stakeholders • Application of technical tools to reconstruct the fisheries • Improvement of buffer zones ▪ Habitat restoration should be implemented through suitable co-management arrangements taking into consideration the importance of the ecosystem ▪ The "Satoumi Concept" could be considered as one of the Integrated Coastal Management approaches for habitat restoration. Developed by Japan, the "Satoumi Concept" is a form of unified management system for land and sea, where management mechanisms for coastal waters move inland, one step away from integrated coastal management so that land and sea are brought under a unified management policy. In short, the "Satoumi Concept" is meant for environmental conservation of coastal areas in harmony with human interaction on land.	▪ Developing the best practice guidelines on habitat restoration for different water resources such as inland and marine, in conjunction with fishery resources enhancement programs.
	▪ Enhancement of fish populations in restored habitats could be carried out by applying appropriate techniques such as installation of ARs, establishment of fisheries refugia, etc.	▪ Rebuilding sustainable fish populations in restored habitats
	▪ Since indigenous knowledge is crucial for habitat restorations, applicable only in most cases for specific areas and the culture of local communities, science and indigenous knowledge should be combined to ensure the effectiveness of habitat restorations.	▪ Undertaking baseline studies based on indigenous and scientific knowledge
	▪ Impact assessment of lost natural habitats (*i.e.* coral reefs, seagrass, and sea beds) due to human activities (irresponsible fishing or pollution) should be conducted as well as raising the awareness of stakeholders on the importance of habitats to humans and fishes.	▪ Conducting impact assessment of lost natural habitats, and raising the awareness of stakeholders on conservation and protection of the natural habitats

II. Fishery Resources Enhancement through Artificial Propagation and Stock Release		
Issues and Challenges	**Recommendations**	**Strategic Plans**
Potentials and limitations of stock enhancement and restocking		
▪ Selection of species and release area considerations • Lack of species and site specific protocols and guidelines for successful stock enhancement and restocking • Techniques (specific to stock enhancement) for ex-ante impact assessment and monitoring (biological, environmental, social, and economic) are not available ▪ Strategy to ensure sustainability of activities and benefits achieved from stock enhancement is not yet developed ▪ Although benefits from stock enhancement and restocking are urgently needed and appreciated, the technical capabilities and financial resources of most Member Countries could be limited	▪ Stock enhancement and restocking activities should take into consideration the following: • Development of species-specific and site-specific strategies to ensure success of activity; - Give high importance to availability of scientific information and biology of the target species - Ensure appropriate choice of species – benthic over pelagic and migratory species - Provide adequate preparation and rehabilitation of receiving habitats to ensure likelihood of success - Give preference to marine reserves as release sites for managed monitoring and harvesting • Active involvement of the local people (especially the fisherfolks) in the planning, implementation, and monitoring activities, with understanding that the objectives of the activity and its long-term sustainability will largely depend on their continuous active involvement and participation; • Well-defined governance arrangements, and access and harvest rights through consultations with various stakeholders in enhancement and restocking activities; • Conduct of cost-benefit analysis of release and stock enhancement activities; • Implementation of long-term planning with all stakeholders to ensure availability of sufficient funds and manpower resources; • Participation of the local government units and their assured commitment to adopt and sustain stock enhancement initiatives (with donor funds) beyond project completion date; • Creation of supplemental and alternative livelihood strategies to encourage fisherfolks' participation and compliance to regulations; • Promotion of multi-stakeholder involvement and embedding conflict management in all phases of stock enhancement activity (including planning for and prioritizing a bottom-up approach in policy and regulation formulation); • Implementation of regulations and networking with enforcement agencies for protection of released stocks and management of recaptures; and • Implementation of activities, in conjunction with other management and conservation measures, to ensure that resources are utilized in sustainable manner.	▪ Developing regional guidelines or criteria for feasibility assessment and improvement and disseminating the Guidelines to Member Countries *[**Note:** the Guidelines will take into consideration the elements for higher success of restocking and stock enhancement covering the technical (choice of species, biology of species, sustainable supply of quality seeds and stocks), environmental (suitability of site), social and institutional (involvement and strong support of local communities, local government agencies, and research institutions), and economic aspects (funds)].* ▪ Formulating a "Strategy or Framework for Sustainability of Stock Enhancement Initiatives" and disseminating this Framework to Member Countries
Release strategies and ecological interaction with natural stocks		
▪ Lack of release protocols and guidelines (specific to stock enhancement)	▪ Assess the initial status of the community structure of the release site and monitor over time to determine the effects of interaction with the released stocks ▪ Determine the appropriate size of release of stocks to ensure high survival, avoidance of predators, and economic efficiency ▪ Conduct proper behavioral conditioning of stocks prior to release ▪ Promote regular and long-term continuous monitoring to determine effectiveness ▪ Develop effective marking techniques for stock enhancement • Determine appropriate tags for proper identification of released stocks and for effective long-term monitoring	▪ Establishing protocols and guidelines based on scientific findings and in accordance with existing policy instruments and regulations ▪ Implementing effective institutional frameworks, policy instruments for the release of stocks, monitoring, and enforcement mechanisms at national and local levels
▪ Capacity of Member Countries on ecological risk assessment and effective monitoring needs to be assessed and strengthened	▪ Based on needs of Member Countries, enhance their capacity on the application of decision-making tools for stock release (*e.g.* ecological risk assessment tool)	▪ Developing and implementing capacity building programs on the application of decision-making tools for stock release

II. Fishery Resources Enhancement through Artificial Propagation and Stock Release (Cont'd)		
Issues and Challenges	**Recommendations**	**Strategic Plans**
Aquaculture-based enhancement and restoration		
Genetic, health, and biodiversity considerations • Indiscriminate stocking or translocation of non-indigenous species or stocks poses adverse genetic and health risks	Importance of the genetic and health information of species should be well recognized to minimize genetic effects, transfer of diseases, and protect biodiversity	Formulating mechanism that will ensure that stocks for release are healthy and disease-free (for instance, through health certification) and will not pose genetic risks Strengthening information, education and communication (IEC) activities to enhance public awareness on genetic and health risks related to stock release and the need for precautionary measures following relevant Guidelines developed and promoted by FAO
Lack of seed production techniques and facilities intended for enhancement and restocking activities	Increase government investments and solicit donor contributions for aquaculture R&D and related facilities to support wide-scale and high-impact stock enhancement and restocking initiatives	Fostering strong collaboration among R&D institutions, national and local government, and local communities on initiatives that will support wide-scale and high-impact stock enhancement and restocking initiatives

APPENDIX 2. Summary of Issues and Recommendations on the Use of Alternative Protein Sources as Feed Ingredients in the Diet of Aquaculture Species classified as Herbivores, Carnivores, and Omnivores (Catacutan *et al.*, 2015)

FOR HERBIVORES (*e.g.* milkfish, carps, and barbs)
(Herbivores are those that feed on a significant amount of plant materials in their diet)

Issues:
- o Lack of information on alternative feed ingredients from plant-based sources
- o Some alternative ingredients are not available locally in many countries in the region
- o Presence of anti-nutritional factors that affect the nutritional value of many alternative ingredients from plant sources
- o Incomplete information on proximate composition of many alternative ingredients from plant sources
- o Limited study on the feed and feeding of herbivorous species
- o Poor digestibility of many plant protein ingredients
- o Low efficiency of feeds, *i.e.* high feed conversion ratio

Recommendations:
- o Compile and disseminate information on available alternative plant products; facilitate exchange of information both within and outside ASEAN
- o Define and apply strategies that will encourage production of locally available alternative ingredients
- o Create and implement policies that will facilitate the outsourcing of other alternative ingredients
- o Enhance research and development efforts in processing to improve the nutritional value of the alternative ingredients
- o Conduct profiling or characterization of the alternative ingredients
- o Continue research and development to improve the efficiency of feeds, particularly on the feed conversion ratio (FCR)
- o Strengthen collaboration among the government sector (particularly the policy makers), research and development institutions, and the private sector

FOR CARNIVORES (*e.g.* catfish, snakehead, sea bass, grouper, and black tiger shrimp)
(Carnivores require a significant amount of animal-based ingredient in their diets and focus could be made on three groups of aquatic animals –freshwater fishes (catfish, snakehead), marine fishes (sea bass, grouper) and crustaceans (black tiger shrimps))

Freshwater fishes

Catfish (*Clarias* sp.)

Issues:
- o Small-scale farmers are still dependent on on-farm feeds
- o Official data on actual utilization of imported and local fish meal in feed formulation are not available; feed companies usually do not release the details of content of fish meal in commercial formulated diets.

Recommendations:
- o Conduct research on feed development for catfish, particularly on nutrient requirements and protein source substitution (with emphasis on the use of alternatives to fish meal)
- o Refine existing technology on formulation of catfish feed
- o Facilitate sharing of information for further development of feeds

Snakehead (Channidae)

Issues:
- o Farmers rely mainly on trash fish as feed source; about 15% of fish meal are included in aquafeeds
- o Most feed ingredients are imported; some governments regulate the growing of plant-based protein sources such as soybean

Recommendations:
- o Promote to farmers the use of pellet feed instead of trash fish
- o Conduct further studies to clarify the requirements of fish meal in snakehead diets
- o Encourage farmers to grow plants which have potential use as feed ingredients

Marine fishes

Sea bass (Serranidae)

Issues:
- o Sea bass cultured in freshwater and seawater have varying nutrient requirements
- o Commercial feed (> 43% CP) for this species is readily available in some countries such as Thailand and Viet Nam; however, data on actual utilization of fish meal are not available
- o Lack of diets for broodstock (specifically for freshwater and seawater culture)
- o Most feed ingredients used in formulation are imported

Grouper (*Epinephelus* spp.)

Issues:
- o Lack of research on suitable larval feeds
- o Commercial feeds have at least 30% of imported fish meal; heavy reliance on trash fish in feeding grouper
- o Commercial feeds (46-50% CP) for this species readily available in Indonesia but data on actual utilization of fish meal are not available

Recommendations
- o Conduct research to determine suitable larval feed for grouper and suitable broodstock diets for sea bass cultured in freshwater and seawater
- o Conduct research and development on fish meal substitution for sea bass and grouper diets
- o Enhance collaboration among government, R&D institutions, feed industry, and farmers on initiatives related to development of good quality feed and protein source substitution

Crustaceans

Black tiger shrimp (*Penaeus monodon*)

Issues:
- o Reliance on both local and imported feeds but there is an increasing dependence on imported fish meal in shrimp feed production
- o Lack of diets specific for broodstock
- o Lack of high quality alternative protein sources for use in aquafeed formulation

Recommendations:
- o Conduct research and development on fish meal substitution for shrimp diets
- o Conduct research to determine suitable diets specific to shrimp broodstock

FOR OMNIVORES *(Pangasius,* tilapia*)*
(Omnivores feed on mixed plant and animal diet)

Issues:
- o Need additional potential alternative protein sources
- o Limited information on quality of alternative ingredients
- o Lack of information on economic feasibility of use of alternative ingredients that can replace fish meal
- o Inclusion levels of peanut meal in feeds for tilapia are not known
- o Different strains of genetically improved tilapia have varying responses to alternative protein sources
- o Small-scale farmers lack information and knowledge on proper utilization of feed

Recommendations:

- o Improve post-harvest and/or processing technology to enhance the quality and nutritional value of alternative ingredients (*e.g.* peanut meal); research collaboration to address the issue could be on determination of the nutritional value of the new or improved ingredients (*e.g.* amino acid analysis)
- o Conduct national assessment of ingredients in each country in terms of availability, sourcing, sustainability, and cost effectiveness, which will lead to selection of specific ingredients in the country
- o Promote mass production of protein sources and ingredients that are found appropriate after each assessment by country
- o Establish and enhance collaboration with the agriculture sector for the mass production of alternative protein source ingredients
- o Determine optimum inclusion levels (for peanut meal and also for soybean meal) and response of the species in terms of growth and meat quality
- o Generate information on nutrient digestibility of genetically improved strains of tilapia; can be jointly done by institutions with appropriate facilities and expertise
- o Disseminate information to farmers through training programs for extension officers, distribution of information materials, etc.
- o Conduct demonstration or field trials for use of traditional feeds, especially on the use of new alternative ingredients; should involve the cooperation of farmers, extension workers, and feed millers

APPENDIX 3. Aquatic Species Farmed in Southeast Asian Countries and Sources of Seedstocks

Country	Species	Sources of Seedstocks
Brunei Darussalam	Tilapia (*Oreochromis* sp.), giant freshwater prawn (*Macrobrachium rosenbergii*), sea bass (*Lates calcarifer*), grouper (*Epinephelus* spp.), snapper (*Lutjanus* spp.), shrimps (*Penaeus monodon*, *Litopenaeus stylirostris*), trevally (Carangidae)	• Hatchery-bred for most species except for trevally, but if insufficient, certified seedstocks are imported from Malaysia, Indonesia, Thailand, and Philippines (Metali, 2011)
Cambodia	***Indigenous species:*** Pangasiid catfishes (*Pangasianodon hypophthalamus*, *P. bocourti*, *P. larnaudii*, *P. conchophilus*), red tail catfish (*Hemibagrus wyckiode*), snakeheads (*Channa micropeltes*, *C. striata*), silver barb (*Barbodes gonionotus*), saltan fish (*Leptobarbus hoeveni*), marble goby (*Oxyeleotris marmorata*), climbing perch (*Anabas testudineus*), red tailed tinfoil (*Barbodes altus*), grouper (*Epinephelus* spp.), seabass (*Lates calcarifer*), snapper (*Lutjanus malabaricus*), tiger shrimp (*Penaeus monodon*), seaweed (*Eucheuma cottonii*) ***Exotic species:*** Nile tilapia (*Oreochromis niloticus*), carps (*Hypophthalmichthys molitrix*, *Cyprinus carpio*, *Aristichthys nobilis*, *Ctenopharyngodon idella*, *Cirrhina mrigal*), and hybrid clariid catfish (*Clarias* spp.)(Lang, 2015)	• Seedstock for all of the indigenous species are sourced from the wild (Great Lake, Tonle Sap rivers, Mekong River, coastal areas, etc.) except for the P. hypophthalmus, B. gonionotus, L. hoeveni, A. testudineus, B. altus which can be procured from hatcheries • Apart from wild sources, seedstock of grouper, sea bass, snapper and seaweeds are imported • Imported seedstocks come from Viet Nam and Thailand for freshwater species • Indonesia and Taiwan are sources for imported marine species seedstocks • For all exotic species, seedstocks are mainly hatchery-bred (Lang, 2015)
Indonesia	Catfish (*Clarias batrachus*, *Pangasius* sp.), tilapia (*Oreochromis* sp.), carp (*Cyprinus carpio*), gourami (*Osphronemus goramy*), giant freshwater prawn (*Macrobrachium* spp.), shrimps (*Penaeus monodon*, *P. vannamei*), milkfish (*Chanos chanos*), grouper (*Epinephelus* sp., *Cromileptis altivelis*, *Plectropomus* sp.), sea bass/barramundi (*Lates calcarifer*), mullet (*Mugil* spp.), snapper (*Lutjanus* spp.), crabs (*Scylla* sp., *Portunus* sp.), shellfish (abalone, pearl oyster), seaweeds (*Eucheuma cottonii* and *Gracilaria* sp.)	• Hatchery-bred but the supply is still insufficient, hence, some seedstocks are imported or collected from the wild • 240 grouper backyard hatcheries; 1820 milkfish backyard hatcheries (Sugama, 2011)
Lao PDR	Chinese carps (bighead (*Hypophthalmichthys nobilis*), silver (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*)), Indian major carps (rohu (*Labeo rohita*), mrigal (*Cirrhinus cirrhosus*)), common carp (*Cyprinus* carpio), catfish (*Clarias macrocephalus*), barb (*Puntius gonionotus*), and indigenous species, *e.g. Cirrhinus microlepis*, *Morulius chryzophecadion*	• fingerlings are produced in 30 government stations and 33 small-scale private hatcheries (Roger, 2011)
Malaysia	16 marine fish species (including sea bass, grouper and snapper), 4 marine shrimp species (including *P. monodon* and *P. vannamei*), mollusks (blood cockles, green mussels, oysters), seaweeds (*Kappaphycus alvarezi*), giant freshwater prawn (*Macrobrachium* spp.), mud crabs (*Scylla* spp.), 15 freshwater species (including catfishes *Clarias* sp. and *Pangasius* sp., as well as Nile and red tilapia (*Oreochromis* sp.)	• Hatchery bred • Mollusks, giant freshwater prawn, and mud crabs are wild sourced (Hassan *et al*. 2011)
Myanmar	Rohu (*Labeo rohita*), tilapia (*O. mossambicus*), common carp (*Cyprinus carpio*), striped catfish (*Pangasius hypophthalmus*), sea bass (*Lates calcarifer*)**, red snapper**, grouper (*Epinephelus coioides*, *E tauvina*)**, seaweeds (*Eucheuma cottonii*), mud crab (*Scylla serrata*), tiger shrimp (*Penaeus monodon*), and giant river prawn (*Macrobrachium rosenbergii*)	• Hatchery-bred • sea bass, red snapper, and grouper are wild sourced prior to 2004 (Win 2011; *www.fao.org/fishery/countrysector/naso_myanmar/en*)
Philippines	Nile tilapia (*Oreochromis niloticus*), red tilapia (*Sarotherodon* spp.), Chinese carps (Cyprinidae), catfish (Clariidae), milkfish (*Chanos chanos*), shrimp (*Penaeus* spp.), mud crab (*Scylla* spp.), grouper (*Epinephelus* spp.), sea bass (*Lates calcarifer*), red snapper (*Lutjanus* spp.), pompano (Carangidae), rabbitfish (*Siganus* spp.), abalone (*Haliotis* spp.), sea cucumber (*Holothuria* spp.), and seaweeds (*Garcilaria* spp., *Eucheuma* spp., *Kappaphycus* spp.)	• Hatchery-bred; some wild-sourced (Adora, 2011) • For milkfish, some seedstocks are imported from Indonesia
Singapore	Asian sea bass (*Lates calcarifer*), grouper (*Epinephelus* and *Plectropomus* spp.), snapper (*Lutjanus* spp.), pompano (Carangidae), trevally (Carangidae), mullet (Mugilidae), milkfish (*Chanos chanos*), saline tilapia (*Oreochromis* spp.), Pacific oyster (*Crassostrea* spp.), lobster (*Panulirus* spp.), green-lipped mussel (*Perna viridis*), giant snakehead (*Channa micropeltes*), freshwater tilapia (*Oreochromis* sp.), marble goby (*Oxyeleotris marmorata*), and catfish (Clariidae)	• Hatchery-bred for some species • Seedstocks are imported from Indonesia, Malaysia, Philippines, and Taiwan
Thailand	Tilapia (*Oreochromis* spp.), common carp (*Cyprinus carpio*), silver barb (*Barbonymus gonionotus*), snakeskin gourami (*Trichogaster pectoralis*), striped snakehead (*Channa striata*), striped catfish (*Pangasionodon hypophthalmus*), Clariid catfishes, giant freshwater prawn (*Macrobrachium* spp.), marine shrimps (*P. vannamei*, *P. monodon*, *P. merguensis*), green mussel (*Perna viridis*), arc shell (*Anadara* spp.), oyster (*Crassostrea* spp.), sea bass (*Lates calcarifer*), groupers (*Epinephelus* spp.), snapper (*Lutjanus* spp.)	• Private hatcheries especially for freshwater aquaculture seedstocks • Sea bass seeds from government and private hatcheries • Grouper and snapper are mostly from wild seeds (Yashiro *et al*., 2011)
Viet Nam	Black tiger shrimp (*Penaeus monodon*), Mekong Pangasius (*Pangasianodon gigas*), tilapia (*Oreochromis* spp.), Chinese and Indian carps, and giant freshwater prawn (*Macrobrachium* spp.)	• Seeds produced by breeders from five national broodstock centers (under research institutes: RIA 1,2,3) and provincial hatcheries (Luu, 2011) • Sometimes imported seeds are used but imported stocks undergo strict quarantine and quality control (Hishamunda *et al*., 2009)

APPENDIX 4. Genetic Improvement Programs for the Production of Quality Seeds for Aquaculture

Genetic Program and Method	Technology and Product Generated	Southeast Asian Countries where it was developed* and/or available
Nile tilapia		
Genetically improved farmed tilapia (GIFT) program: Combined family and within family selection for improved growth	GIFT Technology/GIFT strains (11th generation GIFT, GIFT Malaysia)	Philippines*, Malaysia
Genomar Project: Combined selection for improved growth, marker assisted selection	GST Technology/Genomar Supreme Tilapia (GIFT-derived stock)	Philippines*
GET-Excel Program: Outcrossing two fast-growing strains (FAST and GIFT) for improved growth	GET Excel Technology/GET Excel and iExCEL or improved GET Excel stocks	Philippines*
Genetically Male Tilapia (GMT) Program: Selective breeding, sex reversal methods	GMT Technology or YY supermale technology/GMT or YY strain	Philippines*, Thailand
Brackishwater Enhanced Selected Tilapia (BEST) Program: Hybridization and outcrossing; Size-specific selection	BEST Technology/Salt-tolerant BEST tilapia strain, improved BEST or iBEST	Philippines*
Cold Tolerant Tilapia Hybridization	Cold Tolerant Tilapia	Philippines*
Freshwater Aquaculture Center Selected Tilapia (FAST) Program: Rotational mating; Hybridization	FAST tilapia	Philippines*
Molobicus or SaltUno project: Hybridization to produce salt-tolerant tilapia	SaltUno strain	Philippines*
BEST 200 Project: Size specific selection	BEST 200	Philippines* (private sector initiative)
Red tilapia		
Interspecific hybridization; conventional breeding of red tilapia for propagation	Red tilapia strains (Philippines, Taiwan, and Thailand strains)	Philippines*, Taiwan*, Thailand*, Malaysia, Indonesia
Carps		
Common carp (*Cyprinus carpio*) Combined selection (four generations family selection with quantitative genetic analysis) for improved growth	Freshwater Fisheries Research Center (FFRC) strain	Freshwater Fisheries Research Center, Wuxi, China (Dong, 2016)
Indian major carp rohu (*Labeo rohita*) Combined selection (eight generations) for improved growth, disease resistance (vs *Aeromonas hydrophila*)	Jayanti rohu	Central Institute of Freshwater Aquaculture, Odisha, India (Mahapatra *et al*., 2016)
Jullien's golden price carp (*Probarbus jullieni*) Molecular biology and genetic engineering techniques	Cryopreserved sperm for planned breeding	Malaysia*
Catfishes (*Clarias* spp.)		
Mass selection, within family selection (*Clarias macrocephalus*) for fast growth, disease resistance (against *A. hydrophila*) Molecular marker-based genetic variation in farmed and wild stocks	Except for improved strain developed in Pitsanulok FTRC, Department of Fisheries, Thailand, no improved strain identified; however, 4th and 2nd generation *C. macrocephalus* used in growth improvement (Jarimopas *et al*., 1990; Komainprairin *et al*., 2004) and strain used in *A. hyrdophila* disease resistance (Na-Nakorn *et al*., 1994) were produced	Thailand (not disseminated but used only for research purposes; Na-Nakorn and Brummett, 2009)
Interspecific hybridization (*C. macrocephalus* × *C. gariepinus*; *C. batrachus* × *C. gariepinus*)	Clariid catfish hybrids	Philippines, Thailand
Giant freshwater prawn		
Broodstock management Strain evaluation	Best or improved strain with good growth and reproductive ability (in progress or already developed)	Philippines*, Thailand*, Malaysia, Viet Nam* (Thanh *et al*., 2009)
Selective breeding	Genetically improved *Macrobrachium* spp. (GI-Macro)	Indonesia*
Marine shrimps		
Selective breeding (*e.g.* family and mass selection) for fast growth and/or disease resistance (some programs are marker-assisted) Hybridization Genomics studies	High health shrimp stock (SPF/SPR) (*Penaeus monodon*, *Litopenaeus stylirostris*, *L. vannamei*) Markers related to disease resistance Thai strain SPF *P. monodon* both fast growing and WSSV disease resistant Thai strain *L. vannamei* resistant to both WSSV and Vibrio	Brunei Darussalam*, Thailand* (Withyachumnarnkul *et al*., and Songsangjinda in FAO 2016), Indonesia

Genetic Program and Method	Technology and Product Generated	Southeast Asian Countries where it was developed* and/or available
Marine fishes		
Grouper (*Cromileptis altivelis*, *Epinephelus fuscoguttatus*, *E. polyphekadion*, *E. coiodes*, *E. corallicola*, *E. tukula*, *E. lanceolatus*, *Plectropomus leopardus*) Genetic characterization using microsatellite markers	Thai and Indonesian orange-spotted grouper *E. coioides*; giant grouper (genetic profiling of Philippine stocks)	Indonesia, Philippines (ongoing)
Domestication, broodstock management, individual selection Interspecific hybridization	Purebreds (2nd generation *C. altivelis*, 3rd generation *P. leopardus*), fast growing and/or disease resistant hybrids (*E. fuscoguttatus* × *E. lanceolatus*, *E. fuscoguttatus* × *E. polyphekadion*)	Gondol Research and Development Institute for Mariculture (GRDIM), government and private hatcheries in Indonesia* (Sugama *et al*., 2016)
Milkfish (*Chanos chanos*) Genetic characterization of Philippine and Indonesian stocks using DNA markers Broodstock management	Genetic diversity databases (mitochondrial DNA and microsatellite DNA) for Indonesian and Philippine milkfish stocks Philippine stocks	Indonesia, Philippines
Asian Sea Bass (*Lates calcarifer*) Selective breeding for disease resistance	High health *L. calcarifer* stock to be developed	Malaysia*
Pompano (*Trachinotus blochii*) Mass selection Broodstock development and management	Ongoing mass selection and broodstock development and management	Philippines
Red sea bream (*Pagrus major*) Ploidy manipulation	Triploid red sea bream	Indonesia (based on experiments done in Japan; Sugama *et al*., 1992)
Shellfishes		
Abalone (*Haliotis* spp.) Genetic characterization Interspecific hybridization	Genetic diversity information on stocks in the Philippines (ongoing), Thailand Better (hybrid) stocks that are fast growing and have good carcass quality (in progress or developed)	Philippines*, Thailand*
Oyster Triploidy induction On-going research on genetic profiling (Philippines)	Triploid oysters produced	Malaysia*, Philippines
Mussel Asian green mussel (*Perna viridis*) hybridization	Ongoing project	Philippines
Seaweeds (*Eucheuma* spp., *Gracilaria* spp., *Kappaphycus alvarezii*, *Kappaphycus spinosum*)		
Genetic manipulation Conventional selection for disease resistance Tissue culture Marker-assisted selection Polyploidy Tissue culture Genetic profiling	Disease-resistant seaweeds Seaweeds with improved carrageenan quality	Malaysia*, Philippines*
Mud or mangrove crab		
Selective breeding (mass selection) Genetic profiling	Fast growing mud crabs with improved reproductive ability (in progress)	Philippines
Eels (*Anguilla* spp.)		
Stock survey and genetic profiling for different species	In progress (Indonesia), completed interspecific genetic analysis (Philippines)	Indonesia
Sea cucumber (*Holothuria scabra*)		
Broodstock development, mass selection	On-going	Philippines

APPENDIX 5. Technical and Non-technical Issues in the Production of Quality Seedstocks for Aquaculture in the Southeast Asian region Aquaculture

Problems	Species		
	Tilapia, carp, catfish, milkfish	Freshwater prawn, marine shrimps, mud crabs, seaweeds, abalone	High-value marine fish species (*e.g.* grouper), emerging species
Stock Availability			
1) Inadequate seed supply (hatchery-bred seeds)	Yes, especially for Clariid catfishes	Yes, especially for mud crabs	True for several species as domestication and hatchery protocols are currently being verified
2) Poor quality of hatchery-bred seeds	True for some species especially those produced from poorly managed broodstock	Slow growth, diseases in hatchery produced seeds	No indications as yet
3) Inadequate or no domesticated broodstock	Slightly inadequate domesticated Clariid catfishes (especially in the Philippines)	Inadequate	Inadequate, especially for some grouper species; none or very few for emerging species
4) Poor broodstock quality	Especially for dwindling and/or ageing stocks of domesticated species (*e.g.* milkfish) however this is currently being addressed through R&D	Matures at small size for mud crab and FW prawn; low PL survival for freshwater prawn and low fecundity for mud crabs, issues which are currently being addressed	No indications as yet; early stages of broodstock domesticated
5) Inadequate or no supply of genetically improved seeds	Especially for catfish and milkfish (currently being addressed through R&D)	Selection programs ongoing	None to date; no selective breeding program as yet
6) Poor, difficult, and expensive access to genetically improved stocks	Poor access particularly for carps	Expensive especially for specific pathogen-free (SPF) shrimp stocks	N/A
R&D Issues and Gaps			
1) Domestication and broodstock management	Continue especially with broodstock management	Need to implement efficient broodstock management	Need to domesticate and follow efficient broodstock management scheme
2) Genetic improvement	Continue producing improved breeds	Start developing; continue strain development in seaweeds	Could commence after successful domestication
3) Quality assessment method	No efficient practical method for quality assessment	Mainly for abalone; already developed especially for shrimps, prawns and seaweeds	No method for quality assessment developed
4) Disease management	Especially for catfish and carps	Genomic approaches are now being used to elucidate the mechanism in some shrimp diseases for a more effective shrimp health management	Vaccine R&D now being conducted for controlling or preventing diseases in high value marine species (for both broodstock and seedstock, if possible)
5) Feeding management (especially for broodstock and larval stages)	Continue research to address gaps	Continue research to address gaps especially in abalone	Intensify research for quality assessment developed
6) Environment management (need to adopt better management practices, biosecurity in farms)	Best aquaculture practices must be promoted in the production of all aquaculture species as a measure to prevent seedstock mortalities	This is of particular importance in marine shrimp seedstock production	Best aquaculture practices must be promoted in the production of all aquaculture species as measure to prevent seedstock mortalities
7) Socio-economic and legal issues (especially marketing of unselected and/or better seeds, formulate seed certification guidelines)	Should be addressed in marketing seedstock of all species	Should be addressed in marketing seedstock of all species	Should be addressed in marketing seedstock of all species

PART V
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