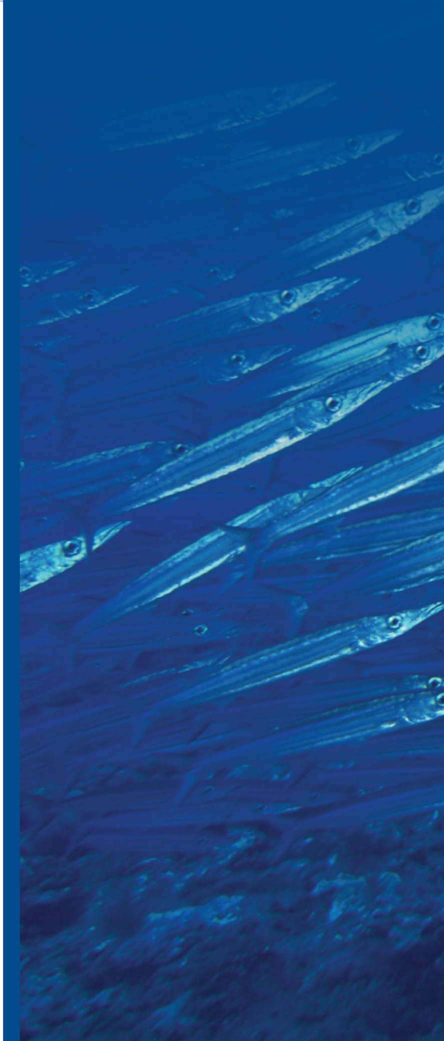
The Southeast Asian State of Fisheries and Aquaculture 2012





Southeast Asian Fisheries Development Center

Southeast Asian Fisheries Development Center (SEAFDEC)

What is SEAFDEC?

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

Mandate:

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

Member Countries:

Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam

The operations of SEAFDEC were undertaken through its Secretariat and four technical departments, namely: Training Department (TD); Marine Fisheries Research Department (MFRD); Aquaculture Department (AQD); and Marine Fishery Resources Development and Management Department (MFRDMD).

PREFACE

Information on status and trends of fisheries is widely recognized to be crucial in serving as a basis for sustainable development and management of fisheries. The "Resolution on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020" adopted during the ASEAN-SEAFDEC Conference in 2011 emphasized the necessity to "*strengthen knowledge/science-based development and management of fisheries*"; while the "Plan of Action" stressed the need 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*".

SEAFDEC throughout the past decades had undertaken several activities to compile various forms of fishery-related data and information. These include regional fishery statistics based on the national statistics data provided by the Southeast Asian countries, as well as other data and information from different SEAFDEC programs/projects, *e.g.* fishery resources surveys in the Southeast Asian waters, information collection of highly migratory species, deep sea fishery resources exploration, tagging of sea turtles and research study on their habitats, tagging of economically-important pelagic species, development and usage of practical indicators for sustainable development and management of capture fisheries, among others. However, the outputs from these initiatives had rarely been integrated or digested to come up with information that could be used to support development and management for sustainable fisheries of the region.

SEAFDEC therefore undertakes a pilot exercise in developing the publication entitled "**The Southeast Asian State of Fisheries and Aquaculture**" or "**SEASOFIA**" aiming to provide platform for compilation of synthesized data and information generated from various programs of activities, incorporating other data and information available in the region, in order to provide better understanding on the status and trends of fisheries and aquaculture of the region. Also included in the publication are selected fisheries-related issues/challenges and the outlook of fisheries and aquaculture, in order to raise awareness/preparedness and enhance the capacity of countries in the region in response to the issues.

This SEASOFIA 2012 is considered as our first step towards this direction. We do hope that you find the information in this publication useful in providing clearer picture and better understanding on the fisheries situation of the region; and could contribute to improving science-based policy planning and management of fisheries in order to achieve sustainable fisheries and enhancing the contribution from fisheries to food security in the years to come.

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Secretary-General
SEAFDEC

Preparation and Distribution of this Document

The Southeast Asian State of Fisheries and Aquaculture (SEASOFIA) was prepared by the Secretariat of the Southeast Asian Fisheries Development Center (SEAFDEC), in collaboration with the SEAFDEC Departments, namely: Training Department (TD), Marine Fisheries Research Department (MFRD), Aquaculture Department (AQD), and Marine Fishery Resources Development and Management Department (MFRDMD). The document is distributed to the SEAFDEC Member Countries and Departments, partner agencies, other fisheries-related organizations, as well as to the public to enhance the better understanding on status and trends of fisheries and aquaculture of the Southeast Asian region.

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List of Acronyms

ASEAN	Association of Southeast Asian Nations
AFCF	ASEAN Fisheries Consultative Forum
APFIC	Asia-Pacific Fisheries Commission
AQD	SEAFDEC/Aquaculture Department
AR	Artificial Reef
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
EAF	Ecosystem Approach to Fisheries
EC	The European Commission
EEZ	Exclusive Economic Zone
EU	The European Union
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
FOVOP	One Village, One Fishery Product
GLP	Good Laboratory Practices
GMOs	Genetically Modified Organisms
GMP	Good Manufacturing Practices
GR	Global Record of Fishing Vessels, Refrigerated Transport Vessels, & Supply Vessels
HACCP	Hazard Analysis and Critical Control Point
ILO	International Labour Organization
IMO	International Maritime Organization
IPOA-Fishing 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
JTEDs	Juvenile and Trash Excluder Devices
LBCRM	Locally-based Coastal Resources Management
MCS	Monitoring, Control and Surveillance
MFRD	SEAFDEC/Marine Fisheries Research Department
MFRDMD	SEAFDEC/Marine Fishery Resources Development and Management Department
MPA	Marine Protected Area
NGO	Non-governmental Organization
PPEs	Pre-processing Establishments
PSM	Port State Measures
RCCRF	Regionalization of the Code of Conduct for Responsible Fisheries

REBYC	FAO Program on Responsible Fishing Technologies and Practices, and By-catch Reduction Technologies and Change of Management
RFBs	Regional Fisheries Bodies
RFPN	SEAFDEC/Regional Fisheries Policy Network
RPOA-IUU	Regional Plan of Action to Promote Responsible Fishing Practices (including Combating IUU Fishing) in the Region
SCS	South China Sea
SEAFDEC	Southeast Asian Fisheries Development Center
SMEs	Small and Medium Enterprises
SPS	Sanitary and Phytosanitary
SSOP	Standard Sanitary Operating Practices
TD	SEAFDEC/Training Department
TEDs	Turtle Excluder Devices
TPEs	Traditional Processing Establishments
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environmental Programme
UNFSA	United Nations Fish Stock Agreement
VMS	Vessel Monitoring System
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western Central Pacific Ocean
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

Fish and fishery products are among the most important agricultural commodities providing significant contribution to the world's food security and economic development. Out of the total value of the global agricultural products reported at US$ 1,168.85 billion in 2009, fish or fishery products accounted for US$ 90.73 billion or about 8% of the total value (WTO, 2010). Aside from its contribution to the world's economies, fish and fishery products are also important source of protein for people worldwide and represent a significant part of the diets of peoples in many countries. From 2000 to 2009, the global fishery production had continuously increased from about 131.0 million MT to 145.1 million MT (**Table 1**) while the percentage of the production for human consumption also gradually rose from almost 74% to 81% (**Fig. 1**). It should however be noted that the increasing trend in total fishery production is mainly due to the increasing contribution from aquaculture sector, while the production from capture fisheries has gradually been declining. With the world's population increasing from 6.1 billion to 6.8 billion over the same period, the per capita fish consumption has also escalated (**Fig. 2**) and is expected to continue to rise particularly in the developing countries where the population and demand for food are continuously growing because of increased income and purchasing power for high value and quality food including food fish. In addition, the fishery sector with its ancillary activities which has expanded with increased numbers of people employed, significantly contributes to improved livelihoods and employment opportunities, as well as to the enhanced well-being of millions of peoples including those in the Southeast Asian region.

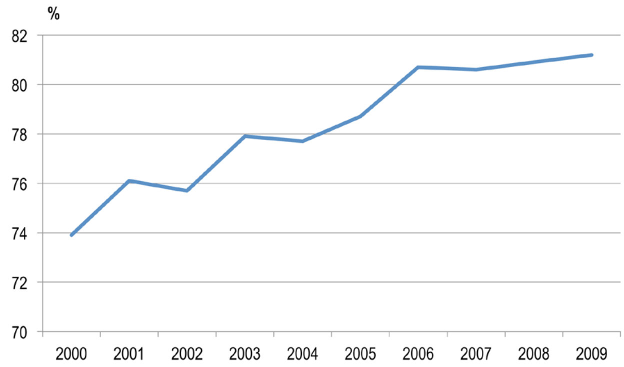

Figure 1. Percentage of fishery production used for human consumption from 2000 to 2009
Sources of data: *FAO State of World Fisheries and Aquaculture 2004 and 2010*

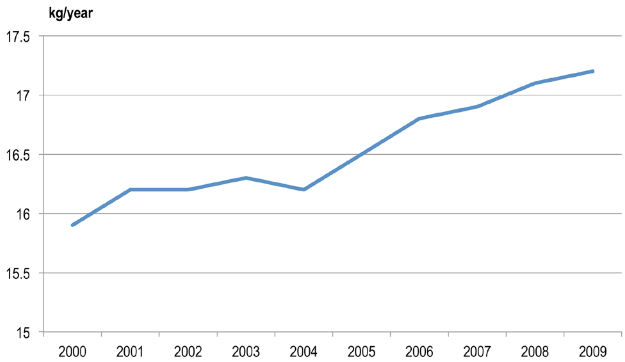

Figure 2. Global per capita fish consumption (kg/year) from 2000 to 2009
Sources of data: *FAO State of World Fisheries and Aquaculture 2004 and 2010*

The global fishery production by continent (**Table 2**) indicates that production from both capture fisheries and aquaculture during the period from 2000 to 2009 had been increasing at the rate of approximately 1.41 million MT per year. In the like manner, production from the Asian Continent (including Southeast Asia) also increased by

Table 1. World's fishery production and utilization from 2000 to 2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production (million MT)										
Capture	95.5	92.9	93.2	90.3	92.4	92.1	89.7	89.9	89.7	90.0
Aquaculture	35.5	37.8	39.8	41.9	41.9	44.3	47.4	49.9	52.5	55.1
Total	**131.0**	**130.7**	**133.0**	**132.2**	**134.3**	**136.4**	**137.1**	**139.8**	**142.3**	**145.1**
Utilization (million MT)										
Human consumption	96.8	99.5	100.7	103	104.4	107.3	110.7	112.7	115.1	117.8
Non-food uses	34.2	31.1	32.2	29.2	29.8	29.7	26.3	27.1	27.2	27.3
Population (billions)	6.1	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.8
% of production for human consumption (%)	73.9	76.1	75.7	77.9	77.7	78.7	80.7	80.6	80.9	81.2
Per capita fish consumption (kg)	**15.9**	**16.2**	**16.2**	**16.3**	**16.2**	**16.5**	**16.8**	**16.9**	**17.1**	**17.2**

Sources: *FAO State of World Fisheries and Aquaculture 2004 and 2010* about 1.96 million MT per year. Specifically in 2009, the Asian Continent remained the world's largest fish producer contributing about 66% to the world's total fishery production.

Moreover, the contribution of the Southeast Asian region to the total fishery production in 2009 was about 30% with respect to the Asian Continent's total production and 20% to the global fishery production. While the ten-year global fishery production seems to follow an increasing trend, some of the world's continents such as the Americas and Europe had been providing stable or gradually declining inputs but the contribution from Asia and the Southeast Asian region has continued to be steadily increasing and providing significant contribution to the rising fishery production of the world.

II. FISHERY PRODUCTION OF SOUTHEAST ASIA

The Southeast Asian region (**Fig. 3**) is bordered by the Andaman Sea and the Indian Ocean on the west, and the western part of the Pacific Ocean on the east. Although the region comprises 11 countries, namely Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Timor-Leste, Thailand and Vietnam; but, due to the inavailability of fishery statistics and information from Timor-Leste, the scope of this publication would focus mainly on the ten ASEAN Member Countries.

In terms of fishery statistics for both capture fisheries and aquaculture, fishery production of the countries in the Southeast Asian region is reported under FAO Fishing Area 57 (Indian Ocean, Eastern), 71 (Pacific, Western Central), 61 (Pacific, Northwest), and 04 (Asia, Inland Water). Based on such arrangement, the total fishery production of the Southeast Asian region from 2000 to 2009 is compiled by SEAFDEC from inputs of the countries and published in the Fishery Statistical Bulletin for the South China Sea Area 2000-2007 and the Fishery Statistical Bulletin of Southeast Asia 2008-2009, as summarized in **Table 3**.

The fisheries of the region are by nature tropical, multi-species and multi-gears, and involve large numbers of fishers and farmers mostly engaged in small-scale fishing operations and aquaculture practices. Indonesia consistently remains the highest producer of fish and fishery products from 2000 to 2009 with an average annual production increase of almost one-half of a million MT (**Fig. 4**). Vietnam which also recorded an increasing production trend of about 280,000 MT per year ranked the

Table 2. Fishery production by continent from 2000 to 2009 (million MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
World	**131.0**	**130.7**	**133.0**	**132.2**	**134.3**	**136.4**	**137.1**	**139.8**	**142.3**	**145.1**
Africa	7.3	7.7	7.6	8.0	8.2	8.4	7.9	8.1	8.4	8.3
Americas	27.6	25.2	26.4	23.2	27.9	26.5	25.1	24.6	24.5	23.6
Asia*	59.4	60.5	61.2	62.3	59.0	60.6	62.1	64.3	65.4	67.0
Southeast Asia**	**16.9**	**17.6**	**18.9**	**20.3**	**21.2**	**23.0**	**24.5**	**25.3**	**27.2**	**28.9**
Europe	18.6	18.4	17.6	17.0	16.4	16.2	15.9	15.9	15.4	15.9
Oceania	1.2	1.3	1.3	1.4	1.6	1.7	1.6	1.6	1.4	1.4

* *Excludes Southeast Asia*
** ***Sources:*** *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
Source of other data: *FAO Fisheries and Aquaculture Information and Statistics Service*

Table 3. Total fishery production of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	2,577	1,575	2,152	2,160	3,133	3,103	3,100	3,227	2,747	2,418
Cambodia	298,798	441,200	424,432	390,657	343,492	546,000	661,542	525,100	536,320	515,000
Indonesia	5,120,490	5,409,504	5,515,648	5,915,989	6,005,622	6,646,965	7,183,586	7,510,767	9,054,873	10,064,140
Lao PDR	71,000	81,000	93,000	95,000	95,000	107,800	107,800	91,660	93,500	105,000
Malaysia	*1,457,139**	1,411,740	1,467,486	1,483,957	*1,537,988**	*1,421,403**	*1,644,527**	1,654,221	*1,753,310**	*1,870,000**
Myanmar	1,309,830	1,474,460	1,606,240	1,987,020	2,148,580	2,581,780	2,817,990	2,808,037	3,147,605	3,491,103
Philippines	*2,993,332***	*3,166,528***	3,369,524	3,619,282	3,926,173	*4,161,870***	*4,408,472***	*4,711,252***	*4,966,889***	*4,079,977***
Singapore	9,984	7,784	7,795	7,109	7,579	7,837	11,675	8,026	5,141	5,687
Thailand	3,713,248	3,648,429	3,797,014	3,914,025	4,137,066	4,132,826	4,051,824	3,675,382	3,204,200	3,137,672
Vietnam	1,961,145	2,009,623	2,647,407	2,859,200	2,944,030	3,397,200	3,656,152	4,315,500	4,559,720	4,782,400
Total	**16,937,296**	**17,621,843**	**18,930,761**	**20,274,399**	**21,147,665**	**22,987,784**	**24,501,878**	**25,302,872**	**27,207,826**	**28,917,096**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figures provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

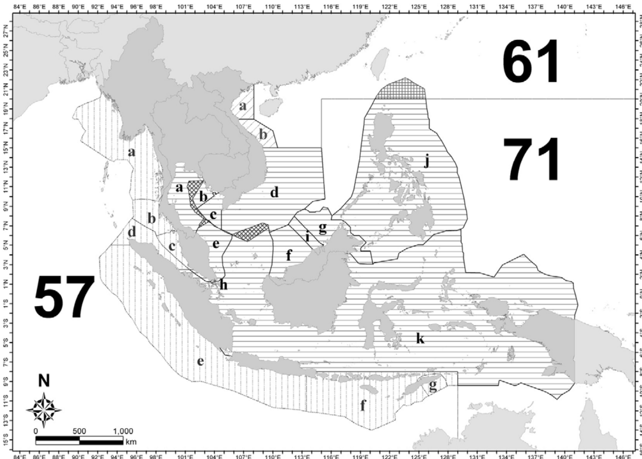

Figure 3. Map of Southeast Asia (above) with corresponding FAO Fishing Areas (below)

second with Myanmar and Philippines having production growth of about 200,000 MT per year placing third and fourth, respectively. Although Thailand's production was second after Indonesia in 2000, its production went through a see-saw pattern during the ten-year period until 2009 that landed the country into the fifth place in terms of total fishery production. From an increasing production growth of about 85,000 MT per year from 2000 to 2004, the fishery production of Thailand decreased from 2005 until 2009 at an average rate of about 200,000 MT per year.

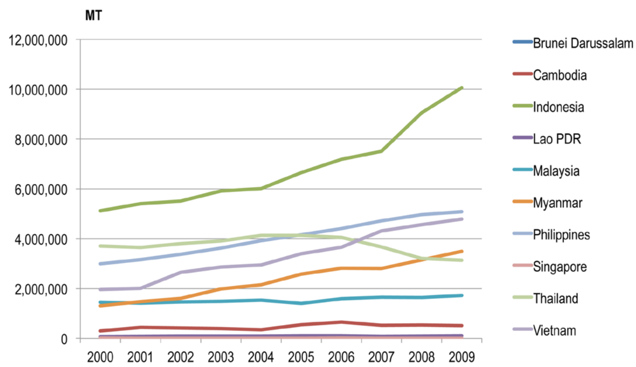

Figure 4. Fishery production of Southeast Asia by country

Table 4. Fishery production (quantity and value) of Southeast Asia by sub-sector in 2009

Sub-sector	Quantity (MT)	Value (US$ 1000)	Value (US$/MT)
Marine Capture Fisheries	14,140,387	10,416,661	737.00
Inland Capture Fisheries	2,397,273	2,834,477	1,182.00
Aquaculture	12,379,436	15,964,173	1,290.00
Total	**28,917,096**	**29,215,311**	

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

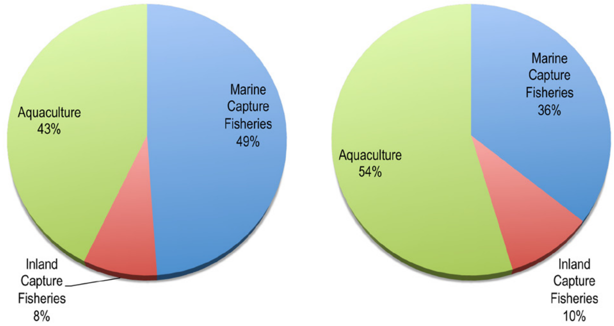

Figure 5. Percentage of Southeast Asia's fishery production by sub-sector in 2009 (left: by quantity; right: by value)

The fishery production of Malaysia also encountered ups and downs during the same ten-year period.

Fishery production of the Southeast Asian region comes from three sub-sectors, namely marine capture fisheries, inland capture fisheries, and aquaculture. **Table 4** which shows the total fishery production of the region by sub-sector in 2009 indicates that the largest portion of the production is derived from marine capture fisheries accounting for approximately 49% followed by aquaculture of about 43%, and inland fisheries 8% (**Fig. 5**). While marine fisheries contribute the largest volume of production, its production value which accounts for 36% of the total production value only comes next to aquaculture which contributes approximately 54% and that of inland capture fisheries was about 10%. While the value per metric ton of aquaculture production was about US$ 1,290/MT that of marine capture fishery production was only about US$ 740/MT.

III. MARINE CAPTURE FISHERIES PRODUCTION OF SOUTHEST ASIA

While the trend of the global marine capture fishery production seems to have slightly declined from 2000 to 2009 (**Fig. 6**), the production trend of the Southeast Asian region had been increasing at the rate of approximately 251,100 MT per year. In 2009, the Southeast Asian region contributed about 18% to the world's global production from marine capture fisheries.

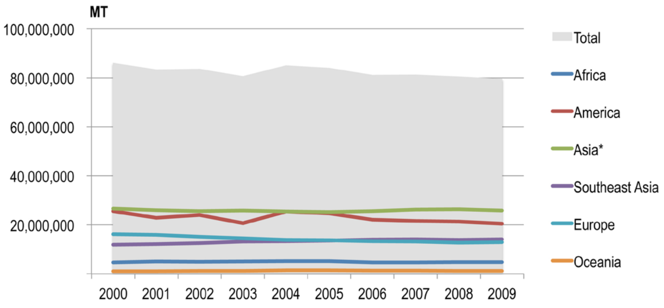

Figure 6. Global trend in marine capture fisheries production (* Asia excludes Southeast Asia)

The marine capture fishery production of the Southeast Asian countries in 2000-2009 (**Table 5**) indicated that Indonesia which is the largest producer accounting for 34% of the total production of the region in 2009. The Philippines which emerged as the second largest producer of the region contributed 17% to the total production of the region. After Indonesia and Philippines come Vietnam accounting for about 15% of the total production, Myanmar at 13%, Thailand at about 11%, and Malaysia at about 9% of the total production. Moreover, the volumes of the marine capture fishery production of Cambodia, Singapore and Brunei Darussalam represent less than 1.0% of the region's total production while Lao PDR does not produce any marine aquatic products being a landlocked country.

As mentioned earlier, the trend of marine capture fisheries production in the Southeast Asian region has been increasing from 2000 to 2009 at an average increase of about 251,000 MT per year. The countries that contribute to the increasing production trend include Indonesia, Myanmar, Vietnam, Philippines, Malaysia and Cambodia while in the case of Thailand although its production in 2000 was 2,773,665 MT it had some traces of ups and downs in certain years and finally decreased to 1,496,162 MT in 2009. Only small amount of production from capture marine fisheries had been reported by Singapore and Brunei Darussalam.

Specifically, Indonesia's increased production of 14 major groups of marine species that include marine fishes nei

Table 5. Production volume from marine capture fisheries in Southeast Asia by country from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	2,464	1,476	2,044	1,985	2,425	2,709	2,279	2,551	2,357	1,958
Cambodia	3,600	4,200	45,882	55,607	55,817	60,000	60,500	54,900	66,000	75,000
Indonesia	3,807,191	3,966,480	4,073,506	4,383,103	4,320,241	4,408,499	4,512,191	4,734,280	4,701,933	4,789,410
Lao PDR	…	…	…	…	…	…	…	…	…	…
Malaysia	*1,285,696**	1,231,275	1,272,078	1,283,256	1,331,645	1,209,601	*1,371,733**	1,381,424	1,394,531	*1,393,226**
Myanmar	949,670	1,026,460	1,060,250	1,132,340	1,220,030	1,375,670	1,525,000	1,485,740	1,679,010	1,867,510
Philippines	*1,740,309***	1,809,727	1,899,487	2,031,487	2,067,128	2,122,216	2,154,802	*2,328,149***	2,377,514	*2,413,863***
Singapore	5,371	3,342	2,769	2,085	2,173	1,920	3,103	3,522	1,623	2,121
Thailand	2,773,665	2,631,702	2,643,711	2,651,223	2,635,969	2,615,565	2,484,803	2,079,351	1,644,800	1,496,162
Vietnam	1,280,590	1,481,175	1,575,640	1,647,482	1,745,413	1,791,100	1,816,100	1,987,400	1,946,600	2,098,300
Total	**11,880,478**	**12,196,637**	**12,575,367**	**13,188,568**	**13,380,841**	**13,586,961**	**13,938,748**	**14,056,985**	**13,814,368**	**14,140,387**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figures provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

Table 6. Production value from marine capture fisheries in Southeast Asia by country from 2000 to 2009 (US$ Million)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	…	…	…	…	…	…	…	8	7	5
Cambodia	…	…	…	…	…	…	…	…	…	111
Indonesia	1,810	2,225	2,896	2,927	3,164	3,726	4,106	4,868	4,957	1,687
Lao PDR	…	…	…	…	…	…	…	…	…	…
Malaysia	*1,158**	*1,096**	*1,107**	1,056	*1,103**	*1,087**	*1,343**	*1,464**	*1,667**	*1,833**
Myanmar	…	…	…	…	…	…	…	…	1,585	3,081
Philippines	1,445	1,322	1,444	1,459	1,597	1,681	1,997	2,452	2,811	*2,650***
Singapore	11	7	6	6	6	6	111.5	14.3	8.6	10.4
Thailand	1,230	1,197	1,346	1,545	1,535	1,533	1,629	1,586	1,276	1,244
Vietnam	…	924	875	964	…	…	…	…	…	…
Total	**5,723**	**6,771**	**7,676**	**7,958**	**7,405**	**8,094**	**9,091**	**10,421**	**12,336**	**10,417**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
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(*Osteichthyes*), scad nei (*Decapterus* spp.), skipjack tuna (*Katsuwonus pelamis*), short mackerel (*Rastelliger brachysoma*), stelophorus anchovies (*Stelophorus* spp.), kawakawa (*Euthynnus affinis*), goldstripe sardinella (*Sardinella gibbosa*), yellowstripe scad (*Selaroides leptolepis*), Bali sardinella (*Sardinella lemuru*), and frigate tuna (*Auxis thazard*) among others, had contributed to the country's overall increasing production trend. On the other hand, although production from marine capture fisheries of Myanmar and Vietnam had not been classified by species, both countries recorded escalating production trend of marine fishes nei (*Osteichthyes*). In the case of Myanmar, its production is mainly from Area 57 in the Eastern Indian Ocean, while for Vietnam its production comes from Area 71 in the Western Central Pacific Ocean. For the Philippines, increased production of six major groups of marine species that include sardinellas nei (*Sardinella* spp.), skipjack tuna (*Katsuwonus pelamis*), scad nei (*Decapterus* spp.), yellowfin tuna (*Thunnus albacares*), frigate tuna (*Auxis thazard*), and bigeye scad (*Selar crumenophthalmus*) among others, contributed to the country's rising production from marine capture fisheries.

Although some Southeast Asian countries did not report the value of their production from marine capture fisheries, the total value of the region's marine capture fishery production from 2000 to 2008 seemed to have increased corresponding to the increasing trend of the volume of production, but eventually dropped in 2009 (**Table 6**). This could have been due to the drastic drop of the production values of Indonesia and Philippines during the same year. Although Myanmar reported the value of its production only in 2008 and 2009, such value increased by almost 200% between these two years.

While production from marine capture fisheries of Indonesia especially from 2008 to 2009 appears to have been increasing, the value of its production during the same period decreased by about 60%, which could be due to the decreasing values of the production of major species that ranged from 86% for marine species nei, 83% for barramundi (*Lates calcarifer*) and scad nei (*Decapterus* spp.), 81% for skipjack tuna, 80% for narrow-barred Spanish mackerel (*Scomberomorus commerson*), 78% for snappers nei (*Lutjanus* spp.), 77% for longtail tuna

Table 7. Production from marine capture fisheries of the Southeast Asian countries by species groups in 2009

Major species groups	Quantity (MT)										Value (US$ 1000)
	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam	Total	
Shads, milkfish, barramudi, etc.	2	…	87,520	16,773	…	3,553	25	54	…	107,927	42,075
Flounders, halibuts, soles, etc.	9	…	28,930	6,891	…	920	…	6,537	…	43,287	39,906
Red fishes, basses, congers, etc.	1	…	127,980	47,878	…	13,619	96	31,685	…	221,259	108,611
Jack, mullets, sauries, etc.	156	…	791,190	176,736	…	346,167	501	124,756	…	1,439,506	924,786
Herrings, sardines, anchovies, etc.	291	…	569,570	26,024	…	560,739	43	101,608	…	1,258,275	587,971
Tunas	182	…	925,660	56,012	…	612,008	2	47,490	…	1,641,354	1,218,040
Mackerels	578	…	1,258,490	409,517	…	699,498	243	401,564	…	2,769,890	1,990,401
Sharks and rays	87	…	98,750	26,278	…	14,354	278	18,105	…	157,852	174,101
Misc. fishes	493	55,460	401,607	412,878	1,867,510	16,920	460	543,077	1,572,100	4,870,505	3,548,806
Crabs	2	…	69,320	…	…	31,241	32	25,270	…	125,865	156,171
Lobsters	0.3	…	11,500	805	…	293	11	1,006	…	13,615	20,367
Shrimps, prawns, etc.	103	…	139,750	29,264	…	41,511		52,084	…	262,712	508,306
Misc. crustaceans	0.3	5,013	96,160	73,137	…	5,982	332	5,170	127,300	313,094	5,679
Oysters	…	…	333	…	…	…	…	…	…	333	712
Mussels	…	…	520	…	…	29	…	…	…	549	1,570
Cockles, clams, etc.	…	…	71,790	23,746	…	361	…	16,295	…	112,192	141,301
Cuttlefish, squids, etc.	51	…	100,680	81,136	…	70,361	97	112,815	…	365,140	929,808
Mollusks	…	14,527	3,060	…	…	…	…	4,681	…	22,268	3,902
Invertebrates	0.1	…	6,600	4,013	…	1,282		3,965	398,900	414,760	14,148
Total	**1,958**	**75,000**	**4,789,410**	***1,393,226****	**1,867,510**	**2,418,838**	**2,121**	**1,496,162**	**2,098,300**	**14,140,387**	**10,416,661**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figure provided by Fisheries Management Information Division, DoF Malaysia.*

(*Thunnus tonggol*), and 73% for yellowfin tuna (*Thunnus albacares*) among others.

In the case of the Philippines, while its production from marine capture fisheries also increased from 2008 to 2009, the corresponding values decreased by about US$ 500 million in 2009. This could have been brought about by a notable decrease in value of about 89% in marine fishes nei followed by slight decreases by 11 to 17% of the values of Indian mackerel (*Rastrelliger kanagurta*), skipjack tuna, yellowfin tuna, and scad nei (*Decapterus* spp.).

Specifically for 2009, production from marine capture fisheries of the Southeast Asian countries classified into species groups and reported in terms of quantity and value (**Table 7**), indicated that about 34% of the volume of the total marine capture production are from “Miscellaneous Fishes” although such volume was not recorded at more detailed species level. However, for some species that have been classified into major groups, the largest volume was provided by “Mackerels” followed by “Tunas”, “Jack, mullets, sauries”, and “Herrings, sardines, anchovies”. For the non-fish groups, the largest volume was derived from “Cuttlefishes, squids” followed by “Miscellaneous crustaceans” and “Shrimp, prawns”.

However, the highest value of the production per metric ton was that of the mussels at US$ 2,850/MT which were mainly produced by Indonesia and small quantity by the Philippines. This was followed by “Cuttlefishes, squids” at US$ 2,545/MT produced mainly by Indonesia and Thailand; oysters at US$ 2,140/MT from Indonesia; “Shrimp, prawns” at US$ 1,935/MT from Indonesia, Thailand, Philippines and Malaysia; lobsters at US$ 1,495/MT mainly from Indonesia and Thailand; crabs at US$ 1,240/MT from Indonesia, Philippines and Thailand; and sharks and rays at US$ 1,100/MT from Indonesia, Malaysia, Philippines, and Thailand.

3.1 Tunas

Tuna species which are important commercial fishery resources in the exclusive economic zones (EEZs) of the countries in Southeast Asia are taxonomically grouped into the family Scrombridae comprising about 50 species. The important tuna species in the region, in terms of production quantity and value, that are caught include the skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*), albacore tuna (*T. alalunga*), bluefin tuna (*T. thynnus*, *T. orientalis*, and *T. macoyii*), and the tuna-like species such as the long-tail tuna (*T. tonggol*), frigate tuna (*Auxis thazard*), bullet tuna (*A. rochei*), and kawakawa (*Euthynnus affinis*).

As of 2009, only six countries, namely: Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, and Thailand could provide their respective tuna production statistics by species and by gear type, while Cambodia, Myanmar and Vietnam, although generally known to be engaged to a certain extent in tuna fisheries, could not provide their respective current tuna statistics (**Table 8**).

Thus for the Southeast Asian region, the volume of tuna production in 2009 was about 6% of the region’s total fishery production and in terms of value, it contributed about 4%. However, the region’s tuna production accounts for about 12% in terms of volume of the region’s production from marine capture fisheries and also about 12% in terms of value. Indonesia is the leading tuna producer contributing about 56% of the region’s total tuna production with the Philippines coming next contributing about 37%, and then Malaysia and Thailand with more than 3%. Furthermore, although skipjack tuna (*Katsuwonus pelamis*) provided the highest production accounting for more than 34% of the total tuna production of the region, in terms of value bullet tuna (*Auxis rochei*) ranks first at US$ 1,245/MT (**Table 9**) followed by the southern bluefin tuna (*Thunnus*

Table 8. Tuna production of Southeast Asia by country and by species in 2009

Common name	Scientific name	Quantity (MT)						
		Brunei Darussalam	Indonesia	Malaysia	Philippines	Singapore	Thailand	All countries
Frigate tuna	*Auxis thazard*	0.03	135,200	*1,837**	152,338	...	...	**287,538.03**
Bullet tuna	*Auxis rochei*	...	5,310	...	...	...	...	**5,310.00**
Kawakawa	*Euthynnus affinis*	55	189,260	*19,123**	49,973	...	22,177	**282,424.60**
Skipjack tuna	*Katsuwonus pelamis*	80	300,740	4,460	251,524	2	7,532	**564,338.29**
Long-tail tuna	*Thunnus tonggol*	47	98,920	*27,569**	...	...	14,106	**140,634.31**
Albacore tuna	*Thunnus alalunga*	...	37,380	203	...	...	24	**37,607.00**
Southern bluefin tuna	*Thunnus maccoyii*	...	800	...	...	...	...	**800.00**
Yellowfin tuna	*Thunnus albacares*	...	103,390	1,403	152,437	...	1,189	**258,419.00**
Bigeye tuna	*Thunnus obesus*	...	54,660	*1,837**	5,736	...	2,462	**64,283.00**
Total		**182**	**925,660**	***56,432****	**612,008**	**2**	**47,490**	**1,641,354.23**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

Table 9. Total tuna production of Southeast Asia by FAO Fishing Area and by species in 2009

Common name	Scientific name	Quantity (MT)		Total (MT) All areas	Value (US$ 1000)	Ave Value (US$/MT)
		Fishing Area 57	Fishing Area 71			
Frigate tuna	*Auxis thazard*	55,170	232,368	287,538	237,449	825
Bullet tuna	*Auxis rochei*	4,460	850	5,310	6,599	1,245
Kawakawa	*Euthynnus affinis*	97,280	185,145	282,425	197,504	700
Skipjack tuna	*Katsuwonus pelamis*	63,782	500,556	564,338	336,390	600
Long-tail tuna	*Thunnus tonggol*	36,821	103,813	140,634	84,789	600
Albacore tuna	*Thunnus alalunga*	9,467	28,140	37,607	20,260	540
Southern bluefin tuna	*Thunnus maccoyii*	800	…	800	990	1,240
Yellowfin tuna	*Thunnus albacares*	26,183	232,236	258,419	293,437	1,135
Bigeye tuna	*Thunnus obesus*	20,217	44,066	64,283	40,622	630
Total		**314,180**	**1,327,174**	**1,641,354**	**1,218,040**	**740**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

maccoyii) and yellowfin tuna (*Thunnus albacares*) which is mainly produced by the Philippines. Frigate tuna (*Auxis thazard*) which ranks second in terms of tuna production in the region contributed about 18% to the region's tuna production but in terms of average value this species ranks only fourth at US$ 825/MT.

In terms of FAO Fishing Area, the region's tuna production in 2009 mostly came from FAO Fishing Area 57 (Indian Ocean, Western) and Area 71 (Pacific, Western Central) although production figures are mostly based on landings but not on fishing areas. In 2009, the average value of the total tuna production from Fishing Area 71 was about US$ 984 million accounting for 81% of the region's total tuna production value while the average value of production from Fishing Area 57 was about US$ 234 million providing the remaining 19%.

The species coming from Area 71 providing the highest production value is skipjack tuna followed by yellowfin tuna, frigate tuna, and kawakawa, while for Area 57 the species that provided the highest production value is kawakawa followed by frigate tuna and skipjack.

3.2 Sharks and Rays

In contrast with the tuna species, sharks and rays may not be considered as among the major marine fishery commodities of the Southeast Asian region. The species have been considered as non-target species of artisanal small-scale capture fisheries. Generally, landings of sharks, rays and skates comprise only a small percentage of the production from marine fisheries in the Southeast Asian region. Based on available data, production of sharks and rays by type of fishing gears indicated substantial amounts of sharks and rays caught by purse seine, gill net, hook and line, and trawl (SEAFDEC, 2006). In addition, small amount of sharks and rays was also caught by other gears such as traps, seine net, lift-net and push/scoop net but their catches were not significant in terms of quantity. However, it is widely known that the region has the highest diversity of species of sharks and rays, and that several species had been proposed for listing in the Appendices of the CITES during the past decade. Therefore, the compilation of fishery statistics on sharks and rays has become necessary in order to come up with a real picture of the resources in the region, but considering the dearth of information and data on production of sharks and rays in the region, information derived from relevant technical reports especially those that emanate from various relevant R&D activities on sharks and rays should also be availed of.

Based on the data from 2000 to 2009 reported in the SEAFDEC Fishery Statistical Bulletin of Southeast Asia, production of sharks and rays could range from 122,000 to 184,000 MT/year while the total marine capture fishery

Table 10. Contribution of sharks and rays to the total marine capture fisheries production of the Southeast Asian region from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total marine capture fishery production	11,880,478	12,196,637	12,575,367	13,188,568	13,380,841	13,586,961	13,938,748	14,056,985	13,814,368	14,140,387
Production of sharks and rays	167,459	165,551	166,543	184,382	167,604	150,811	155,941	148,932	128,262	122,381
Contribution of sharks and rays (%)	**1.41**	**1.36**	**1.33**	**1.40**	**1.25**	**1.11**	**1.12**	**1.06**	**0.93**	**0.86**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*

Table 11. Production of sharks of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	...	...	...	...	...	...	...	24	29	15
Cambodia	...	...	...	...	...	...	...	...	...	...
Indonesia	68,366	65,860	56,906	58,100	50,967	43,306	55,944	57,462	43,625	40,950
Lao PDR	...	...	...	...	...	...	...	...	...	...
Malaysia	7,948	8,663	8,226	8,696	8,299	9,165	*7,878**	7,684	*7,346**	*7,252**
Myanmar	...	...	...	...	...	...	...	...	...	...
Philippines	2,071	2,681	2,682	3,021	2,977	2,440	2,765	2,638	2,380	2,635
Singapore	43	32	30	17	31	23	38	42	17	20
Thailand	11,039	11,146	13,918	14,409	10,155	7,751	6,082	5,000	2,834	2,826
Vietnam	...	...	...	...	...	...	...	...	...	...
Total	**89,467**	**88,382**	**81,672**	**84,243**	**72,429**	**62,685**	**72,639**	**72,850**	**56,186**	**53,681**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*

Table 12. Production of rays of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	...	...	...	...	...	...	...	70	69	56
Cambodia	...	...	...	...	...	..	...	...	...	...
Indonesia	45,260	44,451	49,492	59,459	57,977	56,731	54,584	51,077	47,609	44,660
Lao PDR	...	...	...	...	...	...	...	...	...	...
Malaysia	16,573	16,532	15,941	19,253	16,754	15,929	*16,046**	14,079	*15,642**	*15,091**
Myanmar	...	...	...	...	...	...	...	...	...	...
Philippines	2,248	2,867	2,986	3,156	2,799	2,308	2,544	2,560	2,370	2,591
Singapore	261	187	162	140	154	164	195	180	117	143
Thailand	13,650	13,132	16,290	18,131	17,491	12,994	10,133	8,116	6,245	6,219
Vietnam	...	...	...	...	...	...	...	...	...	...
Total	**77,992**	**77,169**	**84,871**	**100,139**	**95,175**	**88,126**	**83,302**	**76,082**	**72,076**	**68,700**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*

production of Southeast Asia in 2009 was 14,140,000 MT. This means that less than 1.0% of the total production in 2009 was contributed by sharks and rays (**Table 10**). Specifically, the landings contribute only 1.6% for Malaysia (Ahmad, 2011), 2.2% for Indonesia (Faizah, 2011), and 0.7% for Thailand (Ratanawalee, 2011).

For sharks, the highest producer is Indonesia followed by Malaysia. Although Thailand was also a top producer of sharks in the early 2000s, its production started to decline in 2004 (**Table 11**). Likewise for rays, the main producer is Indonesia followed by Malaysia with Thailand's production declining since 2004 (**Table 12**). Production of the Philippines for both species had also been considerably high. However, records have shown that the overall production of sharks and rays of the region had been slightly decreasing. Even if some countries in this region such as Indonesia, Thailand, Malaysia, and Philippines, have recorded considerable production volume of sharks and rays, only Indonesia was able to report the production of sharks and rays at genus, family and order level as shown in **Table 13**. The other countries reported only the production by major species groups, which could be mainly due to limited ability of local officers in identifying the species of sharks and rays.

In terms of value, Indonesia's production of sharks in 2009 was valued at US$ 12,979,000 or at an average value of about US$ 315/MT, while for rays the total value was US$ 11,030,000 or an average value of about US$ 250/MT. As for Malaysia, the value of its production of rays was US$ 23,164,000 or an average value of US$ 1,540/MT although the production value of sharks was not reported. Likewise for Thailand, the value of its production of rays was US$ 4,736,000 or at an average value of about US$ 760/MT.

Despite the small contribution from sharks and rays to the total fishery production of the region, these commodities provide significant incomes for traditional fishers and serve as cheap source of protein for poor people in remote areas as well as coastal communities. Many products for human consumption could be derived from sharks and rays such as meat (fresh, frozen, smoked, salted) and fins (for the famous fishery product such as the shark fins). Other valuable products include oil (for cosmetics, squalene, pharmaceuticals, lubricants), skin (for food, leather goods,

Table 13. Production of sharks and rays by species and by fishing area of some Southeast Asian countries in 2009 (MT)

English Name	Scientific Name	Fishing Area	Indonesia's Production (MT)	Malaysia's Production (MT)	Thailand's Production (MT)	Philippines's Production (MT)
Thresher shark	*Alopias* spp.	57	6,230			
Thresher shark	*Alopias* spp.	71	2,430			
Hammerhead sharks	*Sphyrna* spp.	57	1,410			
Hammerhead sharks	*Sphyrna* spp.	71	2,060			
Dogfish sharks	*Squalus* spp.	57	2,150			
Dogfish sharks	*Squalus* spp.	71	2,500			
Mackerel sharks	Laminidae	57	140			
Mackerel sharks	Laminidae	71	530			
Requiem sharks	Carcharhinidae	57	2,550			
Requiem sharks	Carcharhinidae	71	20,950			
Sawfishes	Pristidae	57	10			
Sharks nei	Sharks			*7,252**	2,826	2,635
Sting rays	*Dasyastis* spp.	57	11,600			
Sting rays	*Dasyastis* spp.	71	24,270			
Rays, mantas	Rajiformes	57	-	*4,663**	3,141	
Rays, mantas	Rajiformes	71	-	*10,427**	3,078	2,591
Eagle rays	*Myliobatis* spp.	57	1,100			
Eagle rays	*Myliobatis* spp.	71	2,500			
Manta rays	*Mobula* spp.	57	170			
Manta rays	*Mobula* spp.	71	5,110			

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

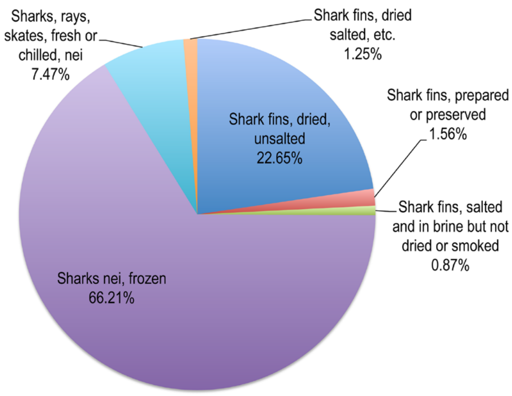


Figure 7. Export volume of sharks and rays by types of products from Southeast Asia in 2006

sand paper, etc.), cartilage (pharmaceuticals), teeth and jaw (souvenir items, accessories), and rostrum of sawfishes (for religious relics, traditional medicines, souvenirs, implements for cock fighting, etc.). Although the economic value of sharks and rays is also low compared with other marine aquatic species, but over the years, human exploitation of sharks and rays species has substantially increased worldwide, threatening the populations of the said species.

It should also be noted that, the products from sharks and rays in the region are mostly intended for export and are prepared in several forms such as shark fins, dried, salted, unsalted or preserved, salted and in brine but not dried or smoked; shark liver oil, fresh or chilled, and frozen. The total volume sharks and rays exported and the total value of the export from the Southeast Asian countries from 1986 to 2006 are shown in **Fig. 7**.

IV. PRODUCTION FROM INLAND CAPTURE FISHERIES OF SOUTHEAST ASIA

In the Southeast Asian region, inland fisheries are generally characterized as small-scale, multi-species and multi-gear, involving large numbers of small-scale and subsistence fishers with large portion of the catch utilized directly for household consumption. In 2009, the total production from inland fisheries in the region accounted for approximately 8% of the region's total fishery production. Based on the production statistics reported by the countries of the Southeast Asian region from 2000 to 2009 in terms of volume and values as shown **Table 14** and **Table 15**, respectively, seven countries, namely: Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, and Thailand were able to report the values of their respective production from inland capture fisheries. The remaining countries at this stage could not yet report their corresponding production values from inland capture fisheries.

Over the past ten years, the Southeast Asian production from inland capture fisheries has been slightly increasing,

Table 14. Production volume from inland capture fisheries of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cambodia	245,600	360,000	360,300	308,750	250,00	444,000	559,642	420,000	430,600	390,000
Indonesia	318,334	310,240	304,989	308,693	330,880	297,370	293,921	310,457	497,740	494,630
Lao PDR	…	…	…	…	...	29,800	29,800	28,410	29,200	30,000
Malaysia	3,549	3,446	3,565	3,828	4,119	4,583	4,164	4,283	4,353	4,469
Myanmar	238,210	254,880	289,940	454,320	502,550	631,120	718,000	717,640	814,740	899,430
Philippines	*152,121**	136,347	131,644	133,292	142,019	143,806	*161,394**	*168,277**	*181,678**	*188,722**
Thailand	201,500	202,500	198,700	198,400	199,600	198,800	214,000	225,600	228,600	245,500
Vietnam	170,00	243,583	226,958	208,623	…	138,800	152,325	133,600	144,800	144,800
Total	**1,159,544**	**1,510,996**	**1,516,096**	**1,615,906**	**1,179,168**	**1,888,279**	**2,136,933**	**2,008,301**	**2,329,524**	**2,397,273**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

Table 15. Production value from inland capture fisheries of the Southeast Asian countries from 2000 to 2009 (US$ 1000)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cambodia	…	…	…	…	…	…	…	…	255,500	334,845
Indonesia	155,472	189,590	237,888	257,779	268,990	323,827	264,372	368,247	521,019	616,640
Lao PDR	…	…	…	…	…	…	…	215,708	240,334	93,168
Malaysia	…	…	*6,316**	*6,316**	*7,632**	*8,446**	*8,470**	*9,855**	*11,556**	*11,014**
Myanmar	…	…	…	…	…	…	…	…	788,325	1,349,145
Philippines	59,285	57,022	64,518	66,029	80,442	84,077	101,477	125,464	145,912	*164,252***
Thailand	174,920	157,072	145,038	170,236	184,658	194,859	222,573	266,740	254,057	273,290
Total	**389,677**	**403,684**	**453,861**	**500,658**	**541,901**	**611,950**	**596,877**	**985,172**	**2,215,437**	**2,834,477**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figure provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

which could have been brought about by many factors that include improvement in the national statistics collection systems and mechanisms. Nevertheless, it should be considered that large portions of the catch from inland capture fisheries are directly utilized for household consumption without proper recording and reporting. At this point in time, it is therefore difficult to estimate the actual trend of the production from inland capture fisheries in the region based only on the current available statistics. Thus, the contribution of inland capture fisheries to the total fisheries production of the Southeast Asian region could not be confirmed in view of the insufficient data from the countries. However, among the Southeast Asian countries, Myanmar, Indonesia, and Cambodia are the top producers from inland capture fisheries (**Table 16**).

Nonetheless, it should be noted that the contribution of Lao PDR to the region's total production from capture fisheries is significantly high considering that all its production from capture fisheries is derived from inland fisheries. The production of Cambodia from inland capture fisheries represents 84% of its total capture fishery production and 76% of the country's total fishery production. On the other hand, the production of Myanmar from inland capture fisheries represents 33% of its total capture fishery production and 26% of the country's total fishery production. Overall, the contribution of the Southeast Asian countries' inland capture fisheries production to the region's total capture fishery production is 15% and to the region's total fishery production at about 8%.

As for the inland capture fisheries production of Indonesia, about 38% is contributed by *Mystacoleucos padangensis* of the family Cyprinidae, about 13% by freshwater fishes nei, 6% by striped snakehead (*Chana striata*), 4% by Nile tilapia (*Oreochromis niloticus*), another 4% by snakeskin gourami (*Trichogaster pectoralis*), and the rest by the various species of freshwater fishes, crustaceans and mollusks. In terms of value, Indonesia's production of the giant freshwater prawn (*Macrobrachium rosenbergii*) is valued at US$ 5,745/MT although its volume of production was only 7,310 MT in 2009. The second highest valued species is the striped snakehead at US$ 2,100/MT followed by snakeskin gourami at US$ 1,365/MT, freshwater fishes nei at US$ 1,135/MT and Nile tilapia at US$ 1,075/MT. The value of its production of *Mystacoleucos padangensis* was US$ 430/MT.

In the case of Thailand, the main inland capture fishery species produced was classified as freshwater fishes nei contributing about 33% of the country's total production from inland fisheries followed by Nile tilapia at 20%, silver barb (*Barbonymus gonionotus*) at 18%, striped snakehead at 8%, and the rest by the other freshwater fishes, crustaceans and mollusks. While the average value of freshwater fishes nei was US$ 730/MT, striped

Table 16. Contribution of inland capture fisheries to the respective Southeast Asian country's total fishery production in 2009

Country	Production from inland capture fisheries (MT)	Total capture fishery production (MT)	% of inland capture fishery production to total capture fishery production (%)	Total fishery production (capture and aquaculture) (MT)	% of inland capture fishery production to total fishery production (%)
Brunei Darussalam	...	1,958	-	2,418	-
Cambodia	390,000	465,000	83.9	515,000	75.7
Indonesia	494,630	5,284,040	9.4	10,064,140	4.9
Lao PDR	30,000	30,000	100.0	105,000	28.6
Malaysia	4,469	1,395,557	0.3	1,729,002	0.3
Myanmar	899,430	2,766,940	32.5	3,491,103	25.8
Philippines	*188,722**	*2,602,585**	*7.25**	*5,079,977**	3.7
Singapore	...	2,121	-	5,687	-
Thailand	245,500	1,741,662	14.1	3,137,672	7.8
Vietnam	144,800	2,243,100	6.5	4,782,400	3.0
Total	**2,397,273**	**16,537,660**	**14.5**	**28,917,096**	**8.3**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

snakehead had the highest average value at US$ 2,025/MT followed by Nile tilapia at US$ 1,070/MT and silver barb at US$ 980/MT. No further analysis could be done on the values of the production from inland capture fisheries of Cambodia and Myanmar because the volumes and values of their respective production were not reported by species. Therefore, even if production from inland capture fisheries is not very high compared to the other fishery sub-sectors, but for some countries in Southeast Asia especially Cambodia, Lao PDR and Myanmar, the contribution of their respective inland capture fishery production to the region's total fishery production is considerably significant as indicated in **Table 16**. Thus, the importance of inland fisheries could not be undermined and its sustainable development should be appropriately addressed under the relevant national and regional fisheries-related mechanisms.

V. AQUACULTURE PRODUCTION OF SOUTHEAST ASIA

The over-exploitation of the fishery resources in the major fishing areas of the world coupled with the deterioration of the habitats resulted in the continuous decline of production from marine capture fisheries, while the demand for fish food remains high and increases to certain extent with the escalating world's population. Aquaculture has the potentials to fill the gap between supply and demand for fish products. The global supplies from aquaculture during the period from 2000 to 2009 had sprung at the rate of 1.46 million MT annually from 2000 to 2009. Asia is the largest producer, with its production (including that of Southeast Asia) accounting for about 91% of the global total aquaculture production, out of which production from the Southeast Asian counties accounted for 17% of the world's total aquaculture production (**Table 17**).

From 2000 to 2009, the total production from aquaculture in the Southeast Asian region grew at an average rate of about 868,330 MT/year, while its contribution to the total fishery production had steadily increased by almost double from 22% to 43% (**Table 18** and **Fig. 8**). Based on culture areas and species cultured, aquaculture is broadly classified into mariculture, brackishwater culture and freshwater culture. In 2009, mariculture contributed about 40% to the total aquaculture production of the region, while 22% and 38% came from brackishwater culture and freshwater culture, respectively.

Table 17. Aquaculture production by continent from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
World	**35,527,690**	**37,871,216**	**39,827,801**	**41,927,958**	**41,932,297**	**44,302,706**	**47,380,956**	**49,919,261**	**52,537,253**	**55,125,167**
Africa	451,363	489,358	568,516	619,604	637,646	727,332	842,978	916,008	1,061,773	1,103,492
Americas	1,457,011	1,765,456	1,873,018	1,975,716	2,162,782	2,192,047	2,405,572	2,385,009	2,527,746	2,609,930
Asia*	27,728,412	29,138,351	30,403,415	31,601,474	30,506,286	31,589,971	33,347,606	34,853,630	35,392,453	36,371,354
Southeast Asia**	**3,696,068**	**4,257,005**	**4,806,000**	**5,439,809**	**6,308,557**	**7,512,534**	**8,426,187**	**9,237,586**	**11,063,934**	**12,379,436**
Europe	2,056,224	2,092,225	2,042,630	2,159,636	2,171,691	2,121,195	2,185,861	2,352,715	2,313,510	2,484,585
Oceania	138,612	128,821	134,222	131,719	145,335	159,627	172,752	174,313	177,837	176,370

* *Excludes Southeast Asia*
** ***Sources:*** *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
Source of other data: *FAO Fisheries and Aquaculture Information and Statistics Service*

Table 18. Total fishery and aquaculture production by aquaculture sub-sector of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total Fishery Production	**16,937,296**	**17,621,843**	**18,930,761**	**20,274,399**	**21,147,665**	**22,987,784**	**24,501,878**	**25,302,872**	**27,207,826**	**28,917,096**
Total Aquaculture Production	**3,696,068**	**4,257,005**	**4,806,000**	**5,439,809**	**6,308,557**	**7,512,534**	**8,426,187**	**9,237,586**	**11,063,934**	**12,379,436**
• *Mariculture*	*1,219,702*	*1,489,952*	*2,114,640*	*2,230,322*	*2,712,679*	*3,005,014*	*3,623,260*	*3,879,786*	*4,646,146*	*4,945,239*
• *Brackishwater culture*	*1,108,821*	*1,191,961*	*1,297,620*	*1,468,748*	*1,514,054*	*1,953,258*	*1,853,761*	*2,032,269*	*2,072,026*	*2,694,336*
• *Freshwater culture*	*1,367,545*	*1,575,092*	*1,393,740*	*1,740,739*	*2,081,824*	*2,554,262*	*2,949,166*	*3,325,531*	*4,345,762*	*4,739,861*

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*

Table 19. Aquaculture production by aquaculture sub-sector of the Southeast Asian region in 2009 (MT)

Country	Quantity (MT)				Value (US$ 1000)	Ave. Value US$/MT
	Mariculture	Brackishwater culture	Freshwater culture	Total		
Brunei Darussalam	72	354	34	460	5,161	11,220
Cambodia	4,925	75	45,000	50,000	87,954	1,760
Indonesia	2,537,100	1,080,700	1,162,300	4,780,100	5,189,522	1,090
Lao PDR	...	...	75,000	75,000	111,801	1,490
Malaysia	*111,524**	*69,296**	*152,630**	*333,450**	700,910	2,100
Myanmar	50,464	2,926	670,773	724,163	853,165	1,180
Philippines	1,860,462	308,440	308,490	2,477,392	*1,710,608***	700
Singapore	3,286	...	280	3,566	8,793	2,500
Thailand	316,927	558,444	520,639	1,396,010	2,422,630	1,740
Vietnam	172,003	554,397	1,812,900	2,539,300	4,867,779	1,920
Total	**4,945,239**	**2,694,336**	**4,739,861**	**12,379,436**	**15,968,676**	**1,290**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figure provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

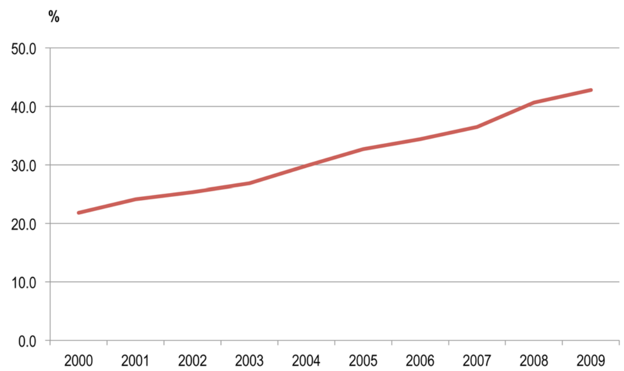


Figure 8. Contribution of aquaculture to the total fishery production of the Southeast Asian region

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2010) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*

Among the Southeast Asian countries, Indonesia is the leading producer of aquaculture products in terms of volume and value (**Table 19**) followed by Vietnam. The Philippines comes third in terms of volume but Thailand ranks third in terms of value. Specifically for mariculture production, Indonesia is the top producer followed by the Philippines, but for production from brackishwater culture, Thailand and Vietnam come next to Indonesia as the highest producer. For the production from freshwater culture, Vietnam emerges next to Indonesia followed by Myanmar (**Fig. 9**).

Indonesia's production from aquaculture in 2009 comes mainly from aquatic plants nei which accounts for about 62% of the country's aquaculture production, followed by freshwater fishes nei (*Osteichthyes*) accounting for 20%, marine fishes nei (*Osteichthyes*) 8%, and marine crustaceans about 7% while other invertebrates and freshwater crustaceans comprise the remaining 3%. In the case of Vietnam, 41% of its aquaculture production comes from Pangas catfish nei (*Pangasius* spp.) followed by freshwater fishes nei (*Osteichthyes*) 36%, giant tiger shrimp (*Penaeus monodon*) 12%, marine mollusks nei 7% and the remaining 4% comprises other marine shrimps and freshwater crustaceans.

For the Philippines, its main aquaculture product is seaweeds mainly the Zanzibar weeds (*Eucheuma cottonii*) which accounts for 59% of the country's production

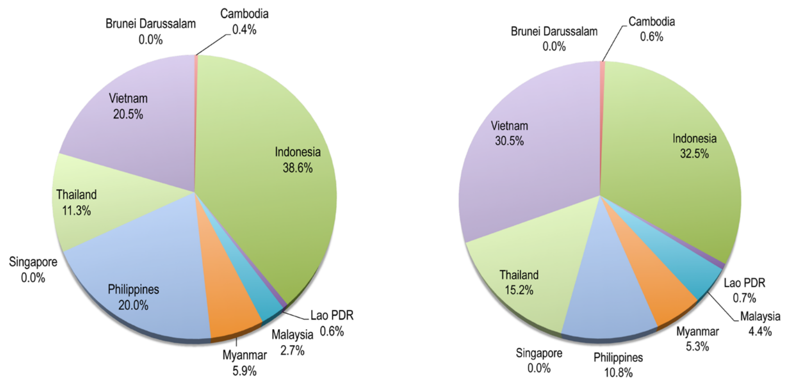


Figure 9. Percentage of aquaculture production of the Southeast Asian countries in 2009: quantity in MT (left) and value in US$ 1000 (right)

from aquaculture followed by milkfish (*Chanos chanos*) accounting for 14%, tilapia (mainly *Oreochromis* spp.) 11%, aquatic plants nei 6%, other seaweeds mainly *E. denticulatum* 5%, shrimps (*P. monodon*) and crabs (*Scylla serrata*) 3%, and oysters and giant mussels 2%. In the case of Thailand, its main production from aquaculture is the whiteleg shrimp (*Penaeus vannamei*) which contributes 38% to the country's aquaculture production followed by green mussels accounting for 17%, tilapia (*O. niloticus*) 15%, catfish hybrid (*Clarias gariepenus* x *C. macrocephalus*) 10%, gourami and silver barb 7%, blood cockle 5%, others including oysters comprising the remaining 8%. For Myanmar, its main aquaculture product is roho labeo (*Labeo rohita*) which accounts for 67% of the country's production from aquaculture. Other freshwater species also contribute 18% to the total aquaculture production while *P. monodon* accounts for 6%, tilapia 5%, *Pangasius* spp. 2%, and other species comprising the remaining 2% of the country's total aquaculture production.

As for the values of aquaculture production, Brunei Darussalam has the highest average value at US$ 11,220/MT, especially for the country's main aquaculture commodity which is the blue shrimp (*Penaeus stylirostris*) valued at US$ 11,430/MT. The county's other products include the giant tiger shrimp (*P. monodon*) valued at US$ 15,000/MT, *Caranx* spp. at US$14,000/MT, grouper (*Epinephelus* spp.) at US$ 17,000/MT, snapper (*Lutjanus* spp.) at US$ 13,500/MT, and the African catfish (*Clarias gariepinus*) at US$ 6,350/MT.

For the Philippines, its main aquaculture product which is the Zanzibar weed is valued at US$120/MT. Milkfish which is the second major product is valued at US$ 1,730/MT while tilapia is valued at US$ 1,370/MT and the other seaweeds are valued US$ 225/MT. The county's other products such as *P. monodon* is valued at US$8,200/MT, *Scylla serrata* at US$ 5,700/MT, oysters at US$ 200/MT, and giant mussels at US$ 145/MT.

In the case of Indonesia, its main production of aquatic plants nei is valued at US$ 275/MT while the other products such as freshwater fishes nei is valued at US$ 1,515/MT, marine fishes nei at US$ 1,300/MT, marine crustaceans at US$ 3,640/MT, and other invertebrates and freshwater crustaceans at US$ 740/MT. For Vietnam, its main product which is the Pangas catfish is valued at US$ 1,500/MT. The other products such as freshwater fishes nei is valued at US$ 1,500/MT, giant tiger shrimp (*P. monodon*) at US$ 4,000/MT, other marine shrimps also at US$ 4,000/MT, marine mollusks nei at US$ 1000/MT, and freshwater crustaceans at US$ 7,000/MT.

5.1 Mariculture

Worldwide, mariculture production had grown from 21.0 million MT in 2000 to 34.8 million MT in 2009, accounting for nearly one-half of the global production from aquaculture. In 2009, Asia (including the Southeast Asia) was the biggest producer of mariculture products at about 31.1 million MT or about 89% of global mariculture production, out of which the Southeast Asian countries contributed 14% of the global production. Indonesia has been the leading producer of mariculture products of which its production in 2009 contributed more than 51% to the region's total production from mariculture, followed by the Philippines at 38% and Thailand at 6%, and the other countries provided the remaining 5% (**Table 20**). In terms of value, Indonesia still led the countries with the value of its mariculture production contributing about 58%, followed by the Philippines (18%), Myanmar (9%), Vietnam (8%), and the remaining countries contributing about 7% to the region's total mariculture production value (**Table 21**).

The major species groups cultured in marine areas in the region are the aquatic plants which accounted for about 87% of the total production from mariculture in 2009 (**Table 22**), followed by marine mollusks (11%), and 2% from marine fish species and others (**Fig. 10**). Although aquatic plants accounted for 87% of the total mariculture

Table 20. Production volume from mariculture of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	53	30	16	18	...	37	500	...	390	72
Cambodia	408	394	4,064	8,324	16,915	16,400	500	16,630	1,370	4,925
Indonesia	197,114	221,010	234,859	249,242	736,689	890,074	1,365,919	1,509,062	2,377,382	2,537,100
Lao PDR	...	...	...	...	...	...	...	...	...	...
Malaysia	*84,962**	*87,468**	*94,671**	*92,936**	*84,699**	*80,239**	*71,374**	*72,922**	*96,159**	*111,524**
Myanmar	23,038	68,854	134,784	25,709	...	804	...	...	48,303	50,464
Philippines	747,414	827,670	936,851	1,039,081	1,273,598	1,419,727	1,566,056	1,626,206	*1,793,395***	1,860,462
Singapore	4,398	3,700	4,303	4,786	4,786	5,280	8,113	4,159	3,235	3,286
Thailand	149,810	246,602	384,094	361,400	400,400	364,061	317,457	309,497	...	316,927
Vietnam	32,900	319,071	396,099	443,135	155,235	213,800	216,200	208,500	48,420	172,003
Total	**1,246,957**	**1,785,154**	**2,205,608**	**2,237,934**	**2,691,311**	**3,009,034**	**3,571,441**	**3,818,848**	**4,646,146**	**4,945,239**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figure provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

Table 21. Production value from mariculture of the Southeast Asian countries from 2000 to 2009 (US$ 1000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	...	...	...	...	...	...	...	...	392	...
Cambodia	...	...	...	...	4,585	...	...	5,300	3,890	19,700
Indonesia	134,182	73,047	122,985	180,007	167,787	353,019	220,568	432,802	983,185	1,297,568
Lao PDR	...	...	...	...	...	...	...	...	...	...
Malaysia	*47,895**	*48,158**	*51,579**	*75,526**	*60,263**	*67,828**	*108,470**	*131,304**	*159,407**	*189,275**
Myanmar	...	...	...	...	...	...	...	...	...	208,905
Philippines	75,410	77,623	86,379	96,373	164,013	171,539	216,342	270,984	500,275	*383,899***
Singapore	5,952	5,382	4,079	5,258	6,187	7,147	7,381	7,980	8,082	7,551
Thailand	40,692	54,847	57,207	62,260	59,915	97,215	1,457,754	...	...	71,837
Vietnam	...	880,737	1,024,056	1,255,758	155,235	622,600	...	189,500	1,493,750	174,000
Total	**273,284**	**1,109,600**	**1,315,130**	**1,619,311**	**559,585**	**1,271,964**	**1,919,809**	**929,804**	**2,994,548**	**2,224,666**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figure provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

Table 22. Mariculture production in the Southeast Asia by species group from 2000 to 2009 (MT)

Major groups	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Marine fishes	21,971	21,580	29,037	38,504	42,216	70,520	71,099	93,653	245,967	64,279
Marine mollusks	291,122	358,311	495,371	470,724	661,716	672,108	617,095	590,202	588,563	553,401
Aquatic plants	910,635	1,017,136	1,147,212	1,257,452	1,987,178	2,266,406	2,883,247	3,134,993	3,811,616	4,277,095
Others	23,229	388,127	533,988	471,254	201	-	-	-	-	50,464
Total	**1,246,957**	**1,435,154**	**2,205,608**	**2,237,934**	**2,691,311**	**3,009,034**	**3,571,441**	**3,818,848**	**4,646,146**	**4,945,239**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*

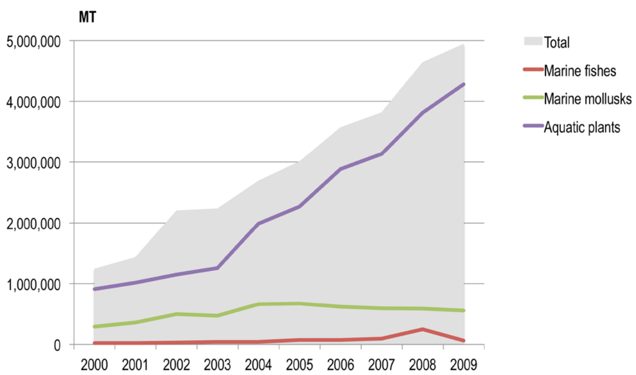


Figure 10. Production trend of aquatic plants, marine fishes and mollusks from mariculture in Southeast Asia

production in terms of value however, their contribution was only 45% to the total value of mariculture production. While marine fishes contributed only 2% to the total marine production in 2009, in terms of value this group contributed 34% to the total value of mariculture products. On the other hand, marine mollusks which contributed 11% to the total volume of mariculture production, its contribution in terms of value was about 12%, while the contribution of marine shrimps to the total value of mariculture production was about 9%.

Table 23. Mariculture production in Southeast Asia by country and by major species in 2009 (MT)

	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam	Total
Aquatic plants nei	...	...	2,537,100	...	...	165,570	...	...	...	**2,702,670**
Euchema cottonii	...	...	...	...	...	1,462,203	...	...	...	**1,462,203**
Euchema denticulatum	...	...	...	...	...	112,222	...	...	...	**112,222**
Marine mollusks nei	...	...	...	...		1,447	...	...	166,003	**167,450**
Perna viridis	...	...	...	...	...	19,936	...	230,678	...	**250,614**
Anadara granosa	...	...	...	...	...	...	...	67,854	...	**67,854**
Crassostrea spp.	...	...	...	...	...	19,931		18,395		**38,326**
Marine shrimps					50,464					**50,464**
Others	72	4,925	...	...	...	79,153	3,286		6,000	**93,436**
Total	**72**	**4,925**	**2,537,100**	**...**	**50,464**	**1,860,462**	**3,286**	**316,927**	**172,003**	**4,945,239**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

The mariculture production by country and by species in 2009 (**Table 23**) indicated that Indonesia contributed the largest amount of aquatic plants production but this was not classified according to species. Only Philippines and Thailand reported their mariculture production at species level. Therefore, it appears that the species with highest production was the Zanzibar weeds (*Eucheuma cottonii*) reported only by the Philippines, followed by the green mussel (*Perna viridis*) reported by Philippines and Thailand, *Eucheuma denticulatum* reported by the Philippines, and blood cockle (*Anadara granosa*) reported by Thailand. It should be noted that Myanmar reported its production of marine shrimps at 50,464 MT comprising the giant tiger shrimp (*Penaeus monodon*) at 46,104 MT and Indian white shrimp (*P. indicus*) at 4,360 MT. The value of the country's production of marine shrimps was recorded at US$ 208,905,000 or at an average value of US$ 4,140/MT.

5.2 Brackishwater Culture

The main brackishwater species cultured in the Southeast Asian region include the crustaceans such as the whiteleg shrimp (*Penaeus vannamei*) and giant tiger shrimp (*P. monodon*), fishes and aquatic plants. Production from brackishwater aquaculture had increased by about 141% during the period from 2000 to 2009 (**Table 24**). Although such production was rather stable from 2000 to 2003, a sharp increase occured during 2004 and 2005 (**Fig. 11**), which could be mainly due to the development of culture technologies and increased production of the whiteleg shrimp by Thailand and Vietnam.

In terms of average value of production from brackishwater aquaculture (**Table 25**), Brunei Darussalam posted the highest at US$ 14,580/MT followed by Cambodia at US$ 10,050/MT. For the other countries such as Vietnam the average value of its brackishwater aquaculture products was US$ 3,560/MT, Thailand at US$ 3,075/MT,

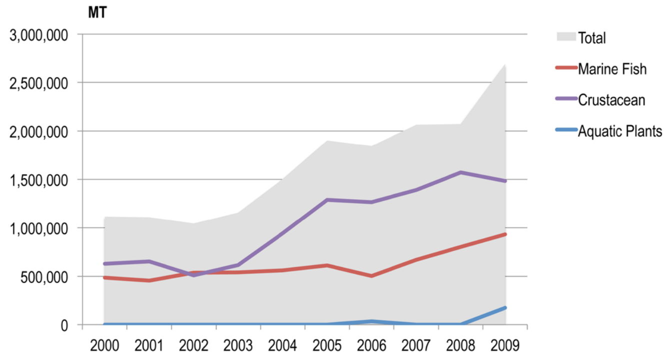


Figure 11. Production of aquatic plants, marine fishes and crustaceans from brackishwater aquaculture of Southeast Asia

Philippines at US$2,900/MT, Malaysia at US$ 2,170/MT, and Indonesia at US$ 2,000/MT. Myanmar and Singapore did not report the values of their respective brackishwater aquaculture production.

Crustaceans such as the whiteleg shrimp, giant tiger shrimp and other prawns including banana prawn provided the highest contribution to the total brackishwater aquaculture production in 2009, in terms of volume at 58% and value at also about 58%. While the whiteleg shrimp contributed 21% in volume its contribution in terms of value was 25%, likewise for the giant tiger shrimp which contributed 15% in volume and 25% in value. However, the other prawns including banana prawn contributed 22% in volume but only 8% in value. Milkfish (*Chanos chanos*) also contributed almost 10% in volume but only 9% in value. Although the region's production from brackishwater aquaculture in 2009 (**Table 26**) is dominated by marine fishes nei contributing about 15% of the total production, analysis could not be made on its production trend considering that the data had not been classified into species level. On the other hand, production of the whiteleg shrimp (*Penaeus vannamei*) which comes with the second highest production volume contributed more than 20% of the region's total brackishwater culture production, with

Table 24. Production volume from brackishwater aquaculture of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	41	31	52	52	598	537	60	611	...	354
Cambodia	20	143	53	90	590	100	130	...	...	75
Indonesia	430,020	510,744	473,128	501,977	480,046	643,975	629,609	629,797	691,432	1,080,700
Lao PDR	...	...	...	...	...	...	...	...	...	
Malaysia	*16,119**	*27,232**	*25,143**	*26,382**	*31,011**	*33,547**	*35,547**	*35,258**	*51,119**	*69,296**
Myanmar	4,964	5,473	6,550	18,421		250,407	60,000	48,303	...	2,926
Philippines	241,455	268,120	254,167	254,744	262,554	277,230	281,316	294,495	*303,244***	308,440
Singapore	55	40	107	30	71	35	34	...	...	...
Thailand	317,263	287,928	276,008	341,878	377,388	414,926	508,150	535,834	805,300	558,444
Vietnam	96,433	...	...	...	339,555	287,200	309,000	500,500	501,600	554,397
Total	**1,115,635**	**1,109,219**	**1,044,967**	**1,157,485**	**1,503,783**	**1,901,773**	**1,841,978**	**2,063,196**	**2,072,026**	**2,694,336**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figure provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

Table 25. Production value from brackishwater aquaculture of the Southeast Asian countries from 2000 to 2009 (US$ 1000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	...	...	...	...	2,695	...	...	3,212	...	5,161
Cambodia	...	...	...	...	767	...	...	...	375	754
Indonesia	731,798	902,128	1,118,924	1,139,019	1,529,358	1,483,289	1,736,275	1,672,408	1,840,902	2,156,102
Lao PDR	...	...	...	...	...	...	...	...	...	...
Malaysia	*125,236**	*201,579**	*167,105**	*165,789**	*173,158**	*172,341**	*162,295**	*165,797**	*209,481**	*271,014**
Myanmar	...	...	...	...	...	...	...	193,212	641,278	...
Philippines	534,739	534,699	485,225	457,412	490,853	535,451	611,344	714,106	831,073	*886,256***
Singapore	430	386	969	313	593	374	625	...	...	...
Thailand	2,206,325	1,875,872	1,248,738	1,081,912	1,175,007	897,455	...	1,523,423	1,602,685	1,717,645
Vietnam	...	...	...	...	1,146,005	1,463,200	...	1,692,500	467,450	1,974,429
Total	**3,631,332**	**3,547,229**	**3,055,403**	**2,904,025**	**4,566,961**	**4,616,652**	**2,602,799**	**6,038,269**	**5,717512**	**7,160,596**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figure provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

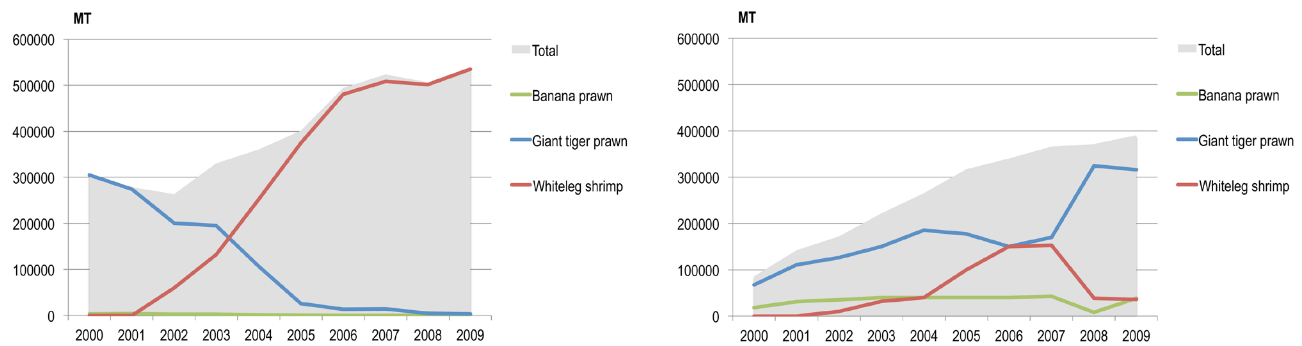


Figure 12. Changes in production trends of whiteleg shrimps and giant tiger shrimps in Thailand (left) and Vietnam (right)

Thailand as the largest producer accounting for about 94% of the species group's total production (**Fig. 12**). Coming next after the whiteleg shrimp is the giant tiger shrimp (*Penaeus monodon*) providing 15% to the region's total with Vietnam as the highest producer providing about 74% of the species production. Milkfish (*Chanos chanos*) is also an important commodity although it contributed only about 10% to the region's total brackishwater culture production with the Philippines as the leading producer of such species (**Table 27**).

5.3 Freshwater Aquaculture

The deterioration of inland fishery habitats had resulted in degrading inland fishery resources despite reports by many Southeast Asian countries that inland capture fishery production had been increasing. In order to increase fish

Table 26. Brackishwater culture production by major groups of species from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Marine fishes nei	76,385	34,467	110,147	109,570	111,743	139,447	64,790	172,224	174,413	672,371
Whiteleg shrimp	…	…	…	132,365				…	745,948	571,000
Tiger prawn	511,867	450,522	439,532	406,519	478,865	604,511	427,467	429,295	522,326	383,696
Milkfish	408,827	421,119	425,892	430,903	448,910	473,924	439,706	498,437	…	260,610
Banana prawn	…	…	…	…	320,429	399,816		…	78,087	64,534
Other prawns	118,392	203,111	69,396	76,145	143,165	284,075	837,503	963,106	224,545	462,671
Aquatic plants	…	…	…	…	…	…	33,321	…	…	171,868
Others	164	…	…	1,984	671		39,191	134	326,707	107,586
Total	**1,115,635**	**1,109,219**	**1,044,967**	**1,157,485**	**1,503,783**	**1,901,773**	**1,841,978**	**2,063,196**	**2,072,026**	**2,694,336**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*

Table 27. Brackishwater aquaculture production in Southeast Asia by country and by major species in 2009 (MT)

	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam	Total
Penaeus vannamei	…	…	…	…	…	…	…	535,000	36,000	571,000
Penaeus monodon	15	…	…	16,351	…	47,830	…	3,500	316,000	383,696
Chanos chanos	…	…	…	…	…	260,610	…	…	…	260,610
Aquatic Plants nei	…	…	171,868	…	…	…	…	…	…	171,868
Penaeus spp.	275	75	402,043	*52,927**	2,204	…	…	453	59,700	527,205
Anadara granosa	…	..	…	64,938	…	…	…	…	…	64,938
Perna viridis	…	…	…	10,596	…	…	…	…	…	10,596
Lates calcarifer	39	…	…	14,229	…	…	…	15,656	…	29,924
Crassostrea spp.	…	…	…	2,128	…	…	…	…	…	2,128
Marine fishes nei	25	…	506,789	*19,650**	722	…	…	3,835	142,697	672,371
Total	**354**	**75**	**1,080,700**	***180,819****	**2,926**	**308,440**	**-**	**558,444**	**554,397**	**2,694,336**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

supply from inland areas, freshwater aquaculture has been widely promoted and practiced in many countries in Southeast Asia. As a result, production from freshwater aquaculture in the region has demonstrated a steady growth over the past decade of approximately 411,000 MT annually from 2000 to 2009 (**Table 28**).

Specifically in 2009, the volume of the region's production from freshwater culture accounted for about 38% of the region's total aquaculture production. In terms of value, this sub-sector accounts for 41% of the region's total aquaculture production value (**Table 29**), making freshwater aquaculture a very important fishery sub-sector. Vietnam contributed the highest production in terms of volume and value followed by Indonesia, Myanmar, and Thailand.

More than 30 major freshwater fish species are being cultured in the Southeast Asian region, about one-half of which are indigenous in the region while the rest are either imported or domesticated for an extended period (*e.g.* tilapia, roho labeo, African (including hybrid) catfish). For this reason, many countries reported on their production by major species groups such as freshwater fishes without providing the details at species level (**Table 30**). Nevertheless, the information provided by the countries in 2009 indicated that freshwater fishes nei accounted for 42% of the region's total production from freshwater aquaculture followed by the Pangas catfish (23%), tilapia nei (12%), roho labeo (10%), catfishes (5%), cyprinidae (4%), and others (4%). In terms of value, freshwater fishes nei provided 47% followed by Pangas catfish (25%), tilapia nei (10%), roho labeo (7%), catfishes (4%), cyprinidae (4%), and others (4%).

Notwithstanding the information provided by the countries on miscellaneous freshwater fishes which are mostly not classified into species level, Pangas catfish (*Pangasius* spp.) contributed the highest production in 2009 accounting for about 23% of total freshwater culture production in the region with Vietnam producing 95%. It is notable that the production of catfish of the region had increased by more than 5 times over the ten-year period from 2000 to 2009. Tilapia comes next providing 11% of the region's freshwater aquaculture production from the Philippines and Thailand, and roho labeo (*Labeo rohita*) at 10% of the region's freshwater production contributed mostly by Myanmar (**Table 31**).

Table 28. Production volume from freshwater aquaculture of the Southeast Asian countries from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	19	38	90	89	110	129	...	63	...	34
Cambodia	14,002	13,463	17,886	14,133	20,170	25,500	...	33,570	38,350	45,000
Indonesia	367,831	401,030	472,974	429,166	137,766	407,047	384,658	327,171	786,386	1,162,300
Lao PDR	...	...	...	...	...	...	...	...	64,300	75,000
Malaysia	50,689	43,456	*46,403**	*49,947**	55,557	62,006	*61,653**	70,064	*95,846**	*152,631**
Myanmar	93,948	115,793	356,230	114,716	426,000	323,779	...	556,354	605,552	670,773
Philippines	112,033	*123,666***	*147,375***	*160,678***	180,875	198,890	257,325	*244,903***	311,059	*308,294***
Singapore	160	702	602	616	549	602	1,471	345	283	280
Thailand	271,010	279,697	361,124	183,311	523,709	539,474	532,252	525,100	525,500	520,639
Vietnam	381,222	390,820	559,960	448,710	703,827	966,300	...	1,485,500	1,918,300	1,812,900
Total	**1,290,914**	**1,368,663**	**1,979,491**	**1,679,020**	**2,048,563**	**2,523,727**	**1,255,362**	**3,292,292**	**4,345,762**	**4,739,861**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*
** *Updated figure provided by the Philippine Bureau of Agricultural Statistics,Department of Agriculture; but not used for the calculation of total production.*

Table 29. Production value from freshwater aquaculture of the Southeast Asian countries from 2000 to 2009 (US$ 1000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	...	...	...	...	398	...	...	...	...	...
Cambodia	...	...	...	...	36,813	...	...	52,738	57,525	67,500
Indonesia	217,067	347,392	440,725	443,349	269,851	332,412	384,658	342,329	1,398,411	1,735,852
Lao PDR	..	...	...	...	...	...	...	...	91,141	111,801
Malaysia	*80,263**	*65,263**	*62,368**	*63,421**	*67,105**	*77,329**	*79,781**	*101,159**	*139,556**	*204,058**
Myanmar	...	...	...	...	...	...	...	1,669,191	141,288	644,260
Philippines	118,147	106,139	114,794	132,546	162,960	185,546	257,325	349,629	387,286	418,956
Singapore	3,564	2,522	1,799	1,861	1,744	2,450	1,471	1,072	1,180	1,242
Thailand	209,990	206,769	.253,349	317,492	479,587	358,509	532,252	611,169	462,616	633,148
Vietnam	...	280,191	316,039	379,767	1,055,741	859,850	...	2,662,750	2,656,500	2,719,350
Total	**629,028**	**1,008,429**	**935,923**	**1,338,492**	**2,075,298**	**1,822,566**	**1,255,362**	**5,779,567**	**4,716,200**	**6,583,413**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*

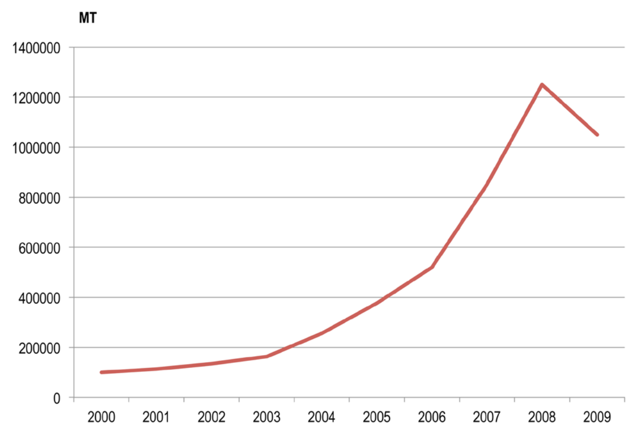


Figure 13. Vietnam's production of Pangas catfish

In 2009, Vietnam reported the highest quantity and value of inland culture production, more than one half of which was derived from the culture of *Pangasius* spp. accounting for about 58% of the country's inland culture production. The production from *Pangasius* spp. in Vietnam had drastically grown from approximately 100,000 MT in 2000 to about 1,250,000 MT in 2008 but dropped to 1,050,000 MT in 2009 (**Fig. 13**).

VI. FISH TRADE

Fish is the most heavily traded food commodity and the fastest growing agricultural commodity in international markets. In addition to its contribution to national economy and capability in generating income, trade in fish and fishery products also plays an important role in improving food security and ensuring the distribution of products to meet the nutritional demands and requirements for food fish worldwide. In 2008, the total export quantity of fish and fishery products was about 23% of world's fishery production while the total import accounted for about 24% of the total fishery production (**Table 32**). While the export of fish and fishery products of the Southeast Asian countries in 2008 represented 17% of the region's fishery production, the region posted a positive trade balance of 1,541,402 MT.

Table 30. Freshwater aquaculture production of the Southeast Asian region by species groups from 2000 to 2009 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carps, barbels and other cyprinids	342,185	409,066	447,496	629,864	551,173	300,195	495,534	428,692	680,758	210,735
Tilapia and other cichilds	244,664	281,880	367,489	373,653	380,584	504,195	530,852	575,560	615,705	540,508
Catfishes	235,689	148,962	171,717	252,733	278,865	667,154	756,841	1,160,620	1,674,598	1,334,894
Gouramis	…	43,350	49,661	67,373		44,418	44,971	32,233	37,883	37,438
Misc. freshwater fishes	125,393	200,486	122,278	38,387	96,465	921,116	1,006,699	922,542	620,456	1,994,409
Fresh. crustaceans	19,949	14,140	16,696	29,024	37,648	46,141	32,294	113,873	37,378	35,637

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*

Table 31. Freshwater aquaculture production in Southeast Asia by country and by major species in 2009 (MT)

	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam	Total
Pangasius spp.	…	…	…	…	18,810	13,944	…	…	22,243	1,050,000	**1,104,997**
Oreochromis (=Tilapia) spp.	…	…	…	…	35,588	34,860	260,911	…	209,141	…	**540,500**
Labeo rohita	…	…	…	…	…	488,046	…	…	2,375	…	**490,421**
Clarias spp.	…	…	…	…	83,727	6,972	2,892	…	136,306	…	**229,897**
Barbonymus gonionotus	…	…	…	…	723	13,944	…	…	57,600	…	**72,267**
Catla catla	…	…	…	…	…	41,832	…	…	…	…	**41,832**
Cyprinus carpio	…	…	…	…	994	20,916	15,691	…	4,026	…	**41,627**
Trichogaster spp.	…	…	…	…	…	…	175	…	36,047	…	**36,222**
Cyprinidae	…	…	…	…	3,688	50,199	…	…	1,122	…	**55,009**
Misc. freshwater fishes	34	45,000	1,162,300	75,000	915	60	28,821	280	51,779	762,900	**2,127,089**
Total	**34**	**45,000**	**1,162,300**	**75,000**	**144,445**	**670,773**	**308,490**	**280**	**520,639**	**1,812,900**	**4,739,861**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

Table 32. World's fishery production and trade by continent in 2008 (MT)

	Total Fishery Production	Total Export of Fish and Fishery products	Total Import of Fish and Fishery products	Trade Balance (Export-Import)
World	**142,326,046**	**32,338,756**	**33,536,329**	**-1,197,573**
Africa	8,424,970	1,618,807	3,248,505	-1,629,698
Americas	24,470,938	7,720,061	4,210,689	3,509,372
Asia*	65,340,506	5,924,837	9,139,516	-3,214,679
Southeast Asia**	**27,260,013**	**4,651,467**	**3,110,065**	**1,541,402**
Europe	15,415,869	11,867,828	13,430,337	-1,562,509
Oceania	1,413,750	555,756	397,217	158,539

* *Excludes Southeast Asia*
** ***Sources:*** *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
Source of other data: *FAO Fisheries and Aquaculture Information and Statistics Service*

6.1 Global Trading of Fish and Fishery Products

From 2000 to 2008, the world exports of fish and fishery products increased in terms of volume by about 646,300 MT/year (**Table 33**) and in terms of value by about US$ 5,205 million annually (**Table 34**). In 2008, Europe exported the largest amount of fish and fishery products accounting for about 37% in terms of volume and 38% in terms of value of the world's total export of fish and fishery products (**Fig. 14**). The Southeast Asian region on the other hand, exported more than 14% of global export volume with value that represents 16% of the world's export value (**Table 34**). From Asia, China is the largest exporter contributing about 10% to the global export value followed by Norway providing about 7%. From among the Southeast Asian countries, Thailand's export value contributes 6% to the world's total export value while Vietnam provides 4%.

In terms of import of fish and fishery products in 2008 (**Table 35**), Europe also imported the largest quantity representing 40% of the world's total import volume and 47% of the world's import value. Asia (excluding Southeast Asia) came next with the import volume equivalent to 27% and 26% in terms of value (**Table 36**), with Japan as the largest importing country with its import value accounting for 14% of the world's import value. The United States of America on the other hand, accounted for about 13% of the world's total import (**Table 37**).

Table 33. World's export volume of fish and fishery products by continent from 2000 to 2008 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
World	**26,522,457**	**27,692,567**	**27,579,545**	**28,229,117**	**29,778,194**	**31,125,973**	**31,487,742**	**31,824,120**	**32,338,756**
Africa	1,429,938	1,448,437	1,495,826	1,443,456	1,362,495	1,438,138	1,577,060	1,569,254	1,618,807
Americas	7,439,299	7,575,941	6,719,867	6,796,415	7,573,772	8,271,059	7,676,682	7,477,837	7,720,061
Asia*	3,934,695	4,313,806	4,690,050	4,651,357	5,103,039	5,372,681	5,974,680	6,132,797	5,924,837
Southeast Asia**	**2,537,650**	**2,794,576**	**3,130,183**	**3,487,477**	**3,726,312**	**3,905,249**	**4,347,417**	**4,391,013**	**4,651,467**
Europe	10,666,929	11,053,966	10,979,693	11,268,697	11,384,394	11,504,192	11,301,402	11,657,352	11,867,828
Oceania	513,946	505,841	563,926	581,715	628,182	634,654	610,501	595,867	555,756

* *Excludes Southeast Asia*
** ***Sources:*** *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
Source of other data: *FAO Fisheries and Aquaculture Information and Statistics Service*

Table 34. World's export value of fish and fishery products by continent from 2000 to 2008 (US$ 1000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
World	**55,845,773**	**56,632,610**	**58,712,141**	**64,309,755**	**71,866,509**	**79,098,102**	**86,548,454**	**94,109,569**	**102,676,390**
Africa	2,736,448	2,849,334	3,118,517	3,368,369	3,293,196	3,713,840	3,906,874	4,494,502	4,777,540
Americas	13,256,480	13,779,546	13,473,722	14,918,822	15,925,983	17,772,863	19,103,365	19,757,890	21,297,994
Asia*	10,369,245	10,342,455	10,916,377	11,585,136	14,075,457	15,390,484	16,672,254	17,675,673	19,000,022
Southeast Asia**	**8,812,594**	**8,728,057**	**8,707,277**	**9,120,338**	**10,052,738**	**11,035,117**	**12,512,487**	**13,682,576**	**16,115,145**
Europe	18,769,641	19,126,103	20,603,409	23,381,528	26,401,855	29,000,684	32,188,631	36,230,015	39,178,009
Oceania	1,901,365	1,807,115	1,892,839	1,935,562	2,117,280	2,185,114	2,164,843	2,268,913	2,307,680

* *Excludes Southeast Asia*
** ***Sources:*** *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
Source of other data: *FAO Fisheries and Aquaculture Information and Statistics Service*

Table 35. World's import volume of fish and fishery products by continent from 2000 to 2008 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
World	**26,514,155**	**27,946,942**	**28,088,132**	**28,574,573**	**30,289,223**	**31,925,268**	**33,379,144**	**34,045,034**	**33,536,329**
Africa	1,593,854	1,864,311	1,731,138	1,861,829	2,289,675	2,431,128	3,845,105	3,850,588	3,248,505
Americas	3,284,576	3,347,550	3,347,352	3,596,394	3,821,087	3,852,586	4,042,879	4,195,907	4,210,689
Asia*	8,115,616	8,339,821	8,664,947	8,110,971	9,006,740	9,492,860	9,127,798	9,051,252	9,139,516
Southeast Asia**	**1,857,630**	**2,020,229**	**2,237,657**	**2,180,413**	**2,446,107**	**2,866,375**	**2,972,007**	**2,961,865**	**3,110,065**
Europe	11,314,999	12,034,262	11,758,543	12,471,731	12,340,682	12,909,988	13,002,845	13,597,405	13,430,337
Oceania	347,480	340,769	348,495	353,235	384,932	372,331	388,510	388,017	397,217

* *Excludes Southeast Asia*
** ***Sources:*** *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
Source of other data: *FAO Fisheries and Aquaculture Information and Statistics Service*

Table 36. World's import value of fish and fishery products by continent from 2000 to 2008 (US$ 1000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
World	**61,016,653**	**60,603,270**	**62,504,836**	**68,429,660**	**76,761,850**	**82,872,583**	**91,311,234**	**99,420,542**	**108,599,363**
Africa	957,275	1,261,522	1,230,671	1,459,686	1,671,522	2,013,573	2,410,767	2,842,462	3,036,319
Americas	13,091,323	12,885,820	12,544,833	14,302,537	15,053,196	15,405,417	17,262,495	18,319,122	19,627,040
Asia*	22,275,946	20,277,573	21,116,032	20,314,354	23,808,717	24,773,774	25,293,048	25,757,485	28,700,820
Southeast Asia**	**1,965,852**	**2,145,850**	**2,297,541**	**2,443,603**	**2,958,752**	**3,277,086**	**3,493,875**	**3,865,759**	**4,822,005**
Europe	22,050,883	23,352,325	24,593,131	29,082,728	32,363,763	36,351,038	41,709,655	47,307,259	51,018,055
Oceania	675,374	680,180	722,628	826,752	905,900	1,051,695	1,141,394	1,328,455	1,395,124

* *Excludes Southeast Asia*
** ***Sources:*** *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010, 2011)*
Source of other data: *FAO Fisheries and Aquaculture Information and Statistics Service*

Table 37. World's top ten exporters and importers of fish and fishery products in 2008

Exporters	Export Value (US$ millions)
1. China	10,114
2. Norway	6,937
3. Thailand	6,532
4. Denmark	4,601
5. Vietnam	4,550
6. United States of America	4,463
7. Chile	3,931
8. Canada	3,706
9. Spain	3,465
10. Netherlands	3,394
Importers	**Import Value (US$ millions)**
1. Japan	14,947
2. United States of America	14,135
3. Spain	7,101
4. France	5,836
5. Italy	5,453
6. China	5,143
7. Germany	4,502
8. United Kingdom	4,220
9. Denmark	3,111
10. Korea	2,928

Source: *The State of World Fisheries and Aquaculture 2010*

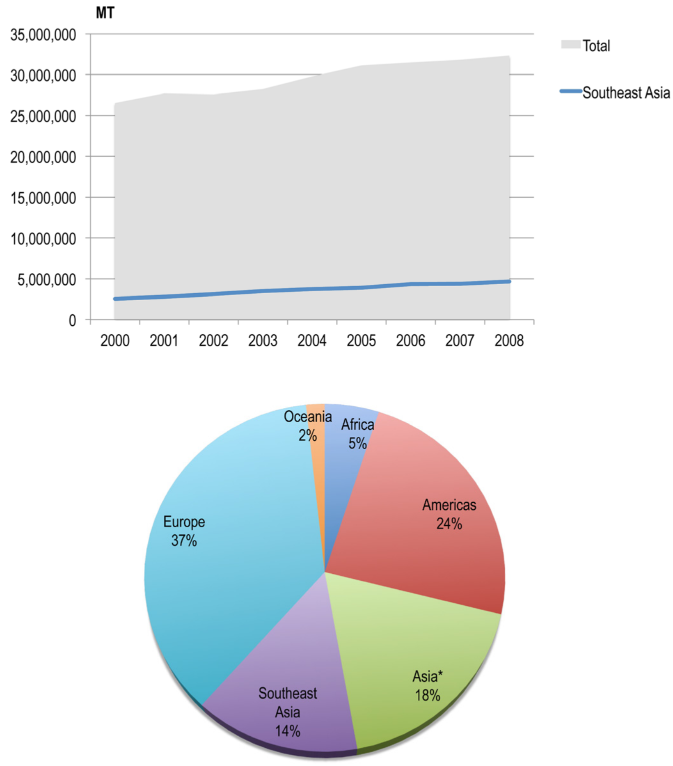


Figure 14. Export volume of fish and fishery products (top) and percentage of export quantity by continent in 2008 (above)

6.2 Southeast Asian Export-Import of Fish and Fishery Products

For the Southeast Asian region, Thailand is the largest exporter of fish and fishery products in 2008, which was about 55% of the country's total fishery production, followed by Vietnam the volume of which was about 23% of its fishery production (**Table 38** and **Table 39**). Although the region's export of fish and fishery products originates mainly from capture and culture fisheries, some products are imported and re-exported as well. As in the case of Singapore, although its import volume was minimal but the total export volume very much exceeded the country's fishery production, since the country imported most products that are meant for re-export.

In terms of export value (**Table 40**), Brunei Darussalam posted the highest average value per metric tons of exported products at US$ 10,900/MT followed by Singapore at US$ 5,415/MT, Vietnam at US$ 4,315/

Table 38. Trading of fish and fishery products by the Southeast Asian countries in 2008 (MT)

Country	Total Fishery Production	Total Export of Fish and Fishery products	Total Import of Fish and Fishery products	Trade Balance (Export-Import)
Brunei Darussalam	2,747	220	4,882	-4,662
Cambodia	536,320	42,610	2,176	40,434
Indonesia	9,054,873	868,442	198,980	669,462
Lao PDR	93,500	17	3,884	-3,867
Malaysia	1,639,017	*302,235**	*383,334**	*-81,099**
Myanmar	3,147,605	351,652	2,416	349,236
Philippines	4,964,703	228,075	210,215	17,860
Singapore	5,141	62,541	225,703	-163,162
Thailand	3,204,200	1,755,255	1,533,690	221,565
Vietnam	4,559,720	1,056,124	253,315	802,809
Total	**27,207,826**	**4,651,467**	**3,110,065**	**1,541,402**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2010)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

Table 39. Export volume of fish and fishery products by the Southeast Asian countries from 2000 to 2008 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brunei Darussalam	285	149	92	144	113	156	736	320	220
Cambodia	43,636	38,454	52,752	56,957	47,272	50,334	48,868	43,985	42,610
Indonesia	490,416	457,913	539,384	830,383	881,677	825,076	885,179	814,303	868,442
Lao PDR	4	30	7	24	11	-	1	33	17
Malaysia	*144,590**	*161,339**	*198,892**	*241,780**	*283,385**	*289,971**	*270,774**	*318,403**	*302,235**
Myanmar	116,609	144,623	201,667	212,999	205,463	278,675	271,071	259,054	351,652
Philippines	215,531	171,361	171,279	188,789	180,648	153,885	171,726	185,918	228,075
Singapore	110,693	91,932	74,428	72,465	78,590	83,229	81,308	69,889	62,541
Thailand	1,162,099	1,250,204	1,280,563	1,440,364	1,436,475	1,570,762	1,743,974	1,823,612	1,755,255
Vietnam	302,942	513,681	606,684	525,090	625,368	668,126	888,664	890,418	1,056,124
Total	**2,537,650**	**2,794,576**	**3,130,183**	**3,487,477**	**3,726,312**	**3,905,249**	**4,347,417**	**4,391,013**	**4,651,467**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*

Table 40. Export value of fish and fishery products by the Southeast Asian countries from 2000 to 2008 (US$ 1000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brunei Darussalam	296	334	459	706	683	1,053	5,305	3,238	2,398
Cambodia	37,691	31,308	32,071	34,744	40,304	51,207	43,995	31,970	31,937
Indonesia	1,610,291	1,560,078	1,516,537	1,579,783	1,736,184	1,845,883	2,019,803	2,170,876	2,600,968
Lao PDR	29	78	27	26	25	21	8	56	40
Malaysia	*355,136**	*358,931**	*384,878**	*442,643**	*592,787**	*641,350**	*646,426**	*756,515**	*769,846**
Myanmar	183,707	218,291	251,534	317,382	318,514	460,089	362,951	358,065	560,568
Philippines	455,984	420,184	453,030	464,463	454,384	384,766	418,364	498,069	671,194
Singapore	455,407	379,215	313,707	320,344	399,887	404,259	382,742	369,982	388,655
Thailand	4,384,437	4,075,341	3,713,299	3,943,194	4,079,407	4,502,821	5,275,349	5,721,525	6,547,742
Vietnam	1,484,283	1,823,102	2,044,630	2,203,499	2,450,112	2,765,365	3,379,955	3,790,167	4,559,252
Total	**8,812,594**	**8,728,057**	**8,707,277**	**9,120,338**	**10,052,738**	**11,035,117**	**12,512,487**	**13,682,576**	**16,115,145**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*

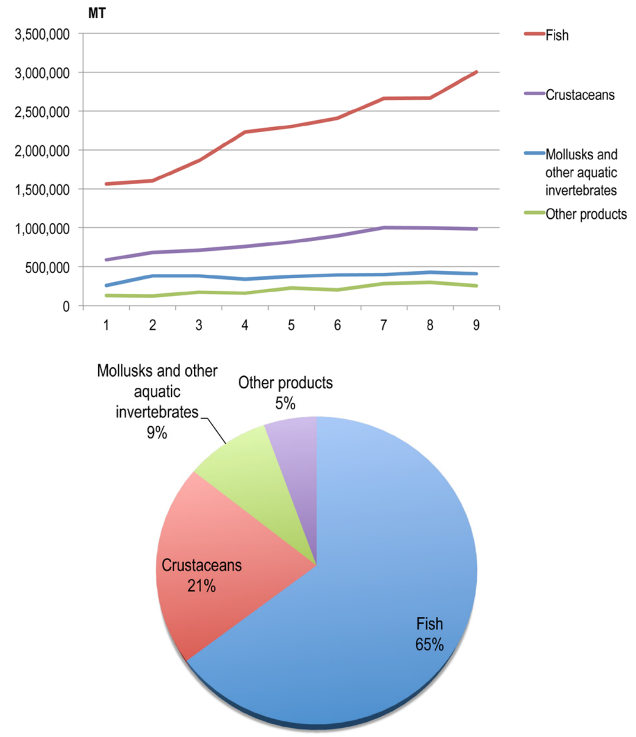


Figure 15. Major groups of commodities exported by the Southeast Asian countries in 2008

MT and Thailand at US$ 3,730/MT. On the other hand, Cambodia posted the lowest average value per metric ton of exported products at US$ 750/MT.

Moreover, from 2000 to 2008, the largest exported commodity is the "fishes" group which accounts for 65% of total export of the region, followed by crustaceans contributing 21% to the total export (**Table 41** and **Fig. 15**). Specifically in the case of Vietnam, its important export products are frozen shrimps, processed Pangas catfish which are mainly exported to Japan, Taiwan, South Korea, Hong Kong, the United States and the European Union. For Thailand, its major export fishery products included shrimps and canned seafood which are exported to the United States, Japan, Canada, and Singapore.

Furthermore, the import quantity of the Southeast Asian region which increased at the rate of about 139,160 MT annually (**Table 42**), posted a positive trade balance of about 1,541,400 MT in 2008. Although Thailand is the largest importing country, it still posted a positive trade balance of 221,565 MT (**Fig. 16**). On the other hand,

Table 41. Fish and fishery products exported by Southeast Asia (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Crustaceans	**588,337**	**684,492**	**711,793**	**758,504**	**818,594**	**899,674**	**1,000,908**	**995,896**	**983,362**
Frozen	417,571	460,098	489,987	512,425	561,982	603,595	666,398	672,100	643,444
Not Frozen	37,001	86,362	80,415	97,085	85,118	106,808	91,361	76,613	75,665
Prepared or preserved	133,765	138,032	141,391	148,994	171,494	189,271	243,149	247,183	264,253
Fish	**1,562,969**	**1,605,154**	**1,862,742**	**2,230,473**	**2,302,817**	**2,407,896**	**2,663,082**	**2,666,187**	**3,004,456**
Fillets, frozen	65,350	87,945	96,744	106,809	163,351	212,908	338,899	297,407	439,987
Meat and fillets fresh or chilled	5,307	7,745	11,833	14,755	5,417	8,037	8,529	31,468	22,213
Meat, whether or not minced, frozen	95,249	128,938	154,204	151,017	140,360	179,521	186,536	198,329	232,794
Prepared or preserved	492,547	567,552	623,194	730,870	732,202	835,383	890,473	905,002	995,289
Dried, salted and smoked	55,366	75,334	80,973	90,029	86,933	126,248	126,801	128,578	123,271
Fresh or chilled, excluding fillets and meat	308,179	310,920	321,933	323,722	321,483	303,516	312,636	335,363	308,280
Frozen, excluding fillets and meat	502,559	386,383	530,208	770,498	803,973	694,053	753,017	732,779	839,921
Live	38,412	40,337	43,653	42,773	49,098	48,230	46,191	37,261	42,701
Mollusks and other aquatic invertebrates	**257,980**	**382,804**	**384,252**	**338,164**	**376,146**	**392,684**	**400,131**	**431,767**	**408,510**
Live, fresh or chilled	17,319	80,811	61,582	71,834	52,703	48,770	23,151	24,841	31,848
Other than live, fresh or chilled	213,050	271,118	289,131	231,276	269,597	293,587	322,156	350,205	323,223
Prepared or preserved	27,611	30,875	33,539	35,054	53,846	50,327	54,824	56,721	53,439
Other products	**128,364**	**122,126**	**171,396**	**160,336**	**228,756**	**204,995**	**283,296**	**297,164**	**255,139**
Total	**2,537,650**	**2,794,576**	**3,130,183**	**3,487,477**	**3,726,313**	**3,905,249**	**4,347,417**	**4,391,014**	**4,651,467**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010)*

Malaysia which ranked second as the largest importing country posted a negative trade balance of about 388,270 MT (**Fig. 17**). Brunei Darussalam which had the least fishery production posted a negative balance of trade of 4,662 MT while Singapore which is the second country with the least fishery production also posted a high negative trade balance of 163,162 MT.

During the period from 2000 to 2008, the value of the products imported by the Southeast Asian countries increased by about US$ 317,350 annually (**Table 43**). In terms of average value per metric tons of imported products, Singapore had the highest value at US$ 4,060/MT followed by Brunei Darussalam at US$ 2,510/MT. As for Thailand which is the largest importer among the Southeast Asian countries, the value of its import was US$ 1,595/MT while the value of the Philippine import was the lowest at about US$ 840/MT.

VII. SUMMARY

Since the early 2000s, the Southeast Asian region has been responsible for the substantial and consistently increasing volume of the world's total fishery production, with the region contributing about 13% in 2000 to about 20% in 2009 or at an average of more than 16% annually. Among the Southeast Asian countries, Indonesia has maintained its position as the leading fish producer with its volume contributing an average of more than 30% annually to the region's total fishery production. The Philippines which ranked as the region's second highest producer contributed an average of about 18% while Vietnam's contribution to the region's total fishery production ranged from more than 11% in 2000 to about 17% in 2009 with an average of about 15% annually. This scenario reflects the important role that Indonesia's fishery sector has played in the region's economies.

On the other hand, the trend of the fishery production of Myanmar has been increasing fast especially starting in 2008. While the country has contributed only about 8% to the region's total fishery production in 2000, by 2009 it accounted for at least 12% with an average contribution of 10% to the region's fishery production from 2000 to 2009. Meanwhile, Thailand seems to be losing its grip on its fishery production as its contribution to the region's overall total had been decreasing from 22% in 2000 to only about 11% in 2009 decreasing at an average of more than 1% annually over the ten-year period. The region's fishery production comes from three major sources, namely: marine capture fisheries, inland capture fisheries and aquaculture. During the ten-year period from 2000 to 2009, marine capture fisheries had contributed substantially to the region's total fishery production followed by aquaculture and inland capture fisheries.

However, the contribution from marine capture fisheries has been decreasing from 70% in 2000 to only about 49%

Table 42. Import volume of fish and fishery products by the Southeast Asian countries from 2000 to 2008 (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brunei Darussalam	6,624	8,335	6,573	7,201	6,812	6,385	7,697	5,382	4,882
Cambodia	3,174	1,074	1,267	2,218	3,071	3,094	3,084	3,862	2,176
Indonesia	171,349	151,957	110,035	92,649	126,826	128,431	165,195	126,003	198,980
Lao PDR	2,510	3,142	2,725	3,026	3,943	3,594	3,028	3,190	3,884
Malaysia	*323,199**	*349,265**	*353,794**	*375,870**	*423,092**	*399,379**	*435,616**	*438,898**	*383,334**
Myanmar	1,525	565	464	1,053	1,650	1,846	1,393	1,699	2,416
Philippines	248,407	180,992	217,069	152,389	134,375	182,765	179,640	202,163	210,215
Singapore	183,934	174,391	179,616	215,305	227,340	253,552	244,646	239,686	225,703
Thailand	813,789	977,656	1,006,347	1,078,966	1,240,567	1,445,348	1,470,636	1,407,414	1,533,690
Vietnam	7,960	42,488	46,062	80,758	105,712	165,588	200,663	228,718	253,315
Total	**1,857,630**	**2,020,229**	**2,237,657**	**2,180,413**	**2,446,107**	**2,866,375**	**2,972,007**	**2,961,865**	**3,110,065**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*

Table 43. Import value of fish and fishery products by the Southeast Asian countries from 2000 to 2008 (US$ 1000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brunei Darussalam	15,239	13,379	13,136	11,847	14,415	15,766	25,646	15,907	12,260
Cambodia	2,724	467	586	3,090	3,225	3,714	4,341	5,086	2,443
Indonesia	101,644	93,730	79,095	75,903	143,669	106,330	142,742	118,966	202,029
Lao PDR	2,069	2,170	1,727	2,333	3,331	3,310	3,084	3,675	4,409
Malaysia	*307,448**	*335,180**	*343,871**	*375,631**	*542,341**	*533,921**	*587,028**	*648,196**	*591,607**
Myanmar	1,894	605	642	1,704	2,791	3,213	2,598	2,931	5,231
Philippines	111,596	71,362	92,524	86,405	73,892	102,798	101,105	132,765	176,560
Singapore	560,405	494,362	513,415	598,724	705,335	776,580	757,639	818,064	916,118
Thailand	826,699	1,072,925	1,079,930	1,134,471	1,255,346	1,457,936	1,573,958	1,750,024	2,447,759
Vietnam	36,242	60,145	116,141	151,622	218,636	276,576	302,425	373,470	461,125
Total	**1,965,852**	**2,145,850**	**2,297,541**	**2,443,603**	**2,958,752**	**3,277,086**	**3,493,875**	**3,865,759**	**4,822,005**

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia; but not used for the calculation of total production.*

in 2009 decreasing by an average of more than 2% every year. This situation would need special attention in order that marine capture fisheries could continue to provide a sizeable amount of fishery production to enhance the region's economies. On the other hand, the contribution from aquaculture to the region's total fishery production had been increasing from 22% in 2000 to 43% in 2009 or at an average rate of about 2.3% annually. Although the trend of aquaculture production is increasing with large volume being contributed to the region's total fishery production, there are still major concerns that need to be addressed in order that aquaculture would remain sustainable.

The region's inland capture fishery sub-sector appears to have potentials for further development especially if the sub-sector is given more attention. The sub-sector's contribution to the region's total fishery production from 2000 to 2009 indicated steady trend of about 8% annually even if the real trend could not be established due to lack of data from many countries. Following such situation, there is a need to improve data collection especially from inland capture fisheries in order that the actual contribution of inland capture fisheries to the region's economies could be established. It should be noted that Indonesia maintains its position as the highest producer of fish and fishery products not only from marine capture fisheries but also from aquaculture and inland capture fisheries as well.

Specifically in 2009, a big portion of Indonesia's production from marine capture fisheries comprised the mackerels which accounted for 26% of the country's total production from marine capture fisheries, especially the short mackerel (*Rastrelliger brachysoma*) followed by tunas providing 19% comprising mostly the skipjack tuna (*Katsuwonus pelamis*) and frigate tuna (*Auxis thazard*). For Vietnam, its main production comes from miscellaneous marine fishes which had not been classified by species. In the case of the Philippines, the main production also comes from mackerels especially the Indian mackerel (*Rastrelliger karnagurta*), accounting for 29% of the country's production from marine capture fisheries and tunas comprising mainly the skipjack and yellowfin tuna (*Thunnus albacares*), providing about 25%. From the current trend, it can be seen that the pelagic fishery resources are very important for the region's marine capture fisheries.

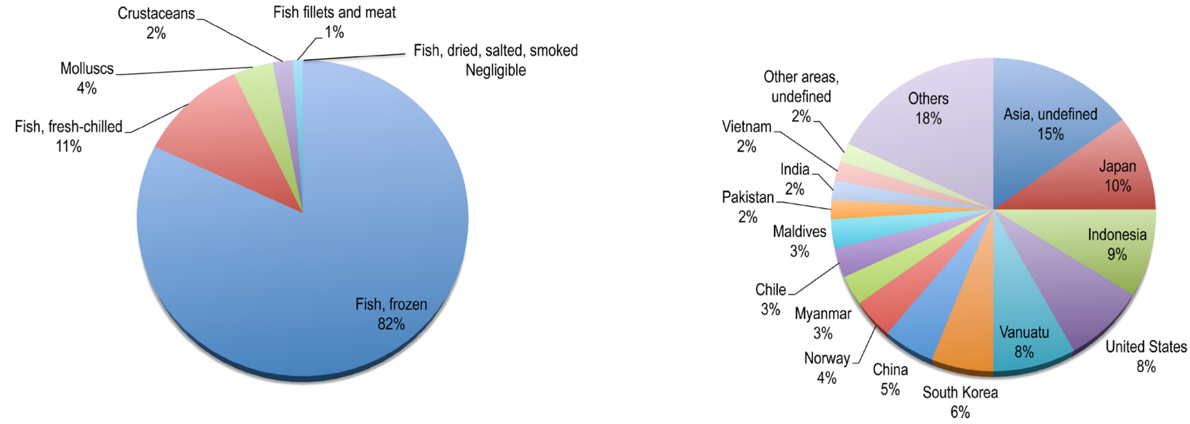


Figure 16. Thailand's import of fish and fish products in 2008 (left) and countries of origin (right)
Source: *Thailand's Trade Statistics for Imports (http://www.ats.agr.gc.ca/ase/5677-eng.htm)*

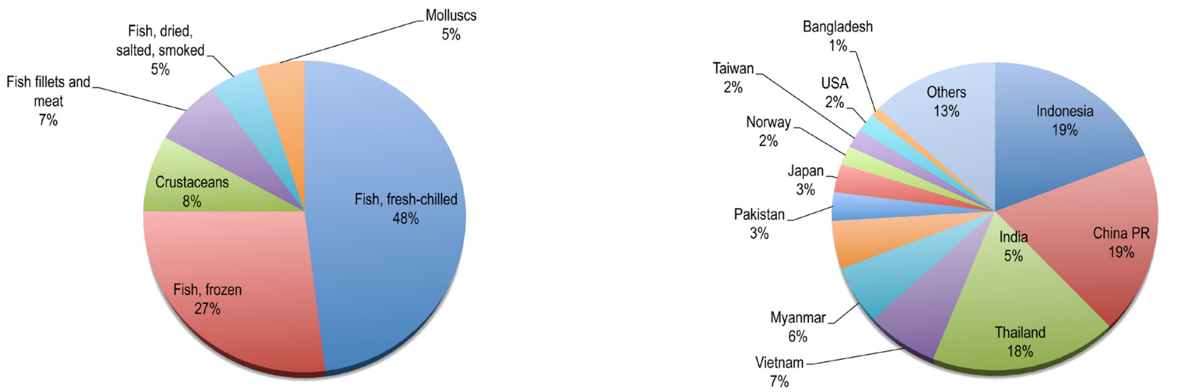


Figure 17. Malaysia's import of fish and fish products in 2008 (left) and countries of origin (right)
Source: *Malaysian External Trade Statistics (http://www.ats.agr.gc.ca/ase/5688-eng.htm)*

In the case of aquaculture, production comes from three main sources, namely: mariculture or marine culture, brackishwater culture, and freshwater culture. Indonesia's main products from mariculture are aquatic plants which had not been classified by species while that of the Philippines are the Zanzibar weeds (*Eucheuma cottonii*) accounting for 79% of the country's production from mariculture. This trend tends to suggest the importance of marine aquatic plants and seaweeds in the region's mariculture industry. For brackishwater culture, Indonesia's main products are miscellaneous marine fishes followed by *Penaeus* spp.although such species have not been specifically classified.

On the other hand, Thailand's production from brackishwater aquaculture comes mainly from *Penaeus vannamei* contributing 96% of the country's production from brackishwater aquaculture, while Vietnam's main production came from *Penaeus monodon* providing 57% to the country's production from brackishwater aquauculture. It should be noted that although the production from brackishwater aquaculture of Brunei Darussalam is minimal at 354 MT, this comprised mainly the Pacific blue shrimp (*Penaeus stylirostris*) accounting for 77% of the country's production from brackishwater aquaculture which is valued at about US$ 14,580/MT. This trend indicates the importance of *Penaeus* spp. to the region's brackishwater aquaculture industry.

In freshwater aquaculture, Vietnam's main production comes from *Pangasius* spp. accounting for 58% of the country's total production from freshwater aquaculture and the remaining 42% is provided by miscellaneous freshwater species which have not been classified by species. For Indonesia, its production indicates miscellaneous freshwater species which have not also been classified by species. Myanmar ranks third in terms of freshwater aquaculture production which comes mainly from roho labeo (*Labeo rohita*) accounting for 73% of the country's total production from freshwater aquaculture. Therefore, the economically important species for freshwater aquaculture in the Southeast Asian region seem to vary depending on the countries' technical capability.

PART II
Issues and Challenges in Sustainable Fisheries Development 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, aquatic plants, and invertebrates. The most economically important species being exploited from the region's pelagic fishery resources as well as from demersal, high sea, and deep sea resources include among others, tunas, mackerels, round scads, anchovies, and sardines. The production trend of various marine aquatic species presented in this publication is based on available data from various sources such as those from the respective country's national fishery statistical reports, the SEAFDEC Fishery Statistical Bulletin for the South China Sea Area until 2007, and the SEAFDEC Fishery Statistical Bulletin of Southeast Asia from 2008 to 2009. Information from these sources are being supplemented with data from the SEAFDEC programs on Information Collection of Some Small Pelagic Species in the South China Sea and Information Collection of the Highly Migratory Species in the Southeast Asian Region Focusing on Tunas, and other technical publications. Nevertheless, the main production data used in the foregoing sections are mostly based on the reports from the respective domestic fisheries under the jurisdiction of the countries in the Southeast Asian region.

1.1 Important Pelagic Fishery Resources

Small pelagic fishes such as scads, mackerels, anchovies, and sardines are among the most economically important commodities for many countries in the Southeast Asian region. These highly migratory fish species are commonly being thought of as moving across the Exclusive Economic Zones (EEZs) of more than one country and thus, are also known as shared stocks. The abundance of these possibly shared stocks show strong inter-annual fluctuations that are also subjected to the impacts of climatic change. The high fluctuations in stock abundance and the variability of their migratory behavior pose a great challenge in identifying not only the unit stocks but also the shared stocks (SEAFDEC/MFRDMD, 2000; SEAFDEC/MFRDMD, 2003). Accurate identification of specific shared stocks is also difficult because of inadequate quality or unavailability of relevant fishery statistical data and information. Considering the significant contribution of small pelagic species to the marine fishery production of the region, any delay in developing regional approach to manage these stocks will further expose these species to possible exploitation which at present, may probably be already at unsustainable levels.

For example, it has been reported in regional statistics that in 2008, small pelagic fish production accounts for more than 28% of the total fishery production from the South China Sea Area excluding the production of Cambodia and Vietnam, and more than 20% of the total fishery production in the Eastern Indian Ocean excluding production of Myanmar (SEAFDEC, 2010). Its contribution is even more significant in Brunei Darussalam, Malaysia and the Philippines although the respective countries' production showed fluctuating increment trends during the past ten years until 2008. Moreover, in some countries such as Indonesia and the Philippines which are the leading producers in terms of quantity followed by Malaysia and Thailand, small pelagic fish production has been considerably significant to the respective countries' economies (SEAFDEC/MFRDMD, 2003).

Considering the escalating figures in human population and the corresponding demand for fish and fishery products, there is a need to improve fishery production to supply such demand, and one option could be to develop fisheries aimed to increase production from under-exploited resources (Siriraksophon, 2006). It has been reported that under-exploited resources or those that are known to exist but have not been harvested to full potential, because of operational and economic constraints.

Moreover, it has also been known that under-exploited stocks exist in the Eastern Indian Ocean and the Western Central Pacific Ocean. These stocks mainly represent the pelagic species such as tunas, scads, mackerels, among others, although there is little scientific evidence to support the existence and extent of availability of these stocks (SEAFDEC/TD, 2006).

1.1.1 Tunas

The most exploited tuna species in the Southeast Asian region include the neritic or coastal tuna as well as oceanic tuna species which comprise the bullet tuna, frigate tuna, eastern little tuna, long-tail tuna, skipjack tuna, albacore tuna, yellowfin tuna, and bigeye tuna. The fishing gears used to exploit the tuna species vary from country to country, however the main type of gears are purse seine, long line, pole and line, trawl, hand line, and gillnet. In Southeast Asia, the main countries catching tuna include Indonesia, Philippines, Thailand, Malaysia, and Vietnam (SEAFDEC, 2010). Although Brunei Darussalam, Cambodia and Myanmar also catch tuna but their production data are minimal compared with those of the aforementioned five major tuna producing countries, but in view of inadequate statistics and landing data, tuna production of Brunei Darussalam, Cambodia and Myanmar have not been included in the foregoing analysis. The trend of the overall total tuna production of Indonesia, Philippines, Thailand and Malaysia from 1997 to 2007 had been increasing from 997,320 MT in 1997 to 1.6 million MT in 2007 representing about 5% annual increase or increasing by about 1.6 times during the last ten-year period (**Fig. 18** and **Fig. 19**).

For Indonesia, the total production increased from 515,158 MT in 1997 to 838,377 MT in 2007, but the catch dropped in 2001-2003 before increasing again. The tuna species are caught by small purse seine, long line, pole and line, and hand line from fishing grounds that cover various sea areas such as West Sumatera, South Java, Malacca Strait, East Sumatera, North Java, Bali-Nusatenggara, South/West Kalimantan, East Kalimantan, South Sulawesi, North Sulawesi, and Maluku-Papua.

On the other hand, production of tuna from the Philippines increased from 312,506 MT in 1997 to 618,500 MT in 2007 by almost twice in 10 years. Although the trend of the country's production also dropped in 2001, such trend rapidly increased starting in 2002 until after 2007. The fishing gears used in the Philippines include mainly the purse seine, ring-net, hand line, and hook and line. Although tunas are also caught in the coastal areas of the Philippines, the country's important fishing grounds for tuna are Sulu Sea and Mindanao Sea. For Thailand and Malaysia, only the production of neritic tuna such as long-tail tuna, bullet tuna and eastern little tuna had been reported during the earlier period. The total tuna production of these two countries did not change much during the 10-year period from 1997 to 2007, where the total catch of Thailand in 2007 was about 119,032 MT and 53,021 MT for Malaysia.

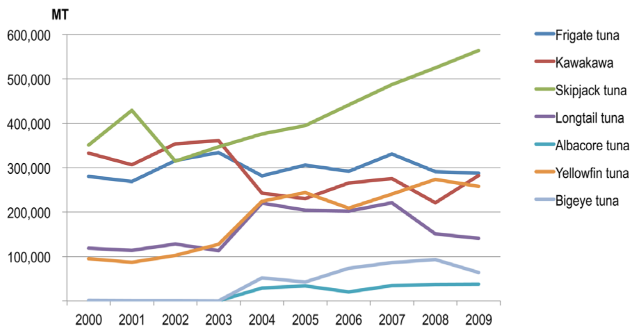


Figure 18. Production of major tuna species of the Southeast Asian region

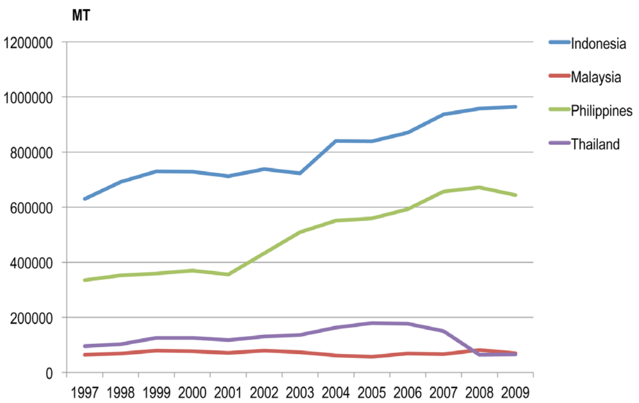


Figure 19. Trend of tuna production from four main tuna-producing countries of Southeast Asia

The main fishing gears used in both countries are purse seine and gillnet. Specifically in 2005, the tuna production of Thailand included about 74% eastern little tuna and 84% long-tail tuna, which had been reported to have come from waters of neighboring countries as shown in **Fig. 20**.

In terms of species composition, tuna caught in each country seems to vary depending on the sea areas and fishing grounds (**Table 8, Part I**). Overall, the highest percentage of about 28% is represented by skipjack tuna and 19% each for frigate tuna and little tuna, while yellowfin tuna and long-tail tuna accounted for about 14% and 12%, respectively of the total production. On the other hand, bigeye and albacore tuna provided less than 5% (**Fig. 21**).

Specifically, the catches landed in Palawan in Western Philippines increased from 38,740 MT in 2001 to 145,832 MT in 2006, an increase of almost 4 times within a period of five years. For the Mindanao Sea in Southern Philippines, the catches also increased from 6,050 MT in 2001 to a high of 183,000 MT in 2006 increasing by about 30 times, which could be because of the expansion of both hand line fisheries targeting the bigeye and yellowfin tunas, and purse seine fisheries targeting the young bigeye, yellowfin and skipjack tunas in the Western Pacific Ocean.

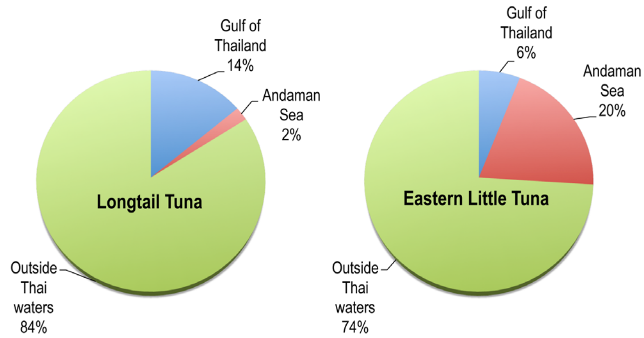


Figure 20. Tuna production of Thailand in 2005: from the Gulf of Thailand, Andaman Sea, and outside Thai waters

The results of a study conducted by SEAFDEC, especially on the catch distribution of tuna in the Southeast Asian region between 2001 and 2006 (**Fig. 22**), indicated that tuna fisheries in the Philippines had been developing very fast especially in the Sulu and Mindanao Seas in 2006 compared to that of 2001. Specifically through various surveys, SEAFDEC Training Department (TD) established the distribution characteristics and stock of transboundary tuna resources in the Eastern Indian Ocean (SEAFDEC/TD, 2002; SEAFDEC/TD, 2003; SEAFDEC/TD, 2006).

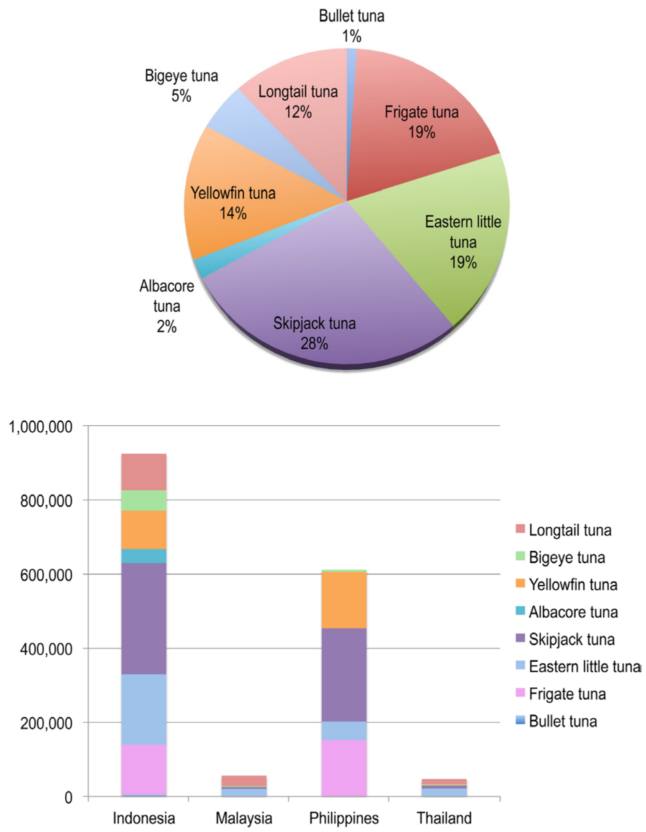


Figure 21. Species composition of tuna from four major tuna-producing countries of Southeast Asia

In 2008 and 2009, the production of tuna from Indonesia was dominated by the skipjack tuna followed by frigate tuna and yellowfin tuna. For Malaysia, the most dominant species was the long-tail tuna, and for the Philippines skipjack tuna provided the highest production followed by yellowfin, frigate and bullet tunas (**Table 44**). In terms of the value of tuna production of Indonesia in 2009 compared with that of 2008, the trend seems to indicate very drastic change which needs to be reconciled.

1.1.2 Round Scads

The three species of scads known to be found in the Southeast Asian region are the *Decapterus russselli*, *D. maruadsi*, and *D. macrosoma*. With round scads as the most common species in the region, these are mostly caught in their immature stage since mature fishes are rare in many areas as these are believed to migrate to deeper waters for spawning. Round scads have also been known to spawn in the central part of the Gulf of Thailand, and there is also an evidence of considerable migrations although no tagging activities have been conducted to confirm this presumption. Thus, stocks of *Decapterus* spp. are known to be migrating in many fishing areas and thus, are shared with possible considerable uncertainty of their limits, specifically from the Gulf of Thailand to Sunda Shelf, in Malacca Strait, Eastern South China Sea, and in the Gulf of Tonkin. However, it is also possible that one or more stocks are not shared especially those found in the waters of Indonesia.

The main fishing gear used to catch round scads is purse seine but the use of luring light techniques is common in Thailand as well as the use of payao, a type of fish aggregating device (FAD) is commonly used in the Philippines. Round scads are also caught by trawl net but it has been recorded that lift-net is used in the east coast of west Malaysia.

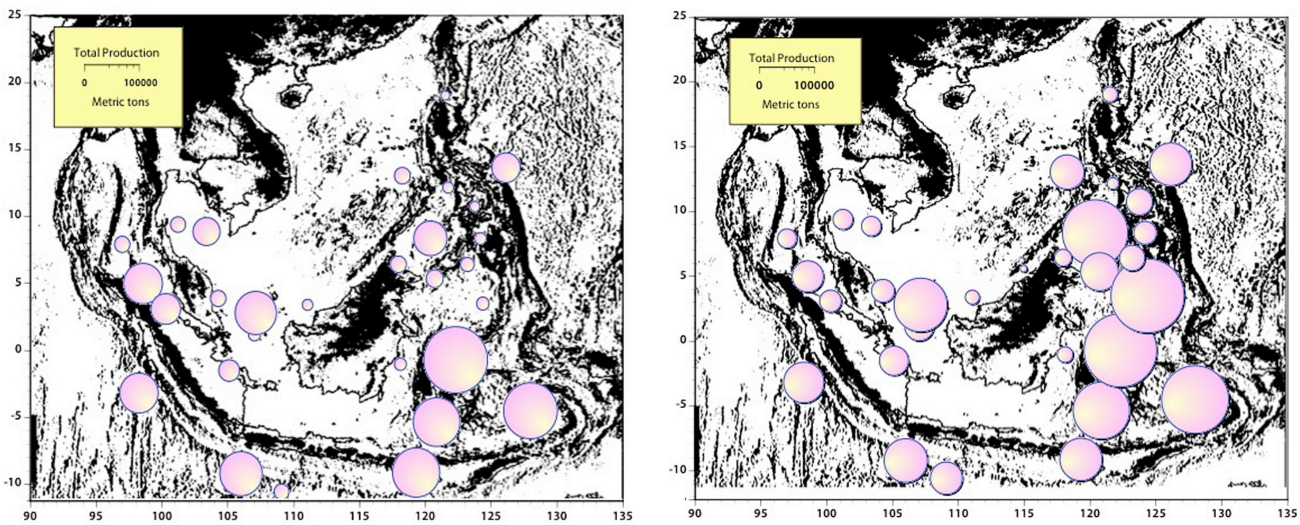


Figure 22. Relative distribution of tuna catches in Southeast Asia in 2001 (left) and 2006 (right)

Table 44. Production of major tuna species in the Southeast Asian region in 2008 and 2009

Country	FAO Common Name	Scientific Name	Quantity (MT)		Value (US$ 1,000)	
			2008	2009	2008	2009
Indonesia	Frigate tuna	*Auxis thazard*	134,744	135,200	10,835,815	51,159
	Bullet tuna	*Auxis rochei*	3,604	5,310	334,017	6,599
	Skipjack tuna	*Katsuwonus pelamis*	296,769	300,740	25,980,578	49,400
	Long-tail tuna	*Thunnus tonggol*	95,229	98,920	11,981,397	28,260
	Albacore tuna	*Thunnus alalunga*	36,538	37,380	6,133,317	19,910
	Southern bluefin tuna	*Thunnus maccoyii*	891	800	168,037	990
	Yellowfin tuna	*Thunnus albacares*	102,765	103,390	14,045,401	38,581
	Bigeye tuna	*Thunnus obesus*	53,979	54,660	6,133,188	20,110
Malaysia	Skipjack tuna	*Katsuwonus pelamis*	*329**	4,460	*390**	6,090
	Long-tail tuna	*Thunnus tonggol*	*41,493**	*27,569**	53,942	*43,209**
	Albacore tuna	*Thunnus alalunga*	359	203	*661**	297
	Yellowfin tuna	*Thunnus albacares*	1,459	1,403	3,812	2,662
	Bigeye tuna	*Thunnus obesus*	1,620	*1,837**	4,466	*3,771**
Philippines	Frigate/bullet tunas	*Auxis thazard/A. rochei*	156,341	-	188,821	-
	Skipjack tuna	*Katsuwonus pelamis*	222,010	251,524	296,506	264,186
	Yellowfin tuna	*Thunnus albacares*	168,411	152,437	292,107	249,592
	Bigeye tuna	*Thunnus obesus*	35,140	5,736	57,510	12,201

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

The total production of round scads based on the national statistics provided by four countries, namely: Indonesia, Malaysia, Philippines and Thailand from 1995 to 2004 indicated gradual increases from 640,000 MT to 792,000 MT, but the trend of the total production varied from 2005 to 2008 with the total production estimated as 785,000 MT in 2008. Considering the distribution of round scads which also indicated abundance in the Gulf of Tonkin of Vietnam, certain volume of catch data should have been reported by the concerned countries but this has not been the case as shown in the statistical reports. This means that the total production of round scads in the Southeast Asian waters could be higher than what is reported elsewhere.

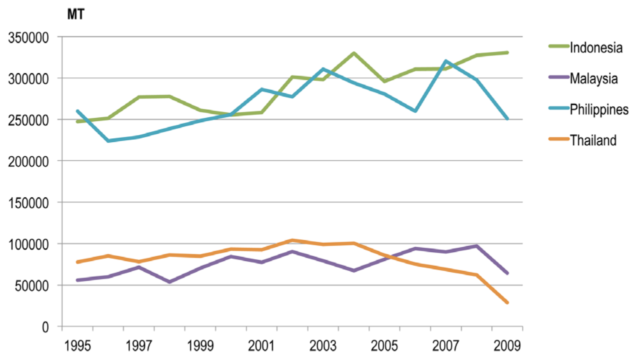


Figure 23. Round scads production in selected Southeast Asian countries (1995-2009)

Nevertheless, in the major producing countries of round scads such as Indonesia and the Philippines, their total catch varied from 250,000 MT in 1995 to about 320,000 MT in 2008 (**Fig. 23**). In the case of Thailand and Malaysia, production also varied from 55,000 MT to 100,000 MT but the catch of Thailand gradually decreased from 100,000 MT in 2004 to 60,000 MT in 2008 while that of Malaysia had been consistent at about 95,000 MT during the same period.

Based on the results of collaborative studies on round scads in the South China Sea conducted by SEAFDEC/MFRDMD from 2002 to 2006, *Decapterus macrosoma* are widely distributed in the coastal areas of the South China Sea from the Gulf of Tonkin, Gulf of Thailand and west coast of Borneo, and in Palawan and west coast of Luzon in the Philippines. The exploitation rate of *D. macrosoma* in the South China Sea varies from 0.42 to 0.90 depending on the specific fishing grounds (**Fig. 24**). For *D. maruadsi*, the exploitation rate also 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 Vietnam where the exploitation rate could be higher than 0.8.

As also reflected in the statistical data, although the production of round scads in the region had slightly increased from 2008 to 2009, the value of these species had abruptly been reduced by millions of US$ (**Table 45**).

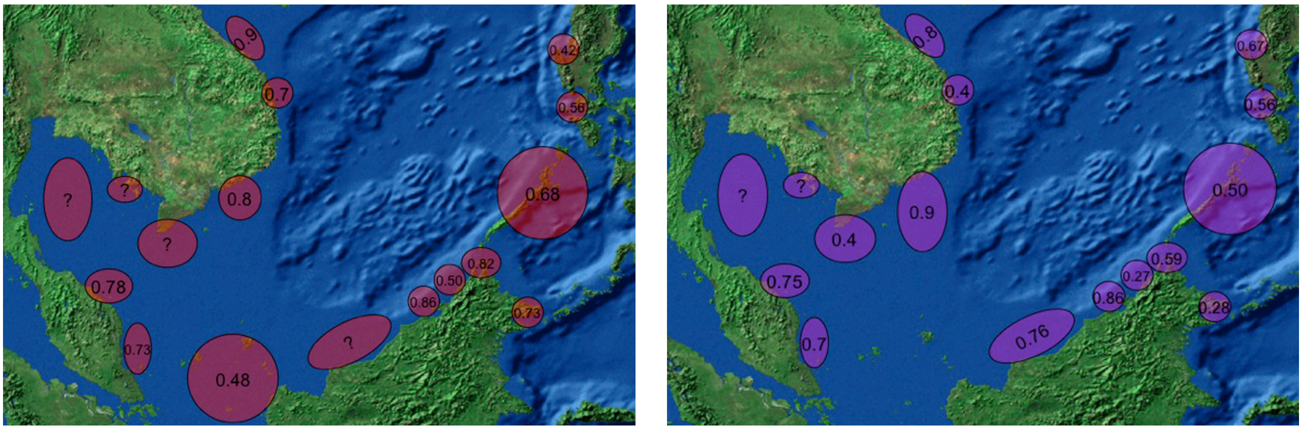


Figure 24. Exploitation rate of *D. macrosoma* (left) and *D. maruadsi* (right) in the South China Sea (2002-2005)

Table 45. Production of major scad species in the Southeast Asian region in 2008 and 2009

Country	FAO Common Name	Scientific Name	Quantity (MT)		Value (US$ 1,000)	
			2008	2009	2008	2009
Indonesia	Scads	*Decapterus* spp.	327,367	330,690	20,053,082	34,560
	Bigeye scad	*Selar crumenophthalmus*	7,927	9,270	535,519	1,290
	Yellowstripe scad	*Selaroides leptolepis*	150,830	153,490	12,102,171	43,890
Malaysia	Indian scad	*Decapterus russelli*	96,946	*92,016**	100,773	*110,850**
	Bigeye scad	*Selar crumenophthalmus*	*55,638**	*47,158**	*72,502**	*74,333**
	Yellowstripe scad	*Selaroides leptolepis*	*20,224**	*18,217**	*22,566**	*21,998**
Philippines	Scads	*Decapterus* spp.	297,892	251,072	315,179	262,969
	Bigeye scad	*Selar crumenophthalmus*	97,149	107,335	124,488	130,356
Vietnam	Indian scad	*Decapterus russelli*	-	27,829	-	33,444

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

1.1.3 Mackerels

In addition to scads, mackerels are also among the most important small pelagic fishes in Southeast Asia contributing about 39% to the small pelagic production or 10% to the total capture production in 2008. Its contribution is more significant in Malaysia, Brunei Darussalam and the Philippines as shown in **Table 46**. However, the production data show fluctuating increment trends for the past ten years until 2008 especially in some countries that provided their respective production data (**Fig. 25**). Indonesia and the Philippines are the lead producers in terms of quantity followed by Malaysia and Thailand. Due to negligible figures in terms of production, the data from Brunei Darussalam and Singapore are not included in the analysis.

Distribution of Scads and Mackerels by Ecosystem

In 2008, scads were reported to be more dominant than mackerels in the South China Sea where production of scads contributed 25% to the total small pelagic production or 7% to the total production while mackerels contributed 15% to the total small pelagic production or 4% of the total production. However, in the Eastern Indian Ocean mackerels are more dominant contributing 26% to the total landings of the small pelagic species, while scads contributed only 12% (**Table 47**). A comparison of the production trends of Indonesia, Malaysia and Thailand indicates that scads are more predominantly caught in the South China Sea than in the Eastern Indian Ocean except for Thailand. However, mackerels which are less dominant in the South China Sea of Indonesia and Malaysia are more dominant in the Gulf of Thailand than in the Andaman Sea of Thailand, suggesting that the species which is dominant in the Gulf of Thailand could be different from those in other parts of the South China Sea.

Nevertheless, the stocks of scads and mackerels in the adjacent EEZs of Thailand and Malaysia in the Eastern Indian Ocean and in the South China Sea Area are most likely shared. Therefore, once the stocks in one of the EEZs are over-exploited these could be replenished through recruitment of the species that originate from the other EEZ. However, over-exploitation of the same stock in both EEZs could lead to stock decline which could possibly result in total collapse of the stocks.

Table 46. Percent contribution of scads and mackerels to total fish production of Southeast Asia in 2008

	Brunei Darussalam	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Vietnam	Average
% to total catch	17	...	12	19	...	19	3	5	...	**10**
% to small pelagic	46	...	37	58	...	43	31	18	...	**39**

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

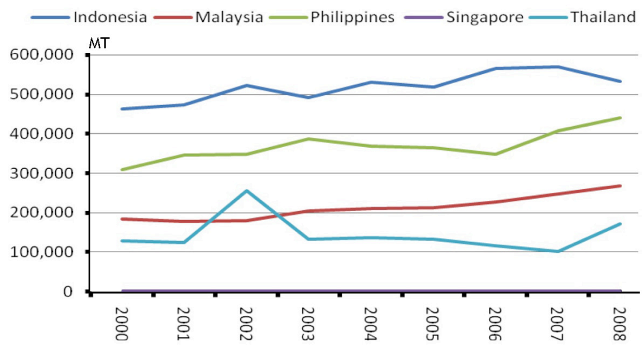


Figure 25. Production trends of scads and mackerels in selected Southeast Asian countries

Status of Scads in Malaysia and Thailand

Scads in the Gulf of Thailand are caught almost 100% by purse seine, while those from the South China Sea and landed in Malaysia are mostly caught by purse seine (89%) and 11% by trawl, drift/gill net, lift-net, and hook and line (**Fig. 26**). Although purse seine is the main fishing gear exploiting scads, the landings of scads by purse seine from these two waters clearly indicate an overall declining trend since 2002 (**Fig. 27**). For Malaysia, scads from the Straits of Malacca and the Andaman Sea are also exploited mainly by purse seine as shown in **Fig. 26**.

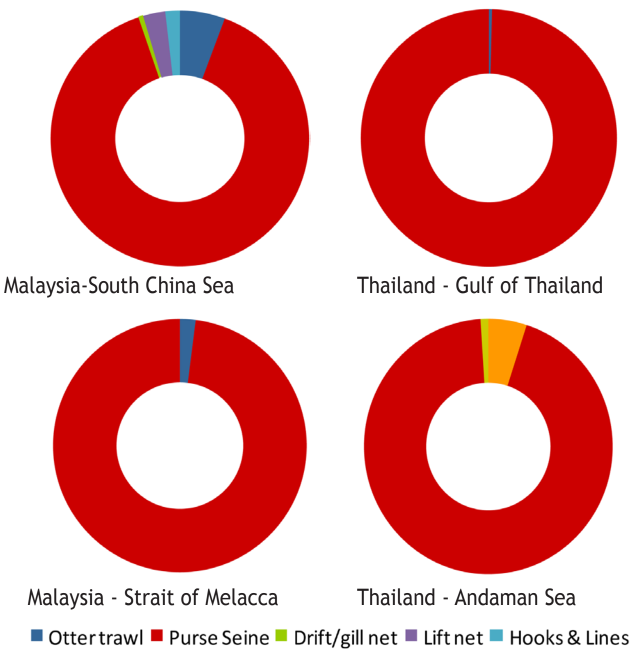


Figure 26. Landings of scads from the South China Sea (above) and Eastern Indian Ocean (below) waters of Malaysia and Thailand in 2007
(Source: Fishery Statistical Bulletin of Southeast Asia 2008 (SEAFDEC, 2010))

Table 47. Contribution of scads and mackerels to the total catch and total small pelagic fish production in the South China Sea and Eastern Indian Ocean in 2008

Ecosystem	Country	Scads		Mackerels	
		Total catch	Small pelagic catch	Total catch	Small pelagic catch
South China Sea	Brunei Darussalam	11	29	6	17
	Cambodia	?	?	?	?
	Indonesia	8	27	5	16
	Malaysia	8	26	4	13
	Philippines	13	29	6	14
	Singapore	3	38	?	?
	Thailand	0.4	1	5	16
	Vietnam	?	?	?	?
	Average	7	25	4	15
Eastern Indian Ocean	Indonesia	3	10	6	18
	Malaysia	6	16	21	59
	Myanmar	?	?	?	?
	Thailand	3	12	2	8
	Average	2	12	5	26

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

While the landings of scads by purse seine in the South China Sea are still increasing which is very prominent in the Straits of Malacca (**Fig. 27**), the same landing trends have also been observed in Malaysia and Thailand generally indicating that purse seines operating in the South China Sea especially in the EEZs of both countries probably exploit the same stock of scads. Since declining landing trends indicate that the stock is already over-exploited, therefore the stock of scads in the Eastern Indian Ocean may probably have already reached an over-exploitation level. As reported in 2008, there were about 2,336 units of purse seiners operating in the EEZs of these two countries. Therefore, it would be necessary to enforce suitable management measures solely for purse seine fishery operations in view of their direct impact on the stocks of scads considering that purse seine is the only gear exploiting the scads.

Status of Mackerels in Malaysia and Thailand

Mackerels are caught by various types of gears in the South China Sea although purse seine, trawl and drift/gill net are the main gears catching these species, and the contribution of mackerels to the landings in Malaysia as

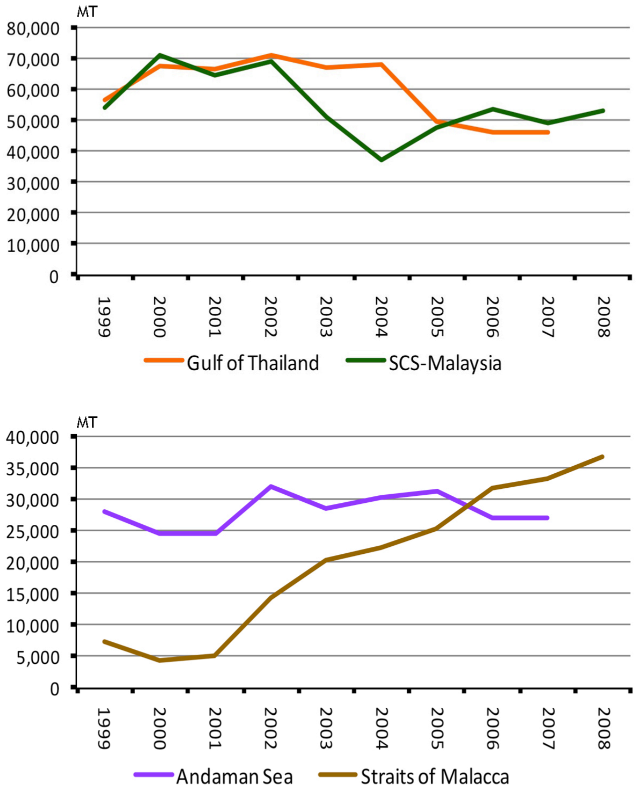


Figure 27. Landing trends of scads caught by purse seines in the South China Sea (above) and Eastern Indian Ocean (below) waters of Malaysia and Thailand in 2007
(Source: Fishery Statistical Bulletin of Southeast Asia 2008 (SEAFDEC, 2010))

well as in Thailand varies. In Malaysia, the catch from purse seines accounted for about 45% of the total catch in 2008, while that from drift/gill nets was 31% and from trawls 18% (**Fig. 28**). On the other hand, purse seine fisheries in the Gulf of Thailand contributed about 46% to the total catch in 2008, trawls contributed 51%, and drift/gill nets 3% (**Fig. 28**). In general, landings using these three main gears in Malaysia indicated fluctuating and declining trends, although a declining trend is more obvious in the Gulf of Thailand (**Fig. 28**). Such situation implies that the mackerel stocks in the South China Sea are already over exploited. Nonetheless, the question on whether these are the same stocks or whether the scads and mackerel stocks are shared among the countries in the region, still remain unanswered.

Records in 2008 indicated that mackerels in the eastern side of the Straits of Malacca are caught by purse seines (43%), drift/gill nets (37%) and trawls (20%). On the other hand, only purse seines and trawls catch substantial amounts of mackerels in the Andaman Sea in 2007, the percentage of which is almost equal to the total production, but landings from the drift/gill nets are almost not significant. Nevertheless, landings by the three main gears in the Straits of Malacca are still increasing by about three times more in terms of quantity than in the Andaman Sea (**Fig. 29**). Although, purse seine landings in the Andaman Sea indicate a continuous declining trend but the trawl landings show the opposite trend. As a whole, both landings have been declining since 2005 which suggest that exploitation could be involved in these two distinct fish stocks since the landing trends in Malaysia follows an opposite trend compared with that of Thailand.

Mackerel stocks are exploited by three main fisheries, namely: purse seine, trawl and drift/gill net. The fishing

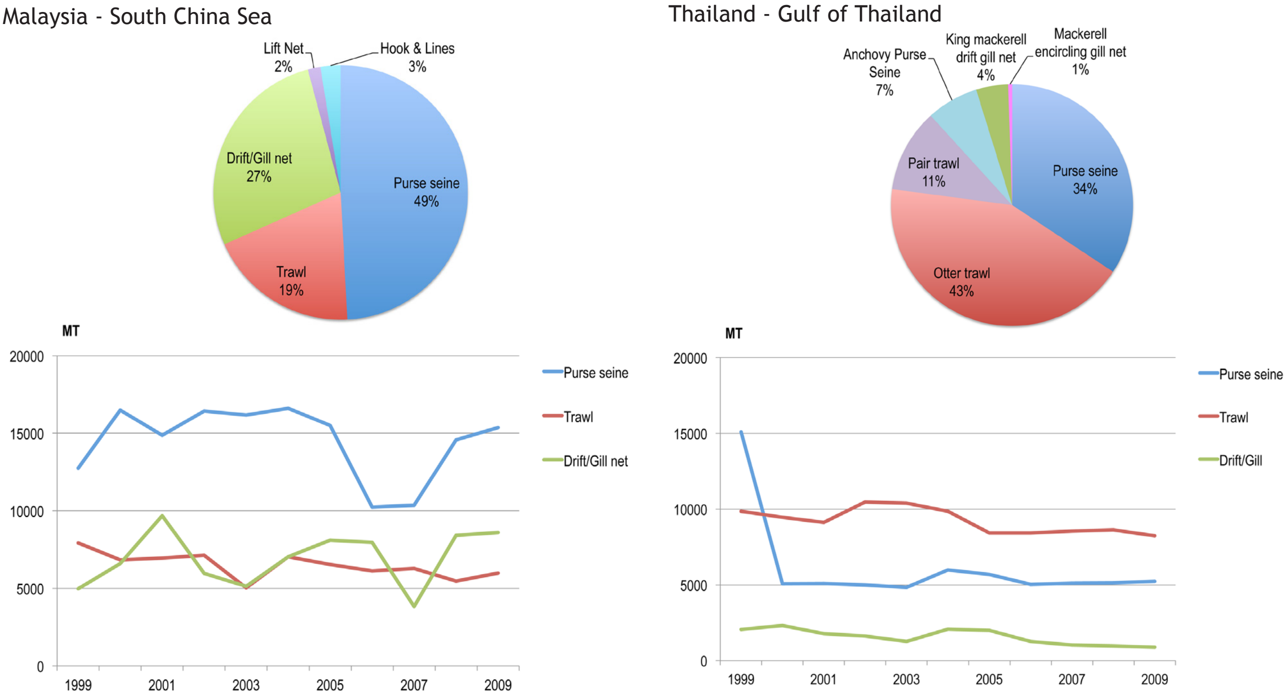


Figure 28. Landing compositions (2009) and production trends (1999-2009) of mackerels by main gear types of Malaysia and Thailand in the South China Sea areas
*(**Source:** SEAFDEC, 2010)*

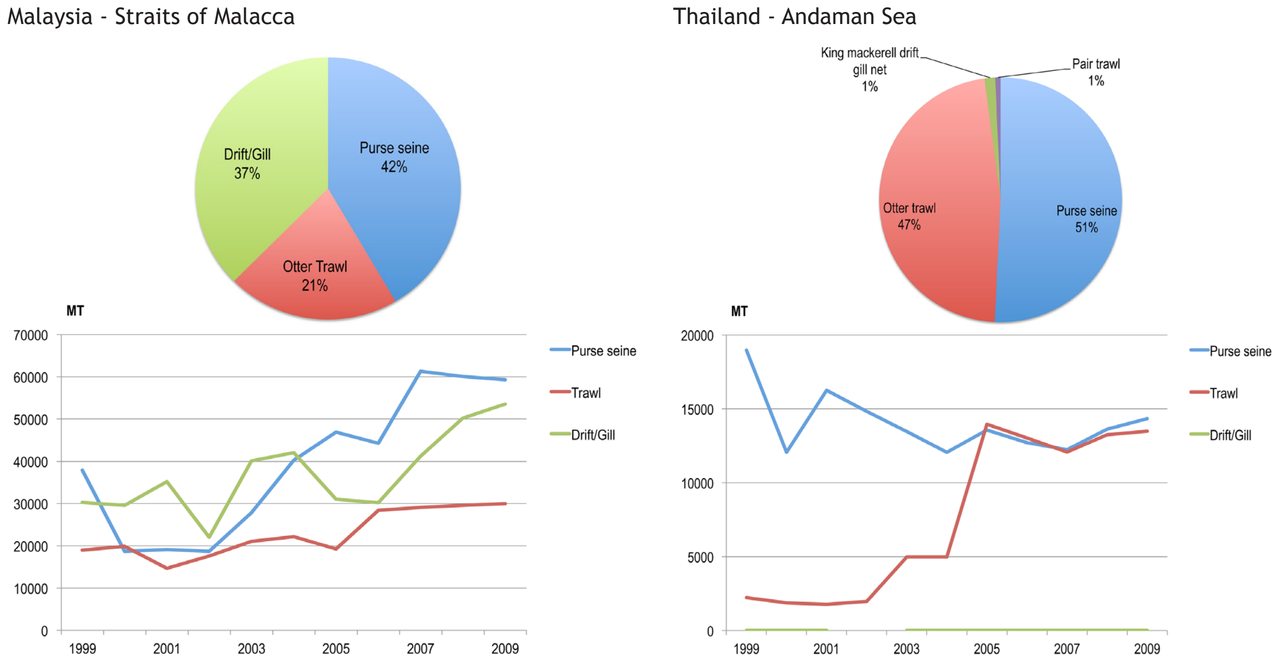


Figure 29. Landing compositions (2009) and production trends (1999-2009) of mackerels by main gear types of Malaysia and Thailand in the Andaman Sea
(Source: SEAFDEC, 2010)

grounds of purse seiners and trawlers are more offshore than those of the drift/gill netters. This requires an analysis of the landing data by species since distribution of the species could be varied. Results of a study conducted by the SEAFDEC/MFRDMD showed that the Indian mackerel (*Rastrelliger kanagurta*) comprised about 25% of the total catch of purse seines in the South China Sea off Malaysia, while the Indo-Pacific mackerel (*Rastrelliger brachysoma*) contributes only about 2% (Raja Bidin and Ku Kassim, 2007). In the Andaman Sea, purse seines using FADs and light purse seines are reported to be catching more Indian mackerels than the Indo-Pacific mackerels which are caught mainly by Thai purse seines. Likewise, trawlers using high opening trawl nets catch mainly the Indo-Pacific mackerels.

Identification of Shared Stocks of Scads and Mackerels

Based on the ten-year fishery statistical data provided and published yearly in the SEAFDEC Fishery Statistical Bulletin of Southeast Asia, the landing trends by group of fishes could be derived but not for the scads and mackerels group since production has not been reported at species level. Moreover, since fish distribution is shown by ecosystem rather than by national boundaries, analysis should also be done by ecosystem for the whole of South China Sea or Eastern Indian Ocean of the Southeast Asian region. In order to do this, countries in the region should provide the required data at certain level that could be used to describe the status of the fish stocks.

The availability of comprehensive statistical data at species level for the whole coverage area will help in the analysis and identification of the possible shared stocks in the region. This information combined with other scientific findings through tagging experiments and molecular analysis could help confirm the existence and extent of the shared stocks. This is important since effective management of shared stocks requires measures to be undertaken for the whole coverage area even if this is beyond the countries' national waters. Just like scads, the production of mackerels also increased from 2008 to 2009 but the value of the production had deeply decreased from 2008 to 2009 (**Table 48**).

1.1.4 Anchovies

Thirteen species of anchovies under the genus *Stolephorus* are found in the Southeast Asian region but only two, namely: *Stolephorus heterolobus* and *S. indicus* are the most common. Stocks of *Stolephorus* spp. are believed to typically form a number of local stocks close to the inshore waters although not always, and are also believed to have no regular migration patterns although moving about within a fairly well defined area. Nonetheless, the anchovies in the vicinity of the Southeast Asian waters are believed to form a transboundary shared stock. Although there could be several other stocks being shared in the region, very little information is available to confirm such situation.

Anchovies like other species feed mainly on planktonic crustaceans and breed throughout the year with a peak during the first part of northeast monsoon in Manila Bay (October to January), and in the Gulf of Thailand from February-April and July to December. Anchovies are

Table 48. Production of major mackerel species in the Southeast Asian region in 2008 and 2009

Country	FAO Common Name	Scientific Name	Quantity (MT)		Value (US$ 1,000)	
			2008	2009	2008	2009
Indonesia	Narrow-barred Spanish mackerel	*Scomberomorus commerson*	126,985	128,250	20,635,834	42,571
	Indo-Pacific king mackerel	*Scomberomorus guttatus*	24,505	26,360	5,029,161	34,850
	Queenfishes	*Scomberoides* spp.	13,412	14,520	1,224,639	5,150
	Blue mackerel	*Scomber australasticus*	455	510	19,285	140
	Short mackerel	*Rastrelliger brachysoma*	249,438	251,510	24,607,984	91,360
	Indian mackerel	*Rastrelliger kanagurta*	16,849	18,170	1,432,386	1,210
Malaysia	Seerfishes	*Scomberomorus* spp.	*14,630**	*12,633**	*53,826**	*46,471**
	Queenfishes	*Scomberoides* spp.	3,322	*2,772**	4,100	*3,509**
	Indian mackerels nei	*Rastrelliger* spp.	*170,321**	*185,490**	*213,153**	*295,038**
Philippines	Narrow-barred Spanish mackerel	*Scomberomorus commerson*	19,005	17,192	39,573	34,497
	Seerfishes	*Scomberomorus* spp.	7,334	-	-	-
	Queenfishes	*Scomberoides* spp.	-	6,959	-	-
	Chub mackerel	*Scomber japunicus*	1,255	1,866	-	-
	Short mackerel	*Rastrelliger brachysoma*	50,986	49,478	62,005	56,642
	Indian mackerel	*Rastrelliger kanagurta*	91,272	87,449	112,728	100,215

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

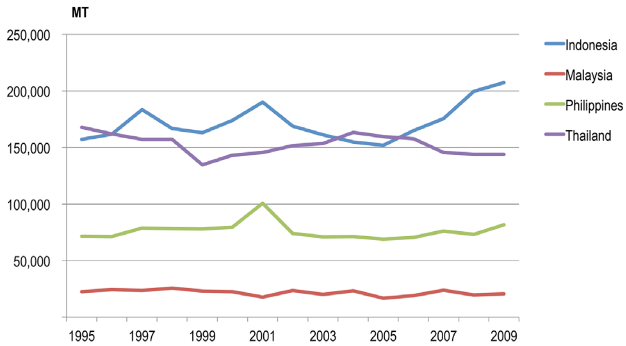


Figure 30. Production status and trends of anchovies in selected Southeast Asian countries (1995-2009)

mainly caught by anchovy purse seine operating in day time as well as in the night time with the use of luring lights, bamboo stake traps, luring light lift-net, set bag net, push net, and incidentally also by trawl fishing operations. The total production of anchovies from 1995 to 2007 based on the statistics from five countries such as Indonesia, Malaysia, the Philippines, Singapore and Thailand varied from 410,000 MT to 454,000 MT. The peak of the catch was observed in 2001 especially in Indonesia and the Philippines (**Fig. 30**).

The production of anchovies from Malaysian waters has not differed during the period from 1995 to 2007, which was around 20,000 MT (**Fig. 30**). Similar trend was also noted in the Philippines where the catch was about 70,000 MT except in 2001. In addition, the catch of anchovies in Indonesia and Thailand fluctuated where the average catch was about 170,000 MT for Indonesia and 150,000 MT for Thailand. Although the data in 2008 and 2009 were insufficient for stock assessment, the data seemed to indicate increasing trend in terms of volume but decreasing in terms of value (**Table 49**).

1.1.5 Sardines

Sardines are pelagic schooling fish species feeding on phytoplankton and zooplankton. There are six species of sardines specifically found in Thailand and in many countries of the region. However, the three common

Table 49. Production of anchovies in the Southeast Asian region in 2008 and 2009

Country	FAO Common Name	Scientific Name	Quantity (MT)		Value (US$ 1,000)	
			2008	2009	2008	2009
Indonesia	Stolephorus anchovies	*Stolephorus* spp.	199,675	207,450	21,013,687	84,201
Malaysia	Stolephorus anchovies	*Stolephorus* spp.	*19,600**	20,732	*24,433**	23,841
Philippines	Stolephorus anchovies	*Stolephorus* spp.	73,235	81,842	65,922	71,467

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*
* *Updated figures provided by Fisheries Management Information Division, DoF Malaysia.*

Table 50. Production of sardines in the Southeast Asian region in 2008 and 2009

Country	FAO Common Name	Scientific Name	Quantity (MT)		Value (US$ 1,000)	
			2008	2009	2008	2009
Indonesia	Spotted sardinella	*Amblygaster sirm*	5,618	6,050	72,258	120
	Goldstripe sardinella	*Sardinella gibbosa*	174,356	175,800	10,645,067	22,110
	Bali sardinella	*Sardinella lemuru*	139,350	139,010	5,345,563	36,790
Malaysia	Diadromous clupeoids nei	*Clupeoidei*	850	1,025	4,382	3,657
Philippines	Sardinella nei	*Sardinella* spp.	369,199	467,853	208,562	232,967

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

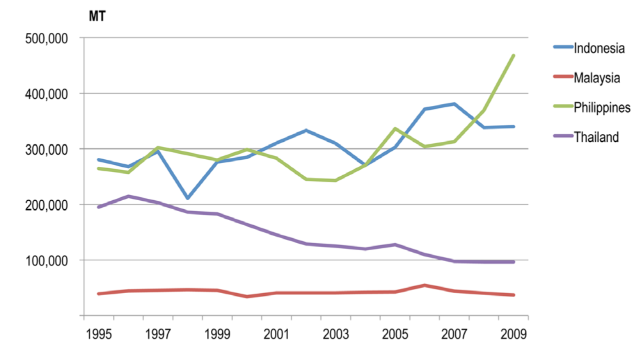


Figure 31. Production status and trends of sardines in selected Southeast Asian countries (1995-2009)

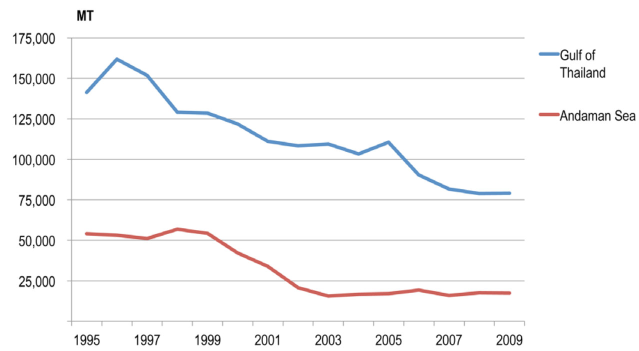


Figure 32. Decline in production trends of sardines in the Gulf of Thailand and Andaman Sea (1995-2009)

species are: *Sardinella gibbosa*, *S. frimbriata*, and *S. albella*. Sardines are normally scattering in the coastal and offshore areas at water depths ranging from 30 to 70 m. The peak of the spawning season of sardines is in March-April and July-August in the Gulf of Thailand. The main fishing gear used is purse seine with and without luring lights, encircling gill net, lift-net, set net, and bamboo stake trap. For countries like Indonesia, Philippines and Malaysia, sardines are also among the important small pelagic species and are usually utilized for several products such as canned, dried, smoked, boiled, fermented (fish sauces), cured, made into fishmeal, and also marketed fresh.

However, the total production of the main sardine producing countries in the region seemed to have fluctuated from 1995 to 2007, with the total catch varying within the range from 730,000 MT and 846,000 MT, with peaks noted in 1996 and 2006. By country, the total catch of sardines was stable at about 50,000 MT in Malaysia, while for Indonesia and the Philippines the catches fluctuated but seemed to follow slight increasing trends during the period from 1995 to 2007 with the sardine catch of the Philippines increasing from 264,000 MT in 1995 to 313,000 MT in 2007. In addition, the sardine catch of Indonesia also increased from 280,000 MT in 1995 to 380,000 MT in 2007 (**Fig. 31**).

Specifically for Thailand, sardines production gradually declined from 220,000 MT in 1996 to about 100,000 MT in 2007 (**Fig. 32**), where most of catch came from the Gulf of Thailand which was about three times more than that of the Andaman Sea. Nonetheless, the total catch also seemed to be declining in the Gulf of Thailand and Andaman Sea from 162,000 MT in 1996 to 82,000 MT in 2007, and from 53,000 MT to 16,000 MT, respectively, and the overall production of sardines in selected Southeast Asian countries from 2008 to 2009 seems to have increased as shown in **Table 50**.

1.2 Deep Sea Fishery Resources

Although almost 50% of the Southeast Asian waters comprised continental shelf but there are also continental slopes and deep basins down to nearly 1,000 to 5,000 meters deep which form the largest habitats of various fishery resources especially around Indonesia, Philippines, and some parts of Andaman Sea (Sukramongkol, 2011). Within the depth of 100 meters, the fishery resources are intensively exploited by trawl fisheries especially the shallow-water fish species which have been well documented (Siriraksophon, 2006; Yasook, 2008; SEAFDEC/TD, 2009). Attempts to assess the status of the demersal resources at the unexploited range of 200-350 meter depths have been undertaken since late 70s by the Norwegian research vessel, Dr. Fridtjof Nansen in association with FAO (Nishida and Sivasubramaniam, 1986). However, information and biological knowledge on the deep sea fauna in the EEZs of the Southeast Asian countries are still inadequate especially the demersal resources in the continental shelf and slope beyond 100-meter depth. Currently, comprehensive knowledge on deep sea fishery resources could only be made available from results of research explorations under some collaborative programs, *e.g.* "Census of Marine Life" survey project in Philippine Waters in 2005-2008, the "OFCF-AMFR Deep-Sea Joint Exploration" survey in the West Coast of Sumatra and Java of Indonesia between 2004 and 2005, "BIOSHELF Scientific Corporation Program" between Denmark and Phuket Marine Biological Center at the Andaman Sea of Thailand between 1996 and 2000 (Aungtonya *et al*., 2000; OFCF and AMFR, 2006; SEAFDEC, 2008; SEAFDEC, 2009b; SEAFDEC, 2010b).

A number of explorations conducted since 2004 in many areas off the Philippines and Indonesian waters where the sea depth ranged between 200 and 1000 meters provided general knowledge about the high diversity and abundance of fishery resources in these areas. Specifically, results of the surveys revealed that these areas serve as habitats of commercially useful species such as the red roughy (*Haplostethus crassispinus*), black roughy (*Haplostethus rubelloterus*), Alfonsino (*Beryx splendens*), and blackthroat seaperch (*Deoderlrieinia berycoides*) in the West Coast of Sumatra and Java of Indonesia, and significant catches of pandalid shrimps (*e.g. Heterocarpus woodmasoni*, *H. hayashii*, *H. dorsalis*) which were recorded in the continental shelf and slope off the West Coast of the Philippine waters (OFCF and AMFR, 2006; SEAFDEC, 2008). Results from the said joint explorations indicated that the fishery resources at the various parts of Indonesia and the Philippines are still under-exploited.

However, the ecosystems and resources are likely becoming vulnerable, particularly taking into consideration the low-productivity species and sensitive deep sea habitats. Such status could also be affected by the countries' current efforts and plans to expand their respective fishery operations towards the deep water areas. Responding to the increased human demand of fishery resources, attempts have been made by many countries to undertake commercial deep sea fishery operations starting in 2008. Commercial deep sea fishing practices such as gillnet, trawl, bottom longline, multiple hook and line, and traps had been undertaken in Indonesia and the Philippines (SEAFDEC, 2010b). However, the possible impacts of deep sea fishing are unknown because such practices are not yet well studied while there are still no specific regulations related to deep sea fishing practices that would ensure sustainable utilization of the deep sea resources in the Southeast Asian region. In addition, there is also limited knowledge on appropriate technologies for the utilization and exploitation of deep sea fishery resources. The FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas had been developed and adopted in 2008. Such Guidelines should therefore be taken into consideration by the countries intending to develop their respective deep sea fisheries. Since the Guidelines include deep sea fisheries within national jurisdictions, the implication of the extent of management requirements for deep sea fisheries in the EEZs should be carefully studied by the concerned countries.

1.3 Species Under International Concern

Driven by the world's escalating population growth and rising global demand for fishery products, fishing capacity has also been increasing over the years. As a result, approximately 47% of the main fishery stocks or species groups are fully exploited and are therefore providing catches that have reached or are very close to their maximum sustainable limits. Over time, the international community has launched various initiatives aimed at improving the conservation status of commercially-exploited aquatic species under the domain of both binding international and soft laws for the protection of various commercially-exploited aquatic species. Several regional fishery bodies (RFBs) and arrangements also play important role in the conservation and management of the fishery of commercially-exploited aquatic species such as tunas, sharks and billfishes in far-flung sea areas covering the coastal states and high sea areas. In order to regulate the trade and secure the sustainability of the fishery of endangered aquatic species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as an international agreement among governments adopted in 1963, ensures that the international trade of specimens of wild animals and plants does not threaten their survival. Through the efforts of CITES, varying degrees of protection have been accorded to more than 30,000 species of animals and plants that are traded as live specimens, fur coats or dried herbs as the case may be.

For marine species, several commercially-exploited aquatic species have already been listed in the CITES Appendices such as the African blind barb fish and black corals (Appendix II in 1981), giant clams and hard corals (Appendix II in 1985), queen conch (Appendix II in 1992), sturgeons and paddlefish (Appendix II in 1998), coelacanths (Appendix I in 2000), basking shark, whale shark, and seahorses (Appendix II in 2002), humphead wrasse (Napoleon fish), great white shark, and Mediterranean date mussel (Appendix II in 2004), sawfishes (Appendices I and II in 2007), and European eel (Appendix II in 2007). Recently, the Atlantic bluefin tuna, red and pink corals, and eight shark species were proposed to be listed in the CITES Appendices during the last COP15-CITES in 2010. The Southeast Asian countries have noted the issues carefully because such aquatic species are economically-exploited in the region and thus, are economically important considering their close relationship with the region's traditional fisheries particularly the small-scale fisheries. However, due to insufficient information from stock assessment and scientific evidence, the countries in the Southeast Asian region required more time to undertake the necessary measures to react on the proposal for listing such species in the CITES Appendices. The countries are now developing conservation measures and working towards sustainable fishery management of such species considering that their possible listing in the CITES Appendices could directly or indirectly affect the national economies and livelihoods of small-scale fishers in the Southeast Asian region.

The issues on the sustainable fishery management of economically-exploited aquatic species have been discussed at SEAFDEC Meetings for many years. Specifically, while considering the importance of the issue on sharks and the possible listing of shark species in the CITES Appendices, the 43rd Meeting of the SEAFDEC Council in 2011 requested SEAFDEC to support the Member Countries by coming up with scientific information and evidence to support the development of common position of the Member Countries. In this regard, SEAFDEC also recognized that policy recommendations and management plan on the improvement of data collection of commercially-exploited species in the Southeast Asian region would be crucial in order to come up with the required information that would support the assessment of the stocks of such species.

1.3.1 Sharks and Rays

Sharks and rays, (Subclass Elasmobranchii) biodiversity in Malaysia, Indonesia and Thailand is the richest in the Southeast Asian Region, with at least 252 species from 44 families comprising 129 species of sharks under 7 orders and 27 families and 123 species of rays from 6 orders and 17 families. The species inhabit the waters of these three countries from fresh water environment to deep ocean. Indonesia recorded the highest biodiversity of sharks with at least 110 species from 26 families, followed by Thailand with 63 species (20 families) and Malaysia with 62 species (18 families). As for rays, Indonesia also have the highest number with 104 species from 17 families followed by Malaysia with 79 species (15 families), and Thailand 64 species and 13 families (**Table 51**).

Only a few species of sharks and rays are dominant but the dominant species are vary among the countries with oceanic species are rarely caught, except for Indonesia. In general the most dominant sharks species caught are spot-tail shark, *Carcharhinus sorrah*; silky shark, *Carcharhinus falciformes*; blacktip reef shark, *Carcharhinus melanopterus*; bull shark *Carcharhinus leucas*; milk shark, *Rhizoprionodon acutus*; scalloped hammerhead shark, *Sphyrna lewini*; grey bambooshark, *Chiloscyllium griseum*; and brownbanded bambooshark, *Chiloscyllium punctatum*. As for rays, the most dominant species in general are blue-spotted maskray, *Neotrygon kuhlii*; whitespotted whipray, *Himantura gerrardi*; scaly whipray, *Himantura imbricata*; pale-edged stingray, *Dasyatis zugei*; leopard stingray, *Himantura uarnak*; whitenose whipray, *Himantura uarnacoides*; and dwarf whipray, *Himantura walga*. The fresh water sharks and rays species such as the Borneo river shark, *Glyphis fowlerae*; giant freshwater stingray, *Himantura polylepis*; white-edge freshwater whipray, *Himantura signifer*, Mekong stingray, *Dasyatis laosensis* and roughback whipray, *Himantura kittiponggi* are rarely found and endemic within certain area and are threatened to overfishing. Sawfishes species such as *Pristis microdon*; knifetooth sawfish, *Anoxypristis cuspidata*; green sawfish, *Pristis zijsron* and smalltooth wide sawfish, *Pristis pectinata* are now very rarely seen and listed as endangered species in all countries.

Most ray species especially those are localized within estuarine and coastal waters are no longer appeared due to heavily fishing pressure. Freshwater ray species especially *Himantura polylepis* is now becoming endangered in all countries. Endemic species especially confined in freshwater rivers such as *Himantura signifier*, *Dasyatis*

Table 51. Number of sharks and rays in Malaysia, Indonesia and Thailand compared with that of the world's total number

Group	Number of Order	Number of Family	Total number of species (Malaysia, Indonesia, Thailand)*	Total number of species (World)**	Percentage compared to number of species in the world
Sharks	7	27	129	479	26.9
Rays	6	17	123	604	20.4
Total	**13**	**44**	**252**	**1083**	**23.2**

Sources:
**SEAFDEC/MFRDMD study*
***Compagno (2002); Compagno and Last (2002)*

Table 52. Number of species and families of sharks and rays in Malaysia, Indonesia and Thailand

Country	Sharks		Rays		Total (Sharks & Rays)	
	Total family	Total species	Total family	Total species	Total family	Total species
Malaysia	18	62	15	79	33	141
Indonesia	26	110	17	104	43	214
Thailand	20	63	13	64	33	127

Sources: *Fahmi, 2010; Vidthayanon, 2020; and Yano et.al, 2005* *laosensis* and *Himantura kittipongi* are also affected by the pressure from fisheries activity and other human-induced sources of habitat degradation.

Even though the number of sharks and rays species recorded in Malaysia, Indonesia and Thailand is more than 250 species, the status of its biomass is still unknown (Ahmad and A.P.K.Lim, 2011). With new species continuously discovered, the number could increase in the future.

Specifically, deep water species are mostly unknown due to limited research activity, while fishers from Indonesia reported to have caught deep water sharks using long line. The total number of sharks and rays in these countries is about 23% of total number recorded in the world which is now more than 1080 species of which sharks account for about 27 % and rays about 20% (**Table 52**).

The abundance of Chondrichthys fauna in the Southeast Asian Region and it adjacent area is due to the region's geographical location covering many seas such as South China Sea, Gulf of Thailand, Sulu Sea, Philippine Sea, Celebes Sea, Flores Sea, Makassar Strait, Karimata Strait, Java Sea, Malacca Strait, Andaman Sea, Indian Ocean and western part of Pacific Ocean. Moreover, the coastal waters of many countries in the region also comprise a rich ecosystem characterized by the existence of areas with extensive coral reefs and seasonal up-welling, as well as nutrient from land that are suitable for breeding, spawning, nursing and growing of wide diversity of fish species including sharks and rays.

Diverse sharks and rays faunas occupy a variety of habitats from freshwater river to oceanic realms beyond the continental shelves. According to Compagno (2002) and Last and Compagno (2002), the habitats occupied by sharks and rays could be categorized into: marine continental and insular shelves (from freshwater lakes and rivers to 200 m depth, the continental and insular slopes below 200 m and extending to 2000 m depth, and oceanic realm beyond the continental shelves and above the slopes and ocean floor. Many species overlap two or more of these categories of habitats which could be classified as shelf to slope (SHS), slope to oceanic (SOC), shelf to oceanic (SHO), shelf to semi-oceanic (SSO) and wide range of habitats (WRH). Others habitats are euryhaline freshwater/ shelves (SHF) confined in oceanic (OCE), continental/ insular shelves (SHL) and continental/insular slopes (SLO). Compagno and Cook (1995) placed freshwater elasmobranch for those species confined in freshwater as obligate freshwater (FWO).

The habitats preferred by species of sharks and rays species in Malaysia, Indonesia and Thailand (Compagno, 2002; Last and Compagno, 2002) indicated that rays are

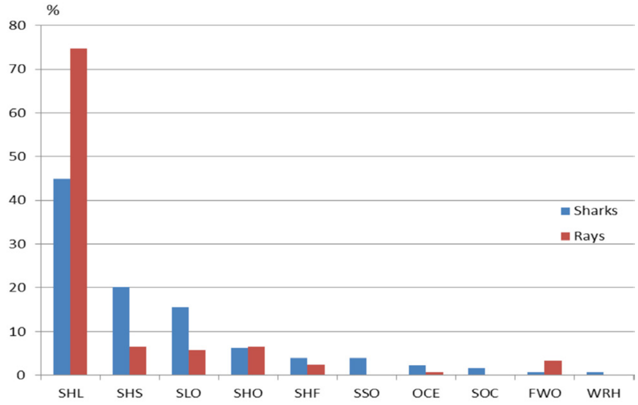


Fig 33: Overall habitat preferred (in percent) by species of sharks and rays in Malaysia, Indonesia and Thailand

mostly adapted to a benthic life style and dominant in continental/insular shelves (SHL). Only some species are pelagic compared to sharks which are dominant in more categories especially within continental/insular shelves (SHL), shelf to slope (SHS) and continental/insular slopes (SLO). In general a total of 58 species of sharks (45%) and 92 species of rays (75%) inhabit the continental/insular shelves (SHL): 26 species of sharks (20%) and 8 species of rays (7%) in shelf to slope (SHS); and 20 species of sharks (16%) and 7 species of rays (6%) in continental/insular slopes (SLO). The other categories such as freshwater (FWO), wide range (WRH), slope to oceanic (SOC), shelf to semi-oceanic (SSO) and oceanic (OCE) are inhabited by only 1-5 species except for shelf to oceanic (SHO) with 8 species of sharks and rays respectively (**Figure 33**).

Various issues on sharks had been raised by the ASEAN and SEAFDEC during the 13th Meeting of the Fisheries Consultative Group of the ASEAN-SEAFDEC Strategic Partnership in 2010, where SEAFDEC was asked to support the Member Countries in coming up with information/ scientific evidence to support the development of regional common position to address the global issues on sharks. Specifically, the Meeting identified the priority areas that should be undertaken by SEAFDEC, which included the improvement of data collection on sharks at the national level and the implementation of human resource development activities on species identification of major shark species in the region. Such issues and challenges in conserving and managing shark and ray resources were followed-up recently at the Special Meeting on Sharks Information Collection in Southeast Asia organized by SEAFDEC in September 2011 in Thailand (**Box1**).

During the Meeting, it was recognized that most of the countries in this region have developed their respective national management plans for sharks (NPOA-Sharks) and are in the process of implementing such plans. The major types of management measures related to sharks and rays conservation include: establishment of shark/ray no-take zones in national Marine Parks or marine protected

Box 1. Recommendations from the Special Meeting on Sharks Information Collection in Southeast Asia, Bangkok, Thailand, 15-17 September 2011

Issues, problems and concerns relevant to sharks collection and utilization in the Southeast Asian region were identified, including the inadequacies in stock assessment of sharks and rays as well as insufficiencies in terms of knowledge and skills in species identification especially for the look-alike species of sharks and rays.

For effective management of sharks and rays in the Southeast Asian region, the Meeting recommended that:

- appropriate methodologies should be developed including the conduct of genetic studies for species identification of dominant species based on dried fins and landed fins;
- R&D aimed at identifying and/or developing appropriate models/methodologies for stock assessment of selected dominant species of sharks and rays should be undertaken;
- effective management tools and fishing techniques should be identified that could lead to the reduction of by-catch from fisheries including endangered species of sharks and rays; and
- collaboration among the SEAFDEC Member Countries for the improvement of data collection and stock assessment especially at sub-regional or regional level should be strengthened.

Specifically, the key issues and constraints on the conservation of sharks and rays confronting the region included:

- Most sharks and rays on the continental shelf are incidentally caught by bottom trawl fisheries, although small numbers of small-scale fisheries also operate bottom long line targeting stingrays. Moreover, most sharks and rays in offshore/oceanic areas are also caught as by-catch using pelagic long line and drift gillnet.
- Insufficient information on stock structure, abundance, life history and reproductive rate of dominant/important commercial species of sharks and rays both for marine and freshwater areas.
- Current national statistical data collection does not record landing of sharks and rays by species, while catches from outside the territory (EEZs) are also merged into the national data.
- Inadequate efforts on the assessment of the status of the habitats of sharks and rays.
- Insufficient knowledge on species identification (limitations in the identification of shark/ray species from the color of fresh and preserved specimens), especially the look-alike species of sharks and rays.
- Inadequate national policy, program and related activity to support effective management of sharks and rays.
- Limited public awareness on sharing of data/information among fishers, local communities, and other key stakeholders to support of the fishery management including management of sharks and rays.
- Inadequate understanding on fishing gears and their practices, especially for the improvement of management measures for sustainable utilization of sharks and rays.
- Limited investments and/or collaboration in research and management of sharks and rays.

areas/periods; and prohibition of the use of specific gears in specific management areas. Moreover, it was also recommended that information collection on sharks and rays in the region should be improved and training on shark species identification should be conducted, while the need to set up routine or long-term information collection on selected sharks and rays species which are commonly found in the region was also raised.

Even though the Southeast Asian region has rich shark and ray resources compared with the other parts of the world, information on population status of sharks and rays and their fisheries is still insufficient. The limited information on catch, landings and trade as well as on the biology of sharks and rays species in Southeast Asia requires that information collection should be improved through appropriate national and regional programs.

1.3.2 Tunas

The major tuna species caught and landed in the Southeast Asia through long line, purse seine, pole and line, hand line, and other gears such as troll line and drift gill net, are the yellowfin tuna, bigeye tuna, skipjack tuna and albacore (SEAFDEC/TD, 2002; SEAFDEC/TD, 2004). Hand line is the most common fishing gear used specifically by small-scale fishers using fishing vessels under 5 GT. Skipjack comprises most of the tuna catch and its potential is estimated to be still moderate which means that the stocks could be exploited (See also details on Tuna Species in **3.1 (Part I)** and **1.1.1 (Part II)**).

An increasing production trend of tunas including neritic and oceanic tunas since 1997 was observed in the Western Central Pacific Ocean (WCPO) sub-area, while production is likely stable in the South China Sea (SCS) and Indian Ocean (IO) sub-areas. Tuna catch landing in the three sub-areas by major tuna species was approximately 550,000 MT/year, where the highest quantity landed was represented by skipjack followed by bigeye and yellowfin tunas. Among the four major tuna species caught in Southeast Asia, skipjack tuna are caught mainly in the WCPO sub-area. However, landing of skipjack tuna of the region has decreased by approximately 150,000 MT from 1997 to 2007. In the IO sub-area, data on skipjack landing shows likely stable level at approximately 50,000 MT/year. Moreover, landing of yellowfin tuna seems likely stable in SCS and IO sub-areas at the level of about 20,000 MT/year, and an increase from 50,000 to 125,000 MT during 1997 to 2007 in the WCPO sub-area. For bigeye tuna, landing data shows similar trend with that of yellowfin tuna in the three sub-areas.

Based on statistics data for Southeast Asia in 2009 (with data provided by Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, and Thailand), the total tuna production of Southeast Asia in quantity was approximately 1,640,000 MT. Indonesia as the leading tuna producer provided 925,660 MT or 56% of the region's total tuna production, followed by the Philippines with 612,008 MT contributing 37%, Malaysia with 56,432 MT accounting for about 3.5%, and Thailand with 47,490 MT providing about 3% of the total production. The total production volume of tuna species contributed 12% to the total marine fishery production of the Southeast Asian region.

In the over all, the national data collection system is constrained by limited number of enumerators especially in remote areas, inadequate understanding on the part of fishers on the importance of collecting fishery data and statistics, and large amount of time and effort needed to compile the necessary fishery statistical data considering the huge number of fishers spread all over the countries (*e.g.* Indonesia has recorded more than 2 million fishers in 2009 with more than 600,000 fishing vessels). The major challenges in tuna data collection are therefore hinged on the number of fishing boats and landing size, and size of the countries' management areas as well as the number of fishers to be managed coupled with inadequate capable personnel in the field (**Box 2**).

In 2010, the tuna catch from the EEZ of the Philippine waters was 574,836 MT, of which commercial tuna fisheries accounted for about 65% while the remaining 35% was contributed by the country's municipal tuna fisheries. The country's commercial tuna fisheries make use of a variety of fishing gears that include purse seine, ring net and hand line while the municipal fisheries employ much larger variety of gears with line gears accounting for about 60% of the municipal catch. The major tuna species caught are the yellowfin tuna, skipjack, eastern little tuna or kawakawa, and frigate tuna (*Auxis thazard*). Earlier, bigeye tuna (<60 cm) which is also caught had been classified as small size yellowfin tuna. In 2005 however, efforts were made to separately classify the catch of bigeye from the yellowfin tuna. As a member of the WCPFC, the Philippines submit tuna catch by species based on data from the country's waters.

In the Southeast Asian region, the production of neritic tuna has gained more economic importance because of the high price of tuna offered by tuna canneries especially in Thailand. The tuna catch of Thailand from the Gulf of Thailand and landed in Thailand comprises three major species of neritic tuna such as frigate, little and long-tail tunas that are mainly caught by tuna purse seine. The catch data also indicates that the most abundant species is long-tail tuna followed by kawakawa.

For the tuna catch from the Andaman Sea landed in Thailand, the main tuna species mainly caught by light luring purse seine are the frigate tuna, kawakawa, bullet, and long-tail tunas, the most abundant of which is bullet tuna followed by frigate and kawakawa. Considering that Thailand is the main supplier of canned tuna in the world market, the demand for tuna by canneries in Thailand has been increasing and could have some impacts on the country's tuna fisheries. It is therefore encouraged that studies on tuna stocks should be urgently conducted to identify the problems, concerns and status of tuna fisheries especially in the case of Thailand.

Box 2. Recommendations from the Special Meeting on Improvement of Tuna Information and Data Collection in Southeast Asia, Songkhla, Thailand, 7-9 September 2011

Aimed at improving the methods of collecting data and information by identifying the gaps in the collection of the data taking into consideration the importance of tuna fisheries in the region especially to the small-scale fishers, the Meeting identified four common issues and concerns in the improvement of collecting tuna data and information:

- inadequate budget and human resources for data collection;
- non-systematic coordination among data collecting/ reporting agencies, private sector and NGOs;
- insufficient efforts on tuna stock assessment in Southeast Asia and database system still scanty; and
- national data collection system needs improvement for the compilation of good quality data (*e.g.* from logbooks, observer program, transshipment reports, tuna cannery records, fishing grounds).

Specially noted on the major gaps and constraints in collecting information on tuna catch data in Southeast Asia were:

- The difficulty of identifying the species of tunas especially in landing sites, considering that most of the catches are small sizes including yellowfin and bigeye tuna. It was therefore recommended that a special training should be conducted on the identification of tuna species especially the juvenile stages of the species, to be able to assess the tuna stocks. As for the appropriate method of stock assessment, it was suggested that existing models that are now being used could be adapted but should take into account the available validated data on total catch, fishing effort, fishing grounds, oceanographic conditions, among others.
- Insufficient number of staff in terms of number and capability for data collection, inadequate financial resources to fund any tuna survey, and the absence of appropriate and cost effective data collection systems.

SEAFDEC was therefore requested to undertake various activities in response to the need of improving the collection of tuna information and data, which include:

- consultation with countries on possible continuation of the development of regional tuna fisheries database;
- improvement of the quality and timeliness of data through capacity building programs, such as data collection onboard tuna fishing vessels (*e.g.* logbooks, observers onboard), from landing sites (catch unloading, species identification), and from cannery (accuracy in species identification);
- conduct of study on reduction of juvenile tuna catch from purse seine, pole and line, FADs, and by-catch in tuna fisheries;
- translation of existing relevant information materials (*e.g.* guidebooks, posters, brochures) issued by countries into English language for dissemination to the other countries in the region; and
- consultation with experts on stock assessment in order to come up with appropriate plan of activity to support the countries in the improvement of their respective information collection systems.

1.3.3 Sea Turtles

Six of seven species of living sea turtles in the world were 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 imbricata*), loggerhead (*Caretta caretta*), and the flatback turtle (*Natator* *depressus*) which can be found only in eastern Indonesian waters (**Table 53**). The flatback turtle is restricted to Australian territories for nesting, but it forages within Indonesian waters (Limpus, 2002), where green turtles are the most dominant species in the Southeast Asian Region.

Sea turtles are important marine animals as traditional living resources in the Asian region. For centuries, people in this region have exploited this resource and some still do until the present. Sea turtles have also been cheap source of protein for poor people especially those living in the coastal areas. During recent decades the demand for its eggs, meat and carcasses had significantly increased considering that sea turtles provide many products for human consumption such as meat and eggs, as well as for commercial purposes such as the carcasses (for souvenirs, accessories) and oil (for traditional medicines), and as important part in religious ceremonies in some countries of this region.

In order to conserve, manage and exploit this resource sustainably, countries in the Southeast Asian region (except Lao PDR and Singapore) have established their own national programs on the conservation, management and enhancement of sea turtles. These include enforcement of gazetted laws and regulations, strengthening of the enforcement agencies, establishment of sea turtle sanctuaries, setting-up of hatcheries, conduct of national and regional tagging programs, tracking of the migration routes using satellite technology, implementation of public awareness activities through education and campaigns, and conduct of relevant R&D activities.

It has been reported that each year thousands of hatchling turtles emerge from their nests in the shores of the Southeast Asian countries (SEAFDEC/MFRDMD, 2004). Sadly, only an estimated one in 1,000 to 10,000 will survive to adult turtles. The natural obstacles confronting the young and adult sea turtles are staggering but the most increasing threats are caused by humans that drive the turtle populations to extinction. Today, all sea turtles found in Southeast Asian waters are federally listed as threatened and endangered. The most common issues that cause the decline of sea turtle population include natural threats and human-induced activities.

In nature, sea turtles face a host of life and death obstacles during their survival. Predators such as raccoons, crabs and ants raid eggs and hatchlings still in the nest. The hatchlings emerging from nests form bite-sized meals for birds, crabs and a host of predators in the ocean. Upon reaching adulthood, sea turtles are relatively immune to predation except for occasional attacks by sharks. Such natural threats are not the only reasons for the plummeting sea turtle populations towards extinction. Human activities have also been recognized as major threats contributing the global declining population of sea turtles. Human-induced activities could include accidental catch by fisheries, illegal trading of sea turtle shells, failure to control and collect marine debris that causes ingestion and entanglement, use of artificial lightings in nesting beaches, coastal armoring, beach nourishment and dredging, pollution in marine areas, insufficient education and public awareness programs, inadequate skills on hatchery management, and economic exploitation of turtles, as well as the impacts of climate change.

Each year hundreds of thousands of adult and immature sea turtles are accidentally captured in fisheries around the world ranging from highly mechanized operations to small-scale fisheries. Global estimates of the annual capture, injury and mortality are overwhelming: about 150,000 turtles of all species killed in shrimp trawls, more than 200,000 loggerheads and 50,000 leatherbacks captured, injured or killed by long lines, and large numbers of all species drowned in gill nets. Although the extent of gill net mortality is not really known, sea turtle capture is significant in study areas while incidence of drowning of sea turtles in gill nets could be comparable with that of trawl and long line mortality. However, deaths in gill nets are particularly hard to quantify because the nets are set by uncounted numbers of local fishers in tropical waters around the world. Other fisheries that accidentally take turtles include dredges, trawls, pound nets, pot fisheries, and hand lines.

Table 53. Sea Turtles which are confirmed to nest in Southeast Asian countries

Country	Leatherback Turtles	Green Turtles	Hawksbill Turtles	Loggerhead Turtles	Olive Ridley Turtles	Flatback Turtles
Brunei Darussalam		√	√		√	
Cambodia		√	√		√	
Indonesia	√	√	√	√	√	√
Malaysia	√	√	√		√	
Myanmar	√	√	√	√	√	
Philippines	√	√	√	√	√	
Thailand	√	√	√	√	√	
Vietnam		√	√	√	√	

Source: *Ahmad et.al, 2004*

It has therefore become a challenge to ensure that fishers develop new methodologies and gears to reduce turtle by-catch which do not necessarily prevent them from making a living. By modifying gears and techniques to protect endangered sea turtles and other non-target species, fishers can improve their efficiency and help in safeguarding the marine ecosystems. For example, the Turtle Excluder Devices (TEDs) had been designed to release turtles trapped beneath the surface in shrimp trawls as well as reduce the capture of unwanted fishes, shorten sorting time on deck and minimize fuel consumption. In addition, TEDs exclude logs and other debris, thus, help in extending net use. In long line fleets, the use of large circle hooks and fish as bait instead of squid reduces sea turtle capture while improving swordfish catch.

Hawksbill turtles are recognized for their beautiful gold and brown shells, and thus have been hunted for centuries to create jewelry and other luxury souvenir items. As a result, these turtles are now critically endangered and scientists estimate that hawksbill population declined by 90 percent during the past 100 years.

To improve their survival, CITES has declared it illegal to trade turtle shells, however, the demand for shells continues until today in the black market contributing to the continued declining population of sea turtles. In many countries, tourists continue to purchase products derived from sea turtles thus, unwittingly support the international trade of these endangered species because of inadequate information on conservation of sea turtles. Presently however, buying, selling or importing sea turtle products have been strictly prohibited by law in many countries around the world. Although the illegal trading of sea turtle products is primarily focused on the hawksbills, other sea turtle species are also killed for their skin to be transformed into leather goods while some beauty products are also known to contain sea turtle oil.

Reports claimed that more than 100 million marine animals are killed each year due to ingestion of and entanglement with marine debris especially plastic materials strewn by humans, more than 80% of which comes from land and washed into the waterways. The debris travels through storm drains into streams and rivers or from landfills into the seas. As a result, thousands of sea turtles accidentally swallow these plastic materials which are usually mistaken for food. Specifically, leatherbacks are unable to distinguish between floating jellyfish which is a main component of their diet or floating plastic materials. The most recognizable debris includes plastic bags, balloons, bottles, degraded buoys, plastic packaging, and food wrappers. Being small, most plastic materials are difficult to see, in fact, some could be invisible to the naked eye. If sea turtles ingest these particles, they become sick or even starve and eventually die from ingestion. Moreover, turtles are also affected to an unknown but potentially significant degree of risk from entanglement in various forms of marine debris such as discarded or lost fishing gear including steel and monofilament lines, synthetic and natural ropes, plastic onion sacks, and discarded plastic netting materials.

Nesting turtles depend on dark and quite beaches to deposit their eggs successfully. Turtles these days are at risk and in danger, in part, because they must compete with tourists, businesses and coastal residents for the use of beaches. Many man-made coastal development activities use a lot of artificial lightings on beaches discouraging the female sea turtles from nesting. As a result, turtles opt for less-than-optimal nesting spots, which could affect the chances of producing viable eggs. In addition, near-shore lightings could make sea turtle hatchlings getting disoriented after coming out from the eggs and wander towards the inland areas where more often than not the hatchlings die of dehydration, predation and being run over by vehicles on busy coastal streets.

In many countries, nesting beaches of sea turtles everywhere have been substantially altered by urbanization and development. Coastal areas are considered prime real estate properties for development and as a result, many of the world's beaches have been heavily developed. Moreover, coastal property owners build armoring structures such as seawalls and rock revetments to help protect their land and properties from erosion. In fact, most governing bodies often address problems on erosion by constructing state-funded coastal armoring projects that include the excavation of inlets and construction of jetties along the coast altering the natural course of the sand.

Man-made structures in coastal areas also prevent sea turtles from continuing their innate life cycles and directly threaten their existence by reducing their suitable nesting habitats and displacing turtles into less-than-optimal nesting areas. Although armoring is intended to decrease sand erosion and, therefore protect the beaches, studies have suggested that areas protected by armoring are more likely to create severe erosion by interrupting natural sand shifts. This means that while property owners are protecting their habitats using coastal structures, sea turtles are losing theirs.

Beach nourishment consists of pumping, trucking or otherwise depositing sand on beaches to replace what has been lost to erosion. While beach nourishment is often preferable to armoring, it can negatively impact the habitats of sea turtles especially when the sand becomes too compact for turtles to nest or in cases where the imported sand is completely different from the original beach sediments, thereby potentially affecting nest-site selection, digging behavior, incubation temperature, and moisture contents of nests.

When re-nourishment takes place during the nesting season, nests can also be buried far beneath the surface or run over by heavy machinery. Dredging can also cause direct threats to sea turtles and their nearshore marine habitats. As recorded, hopper dredges have been directly responsible for the incidental capture and death of hundreds of sea turtles.

Pollution has serious impacts on both sea turtles and their food, and as suggested in recent research studies, a new disease now killing many sea turtles known as fibropapillomas could be linked to pollution in the oceans and in near-shore waters. When pollution contaminates and kills aquatic plants and animals, it also destroys the feeding habitats for sea turtles. Oil spills and urban runoffs such as chemicals and fertilizers contribute to water pollution, where an estimated 36% of all marine pollution from oil comes from cities through drains and rivers. Sea turtles are affected by pollution in more ways than one. For example, turtles do not have to directly ingest a tar ball but the small marine animals on the lower levels in the food chain, like zooplanktons, absorb these chemicals which are then accumulated in their bodies, making the toxins much more concentrated than in the surrounding waters. The zooplanktons are then consumed by larger animals including sea turtles, and thus, the concentration levels of chemicals and pollutants would continue to increase.

Awareness building of the direct stakeholders such as fishers, village folks, tourist operators, and chalet and hotel operators is still insufficient. The inadequate knowledge and awareness on the biology, conservation, protection and other practices relevant to sea turtles have often lead to certain negative attitude towards the plight of turtles, indiscriminate manhandling of turtles and destruction of their habitats. The stakeholders' inadequate knowledge in biological sciences and improper handling of incubation techniques for sea turtles could also cause low hatching rates of incubated eggs and in some cases producing unbalanced sex ratio of the hatchlings. The unbalance sex ratio in turtle hatchlings attributes to the imbalance proportion of adult male and female population of sea turtles. As a result, more infertile eggs are produced by turtle nesters during the nesting season which eventually leads to the declining population of sea turtles in the future.

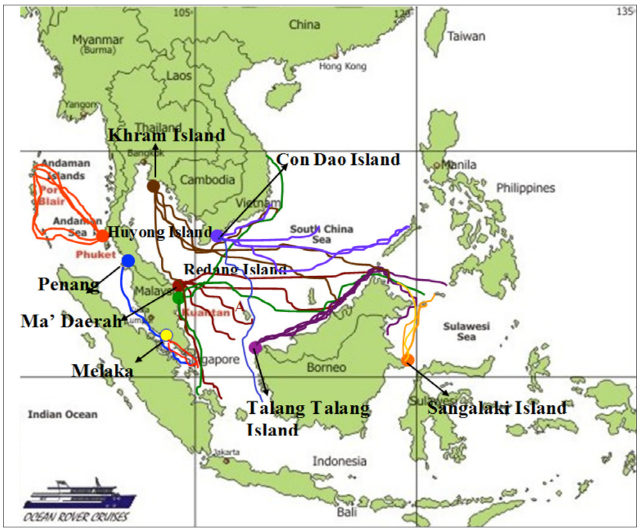
Turtles are exploited for their eggs and meat. The persistent practice of excessive egg harvesting contributes to the dramatic decline in the nesting population of all species. During the past few decades, coastlines have been regarded as common property. This implies that harvesting of turtle eggs is open to all leading to unregulated harvesting of eggs or partially regulated with little restriction to harvest the eggs. To date, consumption and selling the turtle eggs is still common in many Southeast Asian countries. It is therefore necessary that turtle eggs harvested for consumption and commercial purposes should be totally banned in all Southeast Asian countries to ensure the stability of the population of sea turtles in the future. Furthermore, illegal poaching of sea turtles in their foraging habitats is also major issue in the region. Every year, several cases of sea turtle poaching had been reported especially in sea turtle foraging habitats of Sabah and Sarawak waters off Malaysia. Regional agreement and cooperation are indeed substantially important in order to address the turtle exploitation issues and prevent turtle eggs harvesting.

Table 54. Estimated number of sea turtles recorded in the Southeast Asian countries

Country	Number of Individuals	Duration of Monitoring Study
Brunei Darussalam	53 (major sp.; Olive Ridley)	2005-2009
Cambodia	43 (major sp.; Green)	2007-2009
Indonesia	737 (major sp.; Green)	2007-2009
Malaysia		
• Peninsular Malaysia	1,272 (major sp.; Green)	1999-2008
• Sabah Sarawak	26,386 (major sp.; Green)	1999-2009
• Sarawak	7,668 (major sp.; Green)	1999-2008
Myanmar	643 (major sp.; Green)	2001-2009
Philippines (Morong-Bataan, Bagac-Bataan, and Turtle Islands Wildlife Sanctuary (TIWS))	4,249 (major sp.; Green)	1999-2009
Thailand	195 (major sp.; Green)	1994-2009
Vietnam	3,370 (major sp.; Green)	1998-2009

Source: *SEAFDEC/MFRDMD (unpublished report)*

Since sea turtles use both marine and terrestrial habits during their life cycles, the effects of climate change are likely to have devastating impacts on these endangered species. Climate change impacts on the sea turtle nesting beaches which are their reproductive habitats. Sea turtles easily recollect their nesting areas from memory which "imprints with magnetic map" the sandy beach where their eggs are deposited, giving them the unique ability of returning to that same site decades later to repeat their ancient nesting ritual. However, with melting polar ice caps and rising sea levels, these beaches are beginning to disappear. The direct impacts of sea level rise include losing beaches, ecologically-productive wetlands and barrier islands as well as increase in nesting beach temperatures. Considering that the gender of sea turtles is determined by the temperature at which the eggs incubate, increasing nest temperatures had been predicted by scientists to have influenced the production of more female than male hatchlings, creating a significant threat



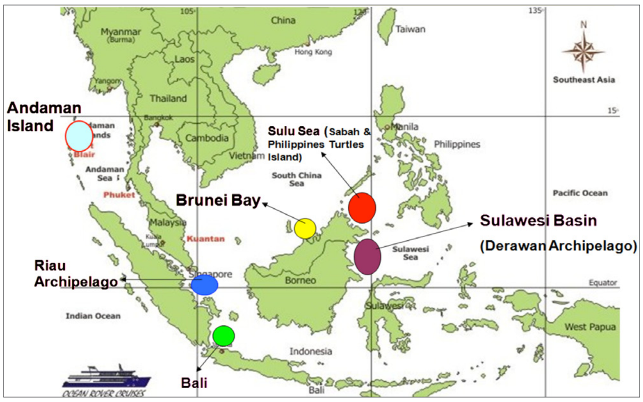


Figure 34. Migration routes of green turtles in the Southeast Asian waters determined through satellite telemetry studies (left) and location of 11 genetically distinct breeding stocks or management units of green sea turtles in Southeast Asia (above)

to genetic diversity.

Climate change which increases water temperatures also changes ocean currents that are critical to migrating turtles, especially for hatchlings that are mostly transported by Sargassum seaweeds traveling with the water currents. Warmer ocean temperatures are also likely to negatively impact on the food resources for sea turtles and virtually all marine species. Coral reefs, which comprise the important food source for sea turtles, are also in great danger from the impacts of climate change.

SEAFDEC Initiatives in Conservation and Management of Sea Turtles

SEAFDEC has played important role in the conservation and management of sea turtles in the Southeast Asian region (Mohd Isa *et al*., 2008). The first regional program on conservation of sea turtles in Southeast Asia was started during the First ASEAN Symposium - Workshop on Marine Turtle Conservation in Manila, Philippines in 1993. Thus, starting in 1996, SEAFDEC/MFRDMD and SEAFDEC Training Department (TD) in collaboration with the ASEAN Member Countries conducted a series of programs in addressing the need to conserve the region's sea turtles species. Starting in 1998, more R&D programs were also implemented with funding support from the Japanese Trust Fund as shown in **Appendix 1**. From the results of the studies, the number of sea turtles recorded in the Southeast Asian countries had been estimated (**Table 54**), of which the green turtles have been recorded with the most number of species.

Based on the results of research studies conducted by SEAFDEC/MFRDMD in the Southeast Asian region, the migratory routes of and the genetically distinct breeding stocks or management units of green turtles are shown in **Fig. 34** while the possible foraging habitats of sea turtles are mapped and shown in **Fig. 35**.

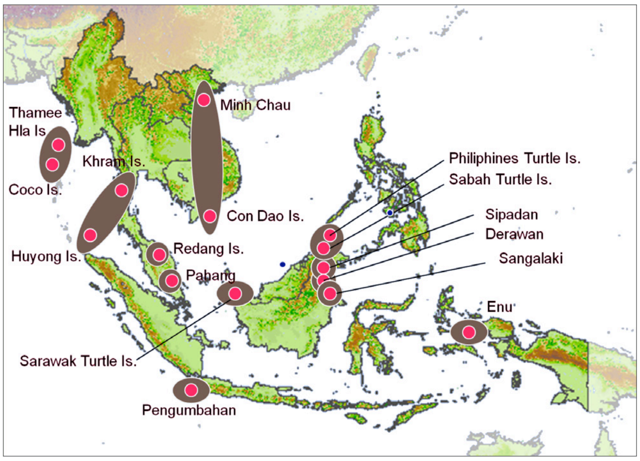


Figure 35. Possible foraging habitats of sea turtles in the Southeast Asian waters based on results of satellite telemetry studies

1.3.4 Sea Cucumbers

Sea cucumbers, especially those belonging to families Holothuriidae and Stichopodidae, form important parts of the multi-species invertebrate group, the products of which support international market demands. Based on the statistics of sea cucumber production of the Southeast Asian countries from 2000 to 2009, total production is highly fluctuating and ranges from about 4,000 to 29,700 MT annually. While the total marine capture fishery production of the region in 2009 was reported to be 14.1 million MT, about 0.033% of the total production was provided by sea cucumbers (**Table 55**). Indonesia and Philippines are the Southeast Asian countries that reported considerable amount of sea cucumber production, however, only the total production figures were reported without further classification to species level (SEAFDEC, 2009). Some countries such as Malaysia, Myanmar, Thailand, and Vietnam, are also known to have certain levels of sea cucumber production, but their reports do not reflect such production and are grouped instead under the "invertebrate group" or "miscellaneous marine aquatic group", probably because the volume of production is not

Table 55. Production of sea cucumbers in some Southeast Asian countries (MT)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	...	...	...	...	...	...	...	3	0.90	0.12
Cambodia	...	...	...	3	...	...	...	...	...	...
Indonesia	4,690	3,517	9,116	3,014	6,930	7,178	29,733	4,273	3,623.00	3,750
Philippines	...	965	...	979	1,006	761		851	777.00	934

Sources: *Fishery Statistical Bulletin for the South China Sea Area (SEAFDEC, 2000-2009) and Fishery Statistical Bulletin of Southeast Asia (SEAFDEC 2010)*

Table 56. Destination countries and value (in US$) of sea cucumber products exported from Indonesia, Philippines and Thailand in 2007

Destination Country	Indonesia	Philippines	Thailand
Hong Kong	497,682	2,976,398	2,494,676
Singapore	256,367	642,446	548,122
Taiwan	30,000	10,132	1,627,500
Malaysia	274,872	73,450	-
USA	13,831	87,651	548,122
Vietnam	288,085	-	819,800
China	-	115,171	-
Japan	-	12,025	-
North Korea*	-	-	561,439
South Korea	-	1,015,263	-

Source: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)*

much and collection of sea cucumber is by nature scattered making data collection for statistical purposes difficult to undertake.

As a result therefore, sea cucumbers contributed very small quantity to the total marine capture fishery production of the region. While there could be weaknesses in data collection of sea cucumber production in most of the countries, the situation makes the understanding of the production status and trends of the species difficult to reckon with, particularly from official statistics figures collected by the countries. Other sources of information including research results and data collected through *ad hoc* schemes should therefore be gathered and incorporated in the over-all production in order to obtain a better picture of the status and trends of sea cucumber production from the Southeast Asian region.

In an attempt to address such concern, SEAFDEC in collaboration with eight Southeast Asian countries, namely: Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Vietnam conducted the Regional Study on Sea Cucumber Fisheries, Utilization and Trade in Southeast Asia in 2007-2008 by collecting secondary data and information available in the respective countries. Results of the study showed that there are approximately 135 species of sea cucumbers found in the region (SEAFDEC, 2009).

Moreover, sea cucumbers are generally harvested by local fishers using simple or traditional methods that vary and range from picking by hand during low tide, snorkeling at the depth of up to 10 meters, punching by a metal spear as well as using trawl nets (Labe *et. al*., 2007). The species are mostly utilized for local consumption while some are exported to Hong Kong markets where fishers are able to obtain high market prices (**Table 56**).

The Regional Study also recognized that there is very limited information on sea cucumbers in terms of statistical records, inadequate information on research works, and insufficient and/or limited biological data and knowledge on species identification. Despite these constraints, consideration is being given to this species group by the Southeast Asian countries especially in view of the declining and diminishing sea cucumber resources, and the emerging global concerns that focused on the conservation and management of sea cucumbers. In fact, such concerns had become one of the most popular issues being discussed in the international community, particularly at the CoP-CITES and several fora of FAO, and it has been anticipated that the listing of sea cucumber species in CITES Appendices could be brought up for discussion during the forthcoming CoP16-CITES in 2013. Therefore, it has become necessary for the Southeast Asian countries to take a serious look into the issues and collect relevant scientific/technical information on economically important sea cucumber species, *e.g.* production, utilization, trade, as well as the conservation and management measures that have been put in place, in order to come up with a common position of the Southeast Asian countries demonstrating that sea cucumber fisheries of the region are being undertaken in sustainable and responsible manner (Labe *et al*., 2007).

1.3.5 Seahorses

Seahorses comprise the genus *Hippocampus* of family Syngnathidae, consisting of 35 genera of pipefishes, pipehorses and seadragons, and falling within the order Gasterosteiformes (Vincent, 1996). Currently, 47 seahorse species have been identified in the world (Lourie *et al*., 1999 and 2004; CITES Species Database, 2011) although species identification still remains challenging with some of the taxonomy unresolved (Koldewey and Martin-Smith, 2010). Seahorses occupy both temperate and tropical coastal waters from about 50° North to 50° South, and are usually found among corals, macro-algae, mangrove roots and sea grasses, with some living in open sandy or muddy bottoms (Lourie *et al*., 2004). Among the 47 species, nine species are confirmed to be distributed in the Southeast Asian region with one species still not confirmed (**Table 57**). Twenty nine and 22 species are traded in the world as live individuals and non-live individuals, respectively. Culture technology has been developed for 18 species where 13 species are being commercially cultured, one species could be cultured but its commercial status is unknown, and four species have been researched on, the results of which have been published in various literatures and journals (Koldewey and Martin-Smith, 2010).

Seahorses have very unique characteristics such as male pregnancy and faithful monogamy as well as lengthy parental care. In addition, the peculiar body-shape and swimming style are also probably ascribed to the high popularity of seahorses not only as aquarium species but also as curio items. Moreover, the demand for sea horses is high especially as ingredients for traditional Chinese medicines (Vincent, 1996). The specialized life history traits of seahorses including male pregnancy, lengthy parental care, small size of brood, strict monogamy in most species, low mobility, small home ranges, and sparse distribution make seahorse populations very susceptible particularly to anthropogenic disturbance (Koldewey and Martin-Smith, 2010).

Utilization and Trade of Seahorses

Direct exploitation, incidental catches by non-selective fishing gear, and habitat loss and degradation have put considerable pressures on seahorse population in many regions of the world (Vincent and Koldewey, 2006). Specifically, seahorses in the Indo-Pacific region may be the most immediately at risk because of their proximity to major markets for the traditional Chinese medicines (Vincent, 1996). All species of the seahorse genus *Hippocampus* are already listed in the Appendix II of CITES in 2002, denoting the potential threats caused by unregulated international trade of these species.

The number of seahorses exported (**Fig. 36**) largely increased in 2003 for non-live commodities and in 2004 for live commodities. However, not all seahorses traded originate from the wild. Captive-bred seahorses accounted for 25-84% (mean 57%) of the total volume traded in 2004-2008 (Koldewey and Martin-Smith, 2010).

Seahorses are exported as live and non-live commodities in the world and from Southeast Asia. From 1997 to 2009, the average percentage of seahorses traded from Southeast Asia was 54% for live seahorses and 82% for non-live seahorses. Since the number of the non-live seahorses is extremely larger than those of the live seahorses, this indicates that majority of seahorses traded in the world could have originated from the Southeast Asian region. During the recent years, Vietnam had been the largest exporter of live seahorses while Thailand leads in the

Table 57. Seahorses *Hippocampus* spp. identified in Southeast Asia

	FAO Common Name	Scientific Name	Type Traded	Culture Techniques	Distribution in Southeast Asia	
					Confirmed	Suspected
1	Barbour's seahorse	*H. barbouri*	L, N	C	ID, MY, PH	
2	Bargiban's seahorse	*H. bargibanti*	N		ID, PH	MY
3	Tiger-tail seahorse	*H. comes*	L, N	C	ID, MY, PH, SG, TH, VN	
4	Denise's pygmy seahorse	*H. denise*	L		ID, MY, PH	
5	Seahorse Spiny seahorse Thorny seahorse	*H. histrix*	L, N		ID, MY, PH, VN	BI, MM, SG, TH
6	Great seahorse Kellog's seahorse Offshore seahorse	*H. kelloggi*	L, N		ID, MY, PH, TH, VN	BI, MM, SG
7	Black seahorse Colored seahorse Oceanic seahorse Spotted seahorse Yellow seahorse	*H. kuda*	L, N	C	KH, ID, MY, PH, SG, TH, VN	BI, MM
8	Japanese seahorse	*H. mahnikei*	L, N	(C)		TH, VN
9	Hedgehog seahorse	*H. spinosissimus*	L, N	C	KH, ID, MY, MM, PH, SG, TH, VN	BI
10	Flat-faced seahorse Long-nose seahorse Low-crowned seahorse Three-spot seahorse	*H. trimaculatus*	L, N	C	KH, ID, MY, MM, PH, SG, TH, VN	BI

Note: *In the column of "Type Traded", 'L' and 'N' denote 'live seahorse' and 'non-live seahorse'; "Cult. Techechniques" distinguished as follows: C=commercial operation, (C)=unknown about the commercial availability, and R=research published only; *: BI=Burunei Darussalam, ID=Indonesia, KH=Cambodia, MM=Myanmar, MY=Malaysia, PH=Philippines, SG=Singapore, TH=Thailand, and VN=Vietnum.*
Source: *Lourie et al. 1999 and 2004; Koldewey and Martin-Smith 2010*

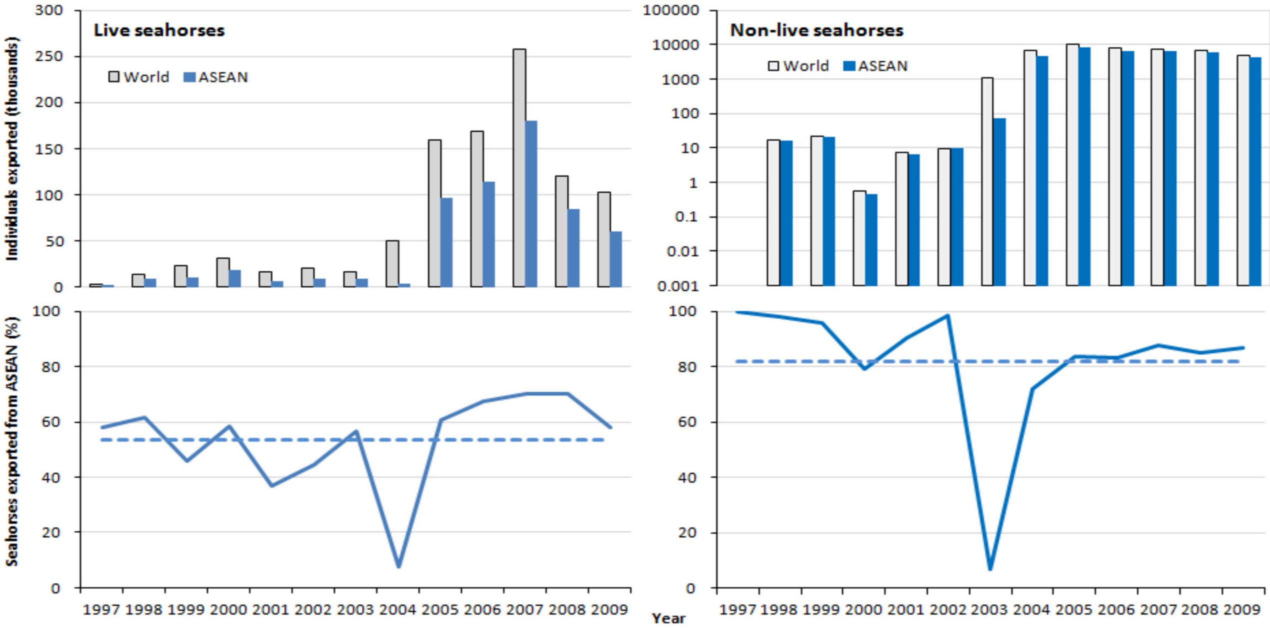


Figure 36. Export of seahorses from the Southeast Asian countries

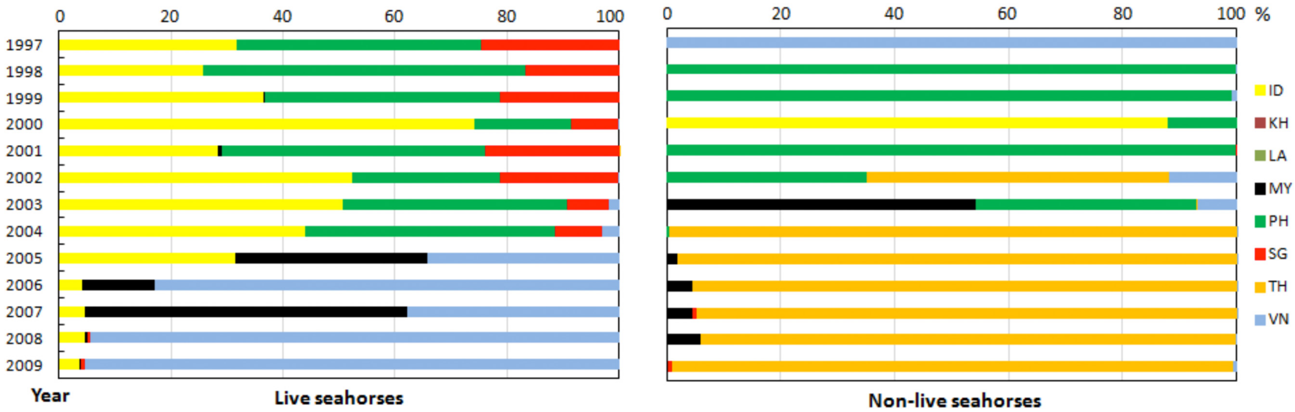


Figure 37. Percentages of seahorses (live and non-live) exported from Southeast Asian region by countries: BI=Brunei Darussalam, ID=Indonesia, KH=Cambodia, MM=Myanmar, MY=Malaysia, PH=Philippines, SG=Singapore, TH=Thailand, and VN=Vietnam

Sources: *CITES trade statistics derived from the CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, United Kingdom*

export of non-live seahorses (**Fig. 37**). The dotted lines show the average values between 1997 and 2009. The data were obtained from CITES trade statistics derived from the CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK. To calculate the individual number of live seahorses, the weight data shown in the database were converted to individual numbers using estimated body sizes by species as 80% of the maximum height as established by Lourie *et al*. (2004) and the average condition factor (CF=BW(g)/MH(cm) x102=0.371) obtained for *Hippocampus barbouri*, *H. comes* and *H. kuda* broodstocks kept at the facilities of SEAFDEC Aquaculture Department (AQD) in the Philippines.

Culture Technologies for Seahorses

Commercial aquaculture of seahorses has been repeatedly considered as possible solution to replace the collection of wild-caught animals, provide economic opportunities for fishers in developing countries and supply future increases in global demand (Koldewey and Martin-Smith, 2010). Commercial development and considerable expansion of seahorse aquaculture occurred in the 1990s (Woods, 2000a; Woods 2000b).

Thereafter, a number of studies on culture technologies have been published. SEAFDEC/AQD also initiated seahorse breeding studies in 1996 and obtained certain level of progress especially on the culture techniques including findings such as year-round breeding in mating pairs of *H. kuda*, the relationship of parturition frequency with seawater temperature and daylight period, tolerance to various salinities, and effects of illumination on growth in sea cages (Hilomen-Garcia *et al*., 2003; Okuzawa *et al*., 2008; Garcia and Hilomen-Garcia, 2009). Nevertheless, considerable technical difficulties remain unresolved especially in breeding and rearing of many seahorse species because of difficulties in feeding and outbreak of disease (Vincent and Kodlewey, 2006; Koldewey and Martin-Smith, 2010).

More recently, however, AQD found that survival and growth of newborn seahorses are significantly improved in UV-treated water while mass mortality is effectively prevented by treating food organisms in formalin (Buen-Ursua *et al*., 2011). Such findings indicate that using disease-free copepods collected from the wild as feed through formalin treatment would advance the development of cost-effective aquaculture for the mass production of seahorses in Southeast Asia. The goal is not to promote new trade or increase existing trade in seahorses as this might encourage the exploitation of seahorses from the wild (Buen-Ursua, personal communication cited by Malaya Business Insight, 2011).

Other than the issues of vulnerability to diseases and finding the correct diet in captive breeding, genetic diversity and genetic purity of native species of restocked seahorses, disease transmission to wild populations as well as risk of community disruptions should be considered in carrying out seahorse releasing programs (Vincent and Koldewey, 2006; Buen-Ursua, personal communication cited by Malaya Business Insight, 2011). The genes of seahorses bred in one place might not be compatible with native seahorses, raising the risk that mixing them could compromise the genes of local seahorses. Stocks bred in hatcheries whose genetic composition is incompatible with the native population should not be released.

Thus, the characterization of the genetic makeup of seahorses bred in hatcheries and those found in the wild is very essential (Buen-Ursua, personal communication cited by Malaya Business Insight, 2011). As regards disease issues, thorough screening procedures are also necessary in any program that transfers captive seahorses into the wild (Vincent and Koldewey, 2006) as sudden influx of new individuals into a small area could result in changes in the social structure of the wild population which could result in increased competition for food, shelter, and mates (Vincent and Koldewey, 2006). Appropriate measures are therefore very important to avoid such risks, which could include development of tagging and/or marking techniques to monitor the release animals and to establish the impact of the stocking practices (Vincent and Koldewey, 2006).

Future Perspectives and Recommendations

Global interest in aquaculture of seahorses and other syngnathids has increased dramatically over the past decade (Vincent and Koldewey, 2006). As predicted from the global trade situation, the global resource level of wild seahorses would continue to decrease particularly in Southeast Asia. It is likely that the situation in the future would worsen and wild stocks of seahorses would encounter the risk of extinction unless immediate actions to stop overfishing and appropriately control the volume of trade are implemented by the countries of origin and trading countries. For example, catch of seahorses should be limited to 10 cm or less in body height which is the minimum size prescribed by the Animal Committee of CITES (Foster and Vincent, 2004) while the export/transport of live seahorses should be governed by specific guidelines (Vincent and Koldewey, 2006). Direct exploitation as well as habitat loss and degradation should be avoided by establishing and strengthening domestic legislations in order to protect seahorse populations in many countries from over-exploitation (Vincent and Koldewey, 2006).

Although culture of seahorses does not target the traditional Chinese medicine (TCM) markets and has not achieved commercial viability, production of cultured seahorses through development of sustainable aquaculture technology should be enhanced in order to protect the wild stocks of seahorses. In addition, since the ratio of wild-caught to cultured seahorses in the live aquarium trade is unknown (Vincent and Koldewey 2006), cultured seahorses could replace the wild seahorses to supply TCM and tonic products, live aquarium fishes, and curio items and souvenirs, thus, preventing further demands of wild seahorses. As emphasized by Vincent and Koldewey (2006), culture technologies for seahorses should be in line with the aim of minimizing negative environmental impacts and maximizing local socio-economic benefits, and through the compliance with the precepts of the Convention on Biological Diversity.

2. INLAND FISHERY RESOURCES

In 2009, the total fisheries production of the region was reported to be 28,917,096 MT of which 2,397,273 MT came from the inland fisheries sub-sector accounting for approximately 8% of the total fishery production (SEAFDEC, 2011). Despite the low figures as reported, the importance of inland fisheries could not be neglected due to its contribution to food security and poverty alleviation for peoples, particularly those from the low income group whose livelihood is very much dependent on the availability of natural resources. However, by the nature of inland fisheries being small-scale, multi-species, multi-gears, involving large number of fishers which are mostly part-time fishers, while the major parts of the fishery production are meant for household consumption, all these factors result in difficulties in the collection and accurate reporting of routine inland fishery data and statistics. Thus, the importance of inland fisheries is hence overlooked by planners and policy makers, giving this sub-sector low priority compared to the other development sectors that share the same water resources. The result could be manifold impacts to fishers and other fishery-related activities in the region while the accumulated impacts over time could be much greater than one can imagine, particularly to those whose livelihoods are dependent on inland fishery activities.

Adding to the above-mentioned situation is the deterioration of natural inland fishery resources and habitats as well as the declining catch caused by irresponsible fishing operations, insufficient fishery management schemes, and the impacts from non-fishery activities. As a matter of fact, aquaculture practices have been introduced and promoted in several areas to increase fish production from inland waters. However, such introduction should be properly managed otherwise it could lead to negative impacts to the ecosystems and inland natural resources. In most cases, the beneficiaries from aquaculture operations may not only be those who lose their benefits from inland capture fisheries in terms of food security and livelihood. The promotion of aquaculture activities that aim to substitute inland capture production therefore undermines the culture value of fish eating traditions and other traditional knowledge which had been passed from generations to generations, and thus, the importance of inland fisheries should be recognized by the present and future planners and policy makers (Mohd Isa *et al*., 2011).

2.1 Status, Issues and Concerns

2.1.1 Inland Fisheries for Food Security and Poverty Alleviation

The inland fishery sector is known to significantly contribute to food supplies and healthy diets of millions of people all over the world. Production from inland fisheries is particularly important for poverty alleviation, food security and enhanced nutritional well-being of many people in rural communities, particularly in the developing countries as well as in the low-income food-deficit countries. In the Asian region, fish contributes to approximately 23% of the animal protein intakes and human diets (FAO, 2003). In certain parts of the region, for example in the Lower Mekong Basin, the importance of inland fishery products such as fish and other aquatic animals, *e.g.* snails, mollusks, shrimps, crabs, snakes, and other reptiles as well as water birds, is even more prominent.

The average basin-wide consumption of fish and other aquatic animals is estimated at 56 kg/capita/yr (Hortle and Bush, 2003), while in high-yielding fishing areas such as the rural communities of the floodplains around the Great Tonle Sap Lake in Cambodia, fish consumption could even be higher. Moreover, inland fisheries also provide direct employment to rural populations in terms of production and indirect employment through processing and trading of fishery products. More importantly, inland fisheries also provide significant opportunities for the integration of fishery operations into rural farming livelihoods, offer buffer against shortfalls in agricultural production, and make available alternative sources of food and income.

2.1.2 Data/Information Collection on Inland Fisheries

One important reason why the importance of inland fisheries is being undermined by non-fishery sectors, planners and policy makers is the lack of reliable data and information on inland fishery production. In view of its very nature, inland fisheries are usually not well-monitored, under-estimated and under-presented in many reports and statistics. Since major parts of the production are intended for household consumption, reliable statistics could not be systematically gathered using the conventional statistical collection methodologies. The discrepancy between officially reported catches where available and the estimates based on independent scientifically-based surveys focusing on collection of actual data, seems to suggest that the total reported production from inland waters is usually under-estimated by at least 2.5 to 3.6 times (Coates, 2002). This also suggests that the contribution of inland fishes to the total fish supplies is significantly higher than the volume that is estimated and reported.

Considering the complexity of inland fisheries and the difficulties in obtaining reliable statistics on inland fisheries, alternative methodologies such as indicator or sampling survey or fish consumption survey could be undertaken to come up with information that reflects the importance and role of inland fishery production in the countries' economies. Moreover, such approach could also provide the necessary conversion factors which when combined with routine fishery statistics or information from national census would generate more accurate information on inland fishery production of the region. In addition, local and indigenous knowledge on inland fisheries especially those associated with the abundance and distribution of species, fishing gears and methods, fish preservation and processing techniques could also be important source of information, and thus, should be gathered to support the sustainable management of the region's inland fisheries.

The need to improve the national statistical systems and capacity to collect data and information on inland fishery statistics is therefore well recognized. Therefore, under the current circumstance, it is necessary that data collected using the existing fishery statistical systems and outcomes from the currently available research studies should be synthesized and packaged, after which such information should be presented to policy makers and planners to raise their awareness and enable them to have better understanding on the importance of inland fisheries in the food security of the region.

2.1.3 *Impacts of Water Barrier Construction on Inland Fisheries*

One of the development projects that could generate significant impacts to inland ecosystems and fishery activities is the construction of water barriers such as dams, weirs, barrages, among others. In the Southeast Asian region, a number of dams and barriers had been constructed for the main purpose of providing continuous supply of water for irrigation, hydro-power electricity generation, domestic use, and flood control. The construction and operation of mainstream dams and other water barriers obstruct upstream and downstream migration of fishes, often resulting in the diminishing, disappearance or even extinction of many riverine fish species. The operation of dams also results in drastic changes of the hydrological patterns of streams, creating negative impacts to the natural population of migratory aquatic species as the release of water from dams does not usually consider the biological needs of aquatic organisms, but by the demand for hydroelectric power.

The operation of dams also reduces water flow during natural flood periods and increases flow during dry periods, resulting in changes of seasonal flood and continuity of the river and habitat systems. As the connection between rivers and floodplains or backwater habitats is essential in the life history of many riverine fishes that take advantage of seasonal floods and utilize the inundated areas for spawning and feeding, the loss or failure of such connection can impact on the species biodiversity which could even lead to extinction of certain species. In addition to changes of water flow patterns, the construction and operation of large hydro-power electricity dams could also impact on the physical characteristics of the water such as drop of upstream water temperature and dissolved oxygen, water stratification, sedimentation, accumulation of organic and inorganic substances including toxic substances. When upstream water is discharged, the impacts from such physical phenomena could also affect the living organisms in the long distance downstream waters.

Therefore, in order to mitigate the impacts from large dams, careful consideration should be given in the design and operation of dams. For example, extracting water from depths where water quality parameters such as water temperature and oxygen concentration of the discharged water are similar to those in the downstream of the dams. Moreover, the operation of dams and discharge of water should be synchronized with the biological rhythms and requirements of the aquatic species inhabiting the dams. This would require close coordination among the concerned agencies especially those involved in electricity generation, irrigation, and fisheries, while the construction of special and supplemental 'balancing reservoirs' or 'water regulating dams' could help in preventing extreme pulse discharges, maintaining the water flow at ecologically acceptable level. In addition, the development of several models of fish passes should be explored and initiated in order to facilitate the migration of aquatic species through various water barriers. Nevertheless, the effectiveness of fish passes which could be influenced by several factors including the dam's height, fish pass design, entrance location, water flow as well as other biological aspects of the aquatic species such as fish size, swimming abilities, migratory behavior, and population size, should be appropriately considered in designing and operating fish passes to ensure its effectiveness in mitigating the impacts from dams to the natural populations of aquatic organisms.

2.1.4 *Inland Fisheries* **vs.** *Aquaculture*

The deterioration of inland fishery habitats as a consequence of the aforementioned concerns results in the decline of the inland fishery resources, despite the seemingly increasing inland capture fishery production as claimed and reported by most of the countries in the Southeast Asian region. Nevertheless, as an attempt to increase fish supply from inland areas, aquaculture of freshwater aquatic species has been promoted and widely practiced in many countries.

The major cultured freshwater fish species that contribute to the total fishery production in the region include *Pangasius* spp., *Oreochromis* spp., *Labeo rohita*, and *Clarias* spp. Although aquaculture practices could contribute to the increase in inland fishery production, it could also generate impacts to inland fishery resources including the nutrient and chemical loads that cause eutrophication or mortality of aquatic animals in natural water bodies. Meanwhile, the collection of wild seeds for aquaculture purposes could impact the natural fishery resources and the introduction of non-indigenous species could lead to changes in species diversify and genetic diversity of certain areas. Moreover, the use of trash fish or fishmeal-based diets for aquaculture competes with the use of low-value fish for human consumption. Therefore, it has become imperative that these issues and concerns should be taken into consideration in the development and promotion of inland aquaculture.

2.2 Challenges and Future Direction

In several regional consultation processes, one of the priority areas raised that need special attention is maintaining the connectivity of the habitats in order to ensure the sustainability of inland fisheries. The construction of water alteration structures such as weirs, dams, roads, could create barriers to upstream and downstream migration of aquatic species, resulting in possible diminishing, disappearance or even extinction of species that migrate in upstream and downstream waters.

It is therefore important to conduct studies that aim to investigate and mitigate the impacts of water barrier construction and operation to the population of important aquatic species in the ecosystems. Conservation and improvement of habitats favorable for the aquatic species such as establishment of fish conservation areas or fishery *refugia*, artificial habitat improvement, deployment of materials and shelters to create nursery and feeding grounds for juvenile and broodstock, could also be undertaken to enhance the populations of various aquatic species. In addition to habitat conservation and rehabilitation, stock enhancement activities could be practiced to improve fish yield particularly for areas where the fishery resources had deteriorated and fallen below the ecosystems' carrying capacity. In an ideal case, stocking should consider the use of indigenous species or low trophic species, with seeds produced specifically for the purpose of stock enhancement.

In using seeds produced from aquaculture for stock enhancement, caution should be made as this approach could create negative impacts on the biodiversity of the ecosystem. Specifically in closed ecosystems such as lakes and reservoirs, the impacts from stocking of hatchery-bred seeds are localized and thus, may not be very substantial. However, the release of hatchery-bred seeds into natural open habitats could result in irreversible damage to the broad ecosystems, which could include loss of biodiversity where exotic species could dominate over the native species or loss of genetic diversity of the species. In general, releasing hatchery-bred seeds should be undertaken in a precautionary manner. Since the nature of inland fisheries and ecosystems are very diverse and could be different from place to place, different approaches should be considered in coming up with appropriate conservation and management measures for particular areas, taking into account the resources as well as the relevant social and economic dimensions. In addition, appropriate indicators should also be identified and used to evaluate the success of stock release and enhancement programs.

Furthermore, considering the wide-range of stakeholders in the fishery and non-fishery sectors involved in the utilization of inland fishery resources and the ecosystems, integrated water resources management approach as well as enhanced coordination and communication among the various agencies sharing the same water resources should be promoted. This could prevent if not minimize the impacts of one to the other sector, while the importance of inland fisheries should be made known and publicized particularly for policy makers and relevant management authorities in order to appropriately mainstream the requirements of inland fisheries into the overall development plan of the countries. Data collection on inland fisheries should be enhanced in order to appropriately value the inland aquatic resources. Routine and non-routine data and information as well as data collected through non-conventional methods such as fish consumption survey, and local knowledge should also be fully utilized for this purpose.

Responsible fishing technologies and practices should also be promoted, with due consideration given to the sustainable utilization of the resources especially the highly abundant but short life-cycle species, and top predator species. To effectively harvest these species without creating impacts to the other non-targeted species, selective fishing gears and practices should be developed and investigated as to their effectiveness and efficiency. In this regard, consideration must be given to relevant ecological and biological parameters, and traditional knowledge of local fishers in harvesting and utilization of the species. In order to reduce pressure to the inland fishery resources and enhance the livelihoods of fishers and the fishing communities, alternative fishery-related livelihoods could also be introduced such as production of value-added products from the catch, promotion of eco-tourism and recreational fishing, and aquaculture including rice-fish culture.

In addition, participatory approach should be considered and promoted for the effective management of inland fisheries. This could include the concepts of co-management, community-based fisheries management, and rights-based fisheries as appropriate as well as the Ecosystem Approach to Fisheries (EAF). Where appropriate, such schemes as granting of fishing rights, application of fishery licensing and registration, could also be promoted to replace open access with limited access to fisheries to ensure the effectiveness of the management measures.

Activities that aim to enhance the awareness of fishers and other resource users of the inland water ecosystems should also be undertaken, focusing on the need to conserve and manage the resources, adopt responsible practices. Moreover, efforts should be exerted to enhance the involvement and participation of fishers in community activities related to the resource conservation and management as well as in MCS activities, and ensure the long-term sustainable utilization of the inland fishery resources.

3. UTILIZATION OF FISHERY RESOURCES

Fishing activities, fish utilization and post-harvest technology in the Southeast Asian region are extremely varied. While fishing activities could range from commercial to small-scale and from marine to inland waters, and using modern and traditional capture techniques, fish utilization and post-harvest technology depend much on the capability of a certain country, its development and on how and where the fish species are caught and processed. For marine capture fisheries in the region, most of the fish caught is landed, and for most part, discards are negligible. This pattern of catch retention is different from other areas of the world which could be due to technological changes as well as economic and marketing pressures particular to the Southeast Asian region. High value fish is well looked after in this region but low-value fish is not. Although all the fish landed is utilized but some volumes of low-value fish catch may contain juvenile fish of high-value species. In addition, some high-value fishes could be reduced to low-value fishes because of poor handling onboard the fishing vessels.

Significant improvements in post-harvest technology of fish as food have taken place over the past decades, which is notable in major fish producing and exporting countries. Improved facilities include cold storages and ice plants as well as infrastructures for fish handling distribution and marketing, and techniques for improved fish handling onboard to maintain the quality of the catch while at sea. Modern fish processing factories have been established in many countries mainly for processing high-value and high-quality fish and crustaceans including tuna and shrimps as frozen, filleted or canned products, with increasing volume destined for export. Concurrently, many new fish products have been developed mainly for export although certain quantities are available in local supermarkets in urban centers such as fish balls, fish cakes, imitation crab sticks, breaded squid rings, breaded fish or shrimp, fish crackers, and other products (Goh and Yeap, 2007; Goh *et al*., 2008).

In the last two decades, the utilization and processing of fish products have significantly diversified, particularly into high-value fresh and processed products, fuelled by the changing consumer tastes and advances in technology, packaging, logistics and transport. Improved processing technology generates higher yields and results in a more lucrative products derived from the available raw materials from fish for human consumption. Nonetheless, some of these developments have also been driven by the demand in domestic retail industry or by a shift in cultured species. Improved processing technologies are also important in the utilization of fish wastes generated by the fish-processing industry.

Most of these improvements have revolved around high-value or "luxury" fish and an industrialized fishery or larger aquaculture enterprises, and account for a small portion of fish used for food in the region. Food fish, especially in rural areas, may come from small-scale fisheries, aquaculture and inland fisheries. In the Southeast Asian region, over 50% of fish is consumed fresh and/or processed into high-value products, 8% to 65% (mostly between 30 and 45%) are converted into traditional products, and another varying percentage is used for direct feeds for livestock or high-value species aquaculture or indirect feeds by converting fish to fishmeal or fish oil. These traditional labor-intensive fish-processing methods provide livelihood support to large numbers of people in coastal or inland water areas in many developing countries. For this reason, such methods are structured to promote rural development and poverty alleviation and are likely to continue to be important components in rural economies (Kato, 2009).

Improvements in processing, packaging, and distribution have facilitated the movement of fish products from local consumption to international markets (Yeap and Chung, 2011). The role of fish trade varies among the countries and represents a significant source of foreign currency earnings, in addition to the sectors' role in employment, income generation and food security. However, it has become imperative for the countries to address the issues related to the requirements of consumers and importing countries in trading of fish and fishery products, which are getting more and more stringent. In the last decades, changes in global dietary patterns had become very notable with a shift towards more protein. This is brought about by rising living standards, population growth, rapid urbanization, increased trade and transformations in food distribution. People in urban areas tend to eat out more frequently, and large quantities of fast and convenient foods are purchased. Supermarkets are also emerging as major force, particularly in developing countries offering consumers a wide choice of safe food with reduced seasonal fluctuation and availability. Supermarkets are not only targeting the higher-income consumers but also lower- and middle-income clients. There is also a greater focus on marketing with producers and retailers attempting to anticipate market expectations in terms of quality, safety standards, variety, and value addition, especially for the more affluent markets. It is in this aspect that consumers increasingly require high standards of food freshness, diversity, convenience and safety, including quality assurances such as traceability, packaging requirements and processing controls.

3.1 Status, Issues and Concerns

3.1.1 Onboard Post-harvest Technologies

Poor handling of catch onboard fishing vessels results in poor quality raw materials, particularly for low-value fishes. Currently, there are new requirements for exporting fish and fishery products that need to be complied with, particularly to the EU such as the requirements for traceability of the products to ensure that fishes are not caught by IUU fishing, as well as fulfill the requirements for food/fish safety. In addition, it has also become imperative for countries to address the issue of by-catch management and reduction of discards. As noted earlier, most fish caught are utilized in the region but unfortunately, many fisheries in the region also capture ecologically important species and juveniles of economically valuable species. Many studies have been conducted to minimize post-harvest losses but issues other than the actual quantity of catch should also be considered as equally important, especially the socio-economic impacts of utilizing by-catch instead of decreasing its capture. Furthermore, the quality and utilization of the catch should be improved, especially the small fishes caught by trawl that turn into mush when landed and which could only be useful as aquafeeds, and small fishes caught by gillnet, by converting such small fishes into high-value traditional products.

In fact, due to supply pressure and the expansion of aquaculture, low-value fishes although giving low economic returns per fish could provide higher returns per volume landed, since low-value fish has a ready market in aquaculture areas and can be sold easily in many localities at higher prices. As reported, the money derived from low-value fishes is one of the main reasons why many fishing vessels continue to be economically viable and remain stable in the fishing industry. Even if the fishery catch comes from short-lived highly productive species, such fisheries could still be sustainable, except when the catches contain large amount of juveniles of economically important species. However, given the many conflicting uses of low-value fish, it is difficult to envisage an appropriate management system that could optimize the utilization of low-value fish supply for human consumption and livestock/aquaculture uses without giving due consideration to the catch of juvenile fish.

Nonetheless, considerable amount of fish that could be marketed as higher value fish are landed as lower value fish because of poor handling on-board fishing vessels. As reported in Vietnam, such volume could come to about 20-60% from offshore trawlers because of poor storage onboard the vessels. It is obvious that with high demand and good economic gain from low-value fish, many fishers could forgo the importance of and need for careful handling and chilling onboard fishing vessels.

Even if it would be theoretically possible to improve the products, lack of chilling equipment and necessary onshore infrastructures limit the small-scale and artisanal fishing vessels from accessing the high-value urban or export markets. Hence, it is not always easy for the vessels to land high quality products for the human consumption market without improving the infrastructures and such approach would entail substantial costs. However, with proper handling on-board fishing vessels, landing and supply of quality fish to local markets would still be possible, especially where fishing grounds are close to ports. On the other hand, industrial vessels with better-trained crew and proper equipment on-board should be better in terms of ensuring high quality catch, but the economic gains of doing so must outweigh the gains of landing fish on low-value markets. As long as the low-value fish market is vibrant, fishers will not exert much effort to improve the overall quality of their landed catch. Thus, as far as the quality of low-value fish destined for reduction is concerned, the very low quality of raw materials would result in low quality of the fishmeal produced.

3.1.2 Onshore Post-harvest Technologies

Advanced post-harvest technologies have always existed in many places and countries, particularly for export oriented products and products destined for urban markets. Nevertheless, for small-scale fisheries, trading in inland fish and fishery products has always been constrained by lack of infrastructures especially in terms of hygienic landing centers, roads, electric power supply, and potable water as well as facilities needed to establish and operate cold chains including ice plants, cold rooms, and refrigerated trucks, that often results in high post-harvest losses, especially in the aspect of quality.

Small-scale fisheries contribute more than one-half of the world's marine and inland fish catch, and nearly all of this is used for direct human consumption. This sub-sector employs more than 90% of the world's fishers and supports about 3 times the number of fishers in jobs associated with fish processing, distribution and marketing, and almost one-half of such workers are women. Moreover, on the average, each jobholder provides three dependant- or family member-ancillary workers. FAO studies have indicated that fish landed for food provides 1.5 man-years/MT of landed weight. Nonetheless, in spite of the contributions of fisheries to the economy, poverty remains widespread for millions of fishing people, thus the reasons which are complex must be tackled in many fronts including strengthening the capacity of those working in various jobs related to post-harvest and marketing.

Inland fisheries could be special case because being extremely small-scale, inland fisheries are usually very individual labor intensive providing small incomes. However, due to the large numbers of people involved, this sub-sector provides significant contribution to rural food security and income generation, and diverse set of livelihood benefits related to food security and poverty alleviation especially to the poorest households in the rural sector. Inland fishery activities employ labor-intensive harvesting, processing and distribution technologies conducted full-time or part-time, mostly supplying fish and fishery products to local and domestic markets as well as for subsistence home consumption. It has been recorded that there are more people involved in inland fisheries than marine fisheries, of which more than 50% are women. Since inland fishers catch less fish per individual than the marine fishers, inland fishery sector is therefore a predominantly component of a mixed livelihoods strategy. As a result, most of the catch goes for domestic consumption and most of the processing is done in small-scale or medium-scale units, where handling and hygienic practices are often inadequate. Owing to the remoteness and isolated nature of many inland fishing communities and the high abundance of fish on a seasonal basis, large amounts of fish from inland capture are cured, and in the Southeast Asian region, a significant portion of the catch from inland fisheries goes into fishery products such as fish sauce and fish paste. In many cases however, food safety issues become a serious concern because the presence of parasites in raw or slightly fermented fish or fish products, or in products that have been improperly frozen, put the well-being of the consumers at risk.

The stakeholders should therefore be made well aware that live parasites could rarely stay alive in well-fermented fish, and parasites do not usually survive when fish are properly frozen. Addressing the above deficiencies requires more capacity building and training in good hygienic practices, focusing more efforts on research work such as for example in systematic loss assessment to develop sustainable loss-reduction strategies, and aspects related to live fish handling, and improved processing including value addition. Many of the aforementioned facts also apply to marine small-scale fisheries, particularly in countries that comprise large numbers of islands. Even if there are commercial and industrial inland and marine fisheries as well as modern small-scale fisheries, these sub-sectors should be made economically efficient especially in providing high-value products, that are meant for international markets. Such scheme would often require specialized catch preservation and distribution, and access to markets.

In all aspects therefore, the promotion of value-added technologies and improved traditional products should be intensified to foster demand, obtain higher economic returns and more fish and fishery products for human consumption, which could also include new non-traditional products. It is also imperative to boost improved packaging or marketing of traditional products to enable such fishery products to gain access to high-end retail outlets and export markets. A number of activities needs be done to alleviate the situation, including the need to encourage governments through their respective national development activities to improve fishery infrastructures where appropriate. There is also the need to develop guidelines for infrastructure requirements of small-scale fisheries especially in landing areas. Overall, efforts of the governments should give more focus on the development of guidelines for handling live fish, conduct of baseline studies on post-harvest losses, continued work on the development of value-added products particularly for low-value fish using low-cost methods as appropriate, investigating the quality and safety of freshwater fish, conduct of training programs on post-harvest technology which could be used by extension workers, and conduct of training for both government and industry officers and workers on critical aspects of handling, processing, distribution and marketing in the fish supply chain, and provision of cold chain at all levels.

3.1.3 Utilization of New Fishery Resources and Waste Products

Post-harvest technological development has changed the utilization patterns practiced in the past especially during the surimi era, where new products which are equally important for food security in the future could now be developed. However, efforts are still necessary on waste reduction and recovery, taking into consideration the environmental impact of fish waste products. R&D activities could emphasize on the aspects of increasing by-product utilization for human consumption, alternative use of waste products for bio-fuels, utilization of wastewater from production sources including from on-board facilities, and pharmacological use of by-products. Moreover, increased utilization of under-utilized species, by-products, and recovery of wastes processing plants should also be explored through continued research on optimum utilization of under-utilized species. Furthermore, studies on waste reduction and recovery, and environmental impact of fish waste products, and on by-product utilization, should be pursued.

3.1.4 Traditional Products and Post-harvest Technologies

Traditional fish processing is part of a “dual economy” in which traditional small-scale activities co-exist with the modern industrialized sub-sector. Traditional industry is characterized by the application of low-level technology, producing relatively poor quality and low-value products. Modern processing which includes proper icing of fish and post-harvest handling had been developed in response to the growing export market and rising living standards, especially in urban communities and markets, with the technology which generally caters to the demand of importing countries. Generally, traditional processes require minimal investments but products turned-over should meet most of the domestic food needs. Hence, the poor sector of society usually undertakes these activities, many of which are women. Value adding in this aspect tends to be very small and such products are usually inexpensive but are unable to enter world markets.

Nevertheless, traditional products that are of good quality would be able to access the urban and international markets, and command very high prices. Among the major problems in traditional products include poor quality and limited supply of raw materials because of the increasing competition for alternative use of raw materials. The other problems are poor infrastructure and insufficient knowledge in processing and preservation technologies, as well in packaging the products and the high costs involved in packaging. However, the biggest problem could be the large numbers of traditional processors that makes it difficult to deal with all of them on an individual basis. For example, Indonesia alone turns over 6.4 million MT/year of fishery products and exports 0.86 million MT/year (mostly shrimp, tuna, and seaweeds), through some 422 export processing plants. Another 59,345 registered traditional processing units take care of the rest of the capture fishery products.

In some countries, fish processing centers or zones have been established to facilitate the acquisition of the necessary equipment, and to ensure that human resource development would be in place for packaging and other relevant aspects in processing. In order to improve the technological problems related to traditional products, work on diversification of raw materials should be intensified to assess the different types of raw materials that can be used for the same traditional products as well as on different materials to generate 'improved' traditional products. There is also a need to enhance community cooperation in producing raw materials and endemic or indigenous ingredients. Training programs on handling, processing, distribution and marketing of traditional products at all levels should be conducted. The appropriate methods of reducing insect infestations should be explored including the use of biological insecticides, and the use of non-food grade additives/preservatives. The development of traditional and value-added products particularly using low-cost methods should be investigated as well as improvement of the efficiency of processing equipment and facilities, and promotion of the use of alternative energy sources. Finally, research on traditional and/or indigenous materials for packaging and use of modern technology to reduce the cost of packaging and better preserve the products should be conducted. Governments should be encouraged to establish fish processing centers to reduce the costs of processing and packaging individual traditional products.

3.1.5 Post-harvest Technologies and Livelihoods

A very proper place to start discussion on this concern is to know the definition of food security. The most recognized definition is the one endorsed by the International Conference on Nutrition (Rome, December 1992) which states that it is "a state of affairs where all people at all times have access to safe and nutritious food to maintain a healthy and active life". It is generally recognized that the root cause of food insecurity is poverty, where people who are susceptible to food insecurity are predominantly those living in rural areas, especially in fishing and fish farming communities. In Southeast Asia, majority of the fisherfolks who are the primary producers of food fish, are still underprivileged and live a very poor life. Eradication of poverty and the maintenance of food security to ensure food for all are now being given high priority by almost all of the governments of the region.

Trade is innate to fisheries, so that the moment a fisher has more than three or four fish for personal consumption, there is pressure to exchange the 'surplus' for money or other goods. Food security from fish has a direct and indirect dimension to it. Fish as food on the plate, that is direct while fish as source of livelihood and income, is indirect. Therefore, in assessing the food security implications of fish trade and processing, these dimensions should be looked at considering the wide diversity of fish. For example, some commodities like tuna and shrimps are for 'luxury consumption' while others like anchovies and other low-value fish are for 'nutritional consumption'. For direct food security issues, the latter should be taken into consideration. Fish contributes importantly to direct nutritional food security in countries where staple crop is particularly low in protein. Even a small quantity of fish can contribute to increasing staple consumption by improving its overall palatability and adding micronutrients to its nutritive value. However, the need for food does not adequately translate fish into food security because this need must be backed by effective demand in the form of purchasing power, a factor which is lacking among many potential consumers of fish in developing countries.

Moreover, even if fish were accessible and affordable, there are other factors that limit food security. People living in adverse environmental surroundings that give rise to poor health conditions cannot absorb such rich proteins. Therefore, people must have the ability to always access, afford and absorb the food they wish to eat, the three basic conditions that must be satisfied in order to achieve genuine direct food security.

The relationship between fish trade and improved fish products and food security is more complex than being thought of and is not necessarily always positive. Production of fish for the high value market can substantially enhance the incomes of poor fishers, and also raises their purchasing power to attain food security. However, in a country where fish is an integral part of the culturally conditioned diet of the domestic population, fish product improvement could reduce the direct food security of the poor domestic consumers. In such cases, the demand is likely related to the inelastic price because if supply is less than the effective demand by even a very small margin, the price of fish would sharply increase. This can lead to undesirable nutritional consequences especially for the poor fish consumers. Therefore, such product improvements would still have an adverse impact on food security for this segment of the population.

There are several issues concerning the production and use of low-value fish in relation to food security. Firstly, the continued expansion of aquaculture in the Southeast Asian region which is dependent on the low-value fish from capture fisheries for feeds. Although the use of low-value fish as direct feeds or for the production of fishmeal for aquaculture is economically viable, which is reflected in the increasing prices of low-value fish, there is also an increasing conflict between the use of low-value fish for feeds and for human consumption. This demand from aquaculture makes the price of low-value fish higher than the price that traditional fish processors could afford in order to generate processed products that many consumers can afford. Even if it has been argued that it would be more efficient and ethical to divert more of the limited supply of low-value fish for human food through value-adding, because the low-value fish as food for domestic consumers is more appropriate than supplying fishmeal plants for export, the income oriented aquaculture industry has to produce high-value commodities for the export market to improve the economies of the countries. Meanwhile, improving the abilities of poor people to generate income can also increase food security especially that large numbers of people are employed in both fishing and aquaculture activities, and thus would eventually get the beneficial effects. However, most value-added products are directed for the higher income and not to the poor income groups where low-value fish was supposed to supply them with affordable fish for consumption.

Secondly, technological innovations, value-adding, and improving the quality of fish have always been beneficial to the peoples and the economies but such measures would require funding in order to get the much needed products, and in the end there would be winners and losers. As a whole, a country could benefit through earnings from export or by supplying more fish to the newly affluent urban population while the fisherfolk and those engaged in processing such new products would also gain some benefits. Value-adding creates employment especially to the young women who are engaged in these jobs and who are from poorer rural areas where other job opportunities are scarce, thus, these new jobs could enhance the food security of many people.

In some countries, a significant number of women earlier involved in fish processing for the domestic market have already been adversely affected since they could no longer get fish as raw materials for their traditional processing activities because of their inability to pay for the high price offered to fishers by alternate processors. This results in loss of income and food security for these groups of women. Furthermore, the perspective of the general consumers on food security could be detrimental to the food security of poor consumers. Many consumers perceive that as export trade and value adding increases, the volume of fish available for local consumption would decrease, which could be valid. However, contextualizing this within the real situation of a country, could give different scenarios with different winners and losers, and thus, there is a need to analyze further such perception.

Lastly, it is a fact that improved quality, technological innovations, value-adding, national marketing systems, and aquaculture as well as regional and international trade, are bound to increase in the future. Although such situation could contribute greatly to food security, but just the same the gains could be skewed to the left or to the right. In one way, these could enhance food security and on the other, could reduce food security at the same instant for different segments of the population. Therefore, it is only through poverty reduction programs that the situation of the poor segments of the society could be improved. Many governments and organizations have been undertaking programs to activate rural fisheries communities and improve their economic status. SEAFDEC for example, had introduced an approach through a program known as "One Village, One Fisheries Product" (FOVOP), which called for fisheries communities to identify a unique and differentiated traditional product, and develop a marketing strategy for such product. However, it was established that such programs would not work without technical assistance, infrastructure support, and in some cases financial incentives. Other management systems such as the ecosystem approach to fisheries (EAF) has post-harvest dimensions incorporated into the human aspects of the system and plays a role in determining the economic "push" and "pull" mechanisms in fishing activities, and also in the social, economic and institutional aspects. Such factors should therefore be considered and should not be left out from any fishery management equation.

Addressing these issues would need a number of activities which could include many of the earlier recommendations as well as those related to marketing, namely: assessment of the marketing strategies that promote fresh and traditional fish products in urban communities; finding ways and means for rural communities to gain better market access for their products; promoting the FOVOP scheme, and developing products and marketing strategies for this scheme; establishment of a joint platform to improve international trade competitiveness of traditional products; harmonizing data collection and reporting systems for traditional products; and conduct of studies on the distribution and marketing of fish and establishing the means of redistributing the benefits along the supply chain towards the primary producers.

Additionally, there is a need to improve the use of incentives/credit schemes to promote the industry and alleviate poverty by: promoting greater access to credit for post-harvest activities and greater support for the development of marketing cooperatives and/or the small and medium enterprises (SMEs), particularly in fishing communities as well as for FOVOP or similar schemes; evaluating the incentives that would foster demand for higher economic returns and more fish for human consumption; and investigating the ways and means for traditional processors to get better access to credit or micro-credit schemes. In essence, the governments should as much as possible, decide and take action to alleviate poverty and improve food security in their respective jurisdictions.

3.1.6 Post-harvest Quality, Safety and Control Systems

Quality, safety and control systems are crucial to every aspect of fisheries from capture to consumption, and apply to government and industry catering to both domestic and export markets. The whole industry needs quality and safety management systems to operate, whether through intuitive knowledge or formal control system or something in-between. Governments generally operate fish inspection and control systems through relevant agencies to ensure that all products meet the export market requirements, but most agencies do not have much control over domestic production except those agencies that take charge of controlling the areas of supply to export processing plants.

Several government agencies including fisheries, health, commerce and trade, state, municipal, and local authorities are currently providing services related to the safety and quality of fish products. However, in some countries there is still lack of coordination among the relevant agencies, thereby creating confusion, and setting conflicting standards and carrying out duplicating roles because different procedures are applied in different areas of responsibilities of the different agencies.

Furthermore, importing countries are becoming more and more demanding in their requirements. In the beginning, importing countries require exporters to meet only the safety requirements under the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) through verification of industry's Hazard Analysis and Critical Control Point (HACCP) control systems, which can be audited by the concerned governments. While adapting to a new global trade environment, new emerging issues with respect to import requirements have developed, which should be dealt with to enable the industry to access the export market, such as traceability and certification of products for safety, sustainability, combating IUU fisheries, social issues, and environmental responsiveness of products from sea, inland waters or from aquaculture. Additionally, there are other issues that should be addressed under the new requirements such as testing the waters and the products for contaminants, toxins, residuals or for genetically modified organisms (GMOs).

Meeting the requirements of the export market is also a food security issue considering that increased foreign exchange contributes to the welfare of the country and to all workers involved in the industry through income generation. In the ASEAN Economic Plan, all ASEAN food inspection agencies including fisheries would be harmonized by 2015, but would require more work on the technical aspects of harmonization, specifically in the harmonization and verification of laboratory testing methodologies, laboratory procedures and practices, and developing Good Laboratory Practices (GLP) in the Southeast Asian region. A system of proficiency testing for regional laboratories should be developed, while additional work is still necessary to harmonize procedures between inspection agencies in the region, and establish equivalency with inspection systems in importing countries. There are also other certification issues especially those related to Halal and organic products. Recently, such harmonization has been initiated under the ASEAN mechanism, although slowly, and addressing some of the foregoing concerns could support efforts in achieving the goal in a shorter time.

Safety of domestic fish products is vitally important to food security by ensuring that consumers eat safe products. During the last decade, much work has been done in adapting HACCP to SMEs that export traditional products and to develop improved operating practices for domestic SMEs like the Traditional Processing Establishments (TPEs) and Pre-Processing Establishments (PPEs) by incorporating Good Manufacturing Practices (GMP) and Standard Sanitary Operating Practices (SSOP). At this point of time, it is not yet practical to apply HACCP to these industries, but instead GMP/SSOP should be applied since it is a prerequisite to HACCP. Up till now, the implementation of GMP/SSOP is still inadequate in source suppliers, processors, and transporters due to high costs involved and lack of encouragement and support even if there is the need for its implementation to be fast-tracked. The aquaculture industry has also been confronted with problems due to the inability of small-scale producers to meet the quality requirements of foreign consumers.

Some other major issues concerning international trade in fishery products in the past biennium, and which continue to affect international trade include the introduction of private standards such as those for environmental and social purposes which have been endorsed by major retailers; certification of aquaculture in general; concern of exporting countries about the impact on their fish exports due to the introduction in 2010 of new traceability requirements in EU markets; process and margins throughout the fisheries value chain; the need to enhance competitiveness of fish products compared with other food products; and perceived risks and benefits from fish consumption. For some products and in some countries, requirements for traceability systems do exist, because many of these systems are privately adopted and are not all-inclusive. However, there is a need for the varying systems to be harmonized within a country and in the Southeast Asian region. In view of the strengthening of the requirements of retailers for selling fish in developed countries, private standards and certification schemes in fisheries and aquaculture are becoming significant features in the international fish trade and marketing.

Nonetheless, the proliferation of these standards and schemes causes confusion on the part of consumers and producers, therefore, a mechanism for judging the quality of the schemes is necessary. Overall, traceability systems that could be applied to the whole supply chain for the region should be developed and which could include regulations, enforcement systems, and certification management mechanisms.

3.2 Challenges and Future Direction

In summary, a number challenges need to be worked out in order to address the aforementioned issues. These could include the development of training materials, conduct of training programs for trainers, and training of the industry in the implementation of GMP/SSOP; and investigating the ways and means for the industry to access to funds for the incorporation of GMP/SSOP in their activities. In addition, there is also the need to improve the methodology for traceability and capacity to deal with new emerging export requirements by investigating the various traceability systems that currently exist, and develop a mechanism to harmonize such systems at the national and regional levels; and investigating new emerging issues, and finding the ways and means of incorporating these into the harmonized certification management mechanism. There is also the need to harmonize the inspection systems and standards in the region by: investigating the certification and accreditation issues related to Halal and organic products; continuing the promotion of the ASEAN laboratory accreditation system, developing methodologies and mechanisms for proficiency testing, and promoting GLP; continuing the process of harmonizing food/fish inspection systems and standards for common products; building capacity in risk assessment and its implementation; investigating how private certification schemes could be incorporated into the national or regional certification management mechanisms; and providing a platform for the sharing of information among the countries in the region on the implementation of harmonization activities within the fisheries sector. Lastly, there is also the need to improve internal regulatory control systems and technical manpower by developing National Plans of Action in conjunction with the need for coordination and control of all aspects of fish handling, processing, distribution, and marketing, by all regulatory agencies; and encouraging the recruitment and training of quality management personnel.

4. FISHERIES MANAGEMENT

In the Southeast Asian region, there is a growing problem of overfished fish stocks and excessive fishing capacity, which could be a result of the number of fishing vessels and increased efficiency of fishing technologies. This together with high levels of Illegal, Unreported and Unregulated (IUU) fishing are generally recognized as important factors that obstruct all efforts of the region to conserve and maintain fish habitats and stocks for long term sustainability. MRAG (2009) estimated that the global economic impact due to IUU fishing could be between US$ 9 billion and US$ 24 billion annually or about 11 million MT and 26 million MT of fish. Attempts have been seriously made by countries in the Southeast Asian region, in seeking ways to improve fisheries management with the objective of reducing IUU and destructive fishing activities. The number of important international instruments, binding or voluntary that have been developed and agreed upon globally are providing guidance to countries on what measures to take and restrictions to apply in order to achieve sustainability in resource utilization. Such important conventions and other instruments include the 1982 UN Law of the Sea Convention (UNCLOS 1982), the United Nations Fish Stocks Agreement (UNFSA), FAO Compliance Agreement 1993, 1995 FAO Code of Conduct for Responsible Fisheries, and the 2009 FAO Agreement on Port State Measures.

4.1 Management of Fishing Capacity and Combating IUU Fishing

In response to the global requirements and the rapidly increasing regional concerns to enhance sustainable exploitation of fishery resources, senior officials and other decision makers of the ASEAN countries have increasingly strengthened their commitment to improve management of fishing capacity and efforts to combat Illegal, Unreported and Unregulated (IUU) fishing. The issue on management of fishing capacity and combating IUU fishing has been seriously addressed by the ASEAN Sectoral Working Group on Fisheries (ASWGFi), the ASEAN Fisheries Consultative Forum (AFCF), the SEAFDEC Council, and the RPOA initiative to combat IUU fishing (based in Indonesia), as well as in the "Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020" (SEAFDEC, 2011b) recently adopted by the Ministers and Senior Officials during the ASEAN-SEAFDEC Conference in 2011.

In addition to the afore-mentioned regional initiatives, there have also been emerging trade-related measures and requirements aiming to combat IUU Fishing and enhance responsible fishing practices, among which is the the European Council (EC) Regulation No. 1005/2008 which established a community system to prevent, deter and eliminate IUU fishing, and the FAO Legally-binding Instrument on Port State Measures (PSM). The EC Regulation aims to restrict the importation to EU and between EU Member Countries of fish and fish products that originate from IUU fishing, and the requirements are in conformity with the FAO/PSM Agreement. In response, countries in the region have developed their respective regulations and systems/mechanisms not only to combat IUU fishing but also to meet the standards and requirements for trade of their fish and fishery products to these international markets, as well as within the region.

In line with the initiatives in combating IUU fishing, in 2010, SEAFDEC also organized an Expert Consultation on Managing Fishing Capacity to Combat IUU Fishing in Southeast Asia, where the Member Countries identified elements for sustainable fisheries management and controlling fishing efforts to combat IUU fishing in the Southeast Asian region. Some of the specific recommendations included the promotion of vessel record and inventory as inputs to information sharing; fishing vessel registration and fishing license (vessel, gear and people) and institutional and legal responsibilities including safety at sea aspects; catch documentation schemes to register catches (*e.g.* log books); port monitoring to include landings by vessels from neighboring countries; certification schemes to address the range of items that need to be certified by whom and how (*e.g.* catches, landings, environmental, social and labor aspects); development of MCS Networks based on the existing initiatives in the sub-region of Southeast Asia to be linked with the Regional Plan of Action (RPOA) to Promote Responsible Fishing Practices (including Combating IUU Fishing) in the Region as well as with the efforts of the ASEAN and SEAFDEC.

4.1.1 Fishing Vessel Registration and Fishing Licensing

In order to ensure that the fishing effort be regulated at acceptable level and enhance sustainable exploitation of the fishery resources, the FAO IPOA-IUU specified one of the responsibilities of Flag State and Coastal State in registering all fishing boats, issuing fishing licenses and collecting data concerning their fishing activities in accordance with the modified method for countries. The SEAFDEC Council during its annual meetings in 2009 and 2010, therefore recommended SEAFDEC to collaborate with FAO and look at the elements needed to improve fisheries management, to control fishing effort and to combat IUU fishing by addressing the issues on fishing capacity, as well as vessel registration and record. It is also envisaged that the establishment of good and systematic schemes for the registration of fishing vessels and issuing of license would allow countries in the region to come up with more reliable data and information on the actual fishing effort, which could further serve as a basis for the development of appropriate policy and management measures to ensure sustainable fisheries in the region.

However, the situation in the Southeast Asian region is very complicate due to the fact that several hundred thousands of boats are small and artisanal fishing boats, and are scattered along the coasts and in villages or landing sites. Furthermore, the fishing gears and practices used by these boats could also be very flexible and change according to the seasonality and abundance of target species. Although most countries in the region have implemented fishing vessel registration and licensing systems, but the degree/methods of registration and licensing could be varied, and the systems mostly focused on large-scale and commercial fisheries. Different countries also apply different definitions/classifications of fishing boats and registration format, which are difficult to change or harmonize among countries.

In addition, note should also be taken that countries in the region have different laws, regulations and agencies that are authorized to undertake vessel registration and fishing licensing. In some countries, *e.g.* Malaysia, Vietnam, only one agency is responsible for registration of fishing vessels and issuance of fishing licenses; while in some other countries, *e.g.* Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Myanmar, Philippines, Singapore, and Thailand, there are more than one agency involved in the process. However, the purpose and mandate of these agencies are generally different, *e.g.* the fisheries-related agency is responsible for regulating and ensuring sustainable fisheries management, while other agencies may focused on other aspects such as safety at sea standards, pollution controls, etc. In some countries, the authority to register smaller vessels even rests with the local government or other local bodies such as the local government unit in the Philippines or the local People's Committee in the case of Vietnam.

During the Expert Consultation organized in 2010, discussion was also made on the necessity for countries in the region to strengthen their fishing vessel registration and licensing system. However several countries expressed their difficulties in recording fishing vessels and registering the fishing boats due to the inadequate number of officers, the lack of stakeholder's cooperation, and the insufficient budget and financial support to undertake the required tasks. In addition, there have also been inadequate information and communication from responsible agencies to enhance the understanding and knowledge of fishing boat owners and other stakeholders on fishing vessel registration and licensing and encourage boat owners to register their boats or obtain appropriate licenses. The Consultation therefore recommended that, at the national level, governments should provide various forms of incentives for fishing boat owners and fishers who apply for registration; establish routine mobile units with designated officers for fishing boat registration and fishing licensing especially in the distant areas; and establish national data record center responsible for collecting data from relevant local offices in the country; while stakeholders' participation throughout the processes of fishing boat registration and fishing licensing and awareness raising activities should be enhanced. In addition, at the regional level, a regional network should be established to promote the sharing of knowledge and information on effective fishing boat registration and fishing licensing; and a regional data center should also be established to facilitate compilation and exchange of data collected by the national data record centers.

In line with the above recommendations, attempts had been continuously made by SEAFDEC in collaboration with the Member Countries to strengthen cooperation especially in the development of mechanisms for information sharing among agencies responsible for the registration of fishing vessels and those that grant the licenses to fish. However, it is necessary to make a clear distinction between a "vessel registration" in accordance with the International Maritime Organization (IMO) and international standards, which allow a vessel to fly a certain flag, and a "record of fishing vessels" that have or have not or need not have any fishing license. The existence of such limitation made it difficult for the countries to promote the collection and compilation of information on registration and licenses, especially in countries with divided institutional responsibilities. It is therefore necessary to develop a Regional Standard for vessel inventory, which could include information on safety requirements since such information could be referred to when the need arises especially in the aspect of preventing accidents at sea and implementation of rescue schemes.

In addition, it was also recommended that legal provisions and requirements of the countries should be reviewed to assess their legal and institutional arrangements for providing support towards the development of national systems for registration and licensing. It is also important to recognize the extent to which the mandates are divided between different agencies to handle fishing vessel registration and the process of issuing licenses to fish, and examine the possibility of having only one agency to handle both systems to simplify the process. Nevertheless, irrespective of the system, linkage and cooperation among the agencies concerned should be strengthened.

In addition to the efforts and initiative as mentioned above, there is also a new global initiative initiated by FAO to combat IUU fishing activities, known as the FAO Global Record (GR) of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels which was designed to include the provision of unique vessel identification (UVI). The implementation of GR is expected to move ahead in steps, starting with vessels larger than 100 Gross Tonnage (GT) and gradually, to include the smaller vessels. The UVI is aimed to increase transparency making it more difficult and expensive for those who would attempt to operate fishing vessels illegally. Although the implementation of the FAO GR is at this stage on voluntary basis but in the future it could be declared a global requirement in order to monitor IUU fishing activities. It is therefore necessary for countries in this region to improve their respective fishing vessel registration system to be able to comply with the requirements that may emerge in the future including those of the FAO/GR.

4.1.2 Catch Documentation including Logbook Systems

The increasing concern and awareness of consumers on safety and quality of fish and fishery products led to the growing number of requirements to ensure good food quality standards. The requirements include compulsory measures to verify the good quality and environmental responsibility of the fishery industries and market organizations through various certification schemes to ensure acceptable standards for international and regional trade in support of responsible and sustainable fisheries. The FAO PSM Agreement and the requirements of EC Regulation No. 1005/2008 imply further that the fishery products intended for export especially through international or regional trade should have verifiable catch documentation. Under the requirements, producers should be able to certify the origin, quality, sustainability, legality of production, production methods including treatment of labor force, and social equity among people involved in the fishery production. These requirements are increasingly well recognized among the countries in the region as could be seen in the "Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020". The main emphasis in the context of catch documentation is to be able to "validate" that the information contained in the documents are reliable. Since countries should now take the opportunity and consider market-based measures as tools to promote their products, combating IUU fishing should be continuously pursued including the promotion of certification and labeling schemes including the processes to validate the information provided. The promotion of "branding" could also be initiated as a cost-effective option to promote products that are produced legally based on environmentally and socially sound practices.

The validity of registration documents and licenses including documents on crew members, are among the basic documents to be provided at fishing ports together with the catch documents. These documents will also be scrutinized during port inspection with, among other things, the objective of combating IUU fishing. Considering that some countries in the region are much more far ahead and advanced in initiating the implementation of processes to register fishing vessels and to issue licenses to fish (vessel, gear and people), the September 2010 Expert Consultation suggested that the experiences of such countries could be shared with other countries in support of the efforts to update and modify their respective registration and licensing systems.

4.1.3 Port Monitoring and Port Inspection

The importance of fishing ports and landing sites to control and monitor catch has been increasingly recognized. All countries involved in marine fisheries need to seriously consider their responsibilities with respect to monitoring of catches at their ports and landing sites as an essential part in support of effective fisheries management. In 2009, the FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSM Agreement) was approved as a legally binding instrument with the main objectives of preventing illegally caught fish from entering international markets through ports and addressing the role of port states in preventing IUU-caught fish at landing sites, in ports and on transshipment vessels which are being considered as first "port". The PSM Agreement was opened for signature until 21 November 2010 and would enter into force 30 days after depositing the 25th instrument of ratification, acceptance, approval or acceptance with FAO. As of 15 August 2011, only 23 states became signatories to the Agreement with Indonesia as the only Southeast Asian country signatory, although Myanmar had acceded to the PSM Agreement based on information from the FAO Legal Office.

The PSM Agreement highlights the role of the port State in the adoption of effective measures through effective port monitoring and stringent inspections as needed from time to time, to control the legality of catches being landed. As an important step towards complying with the EC Regulation, the PSM Agreement could set an example on how the principles could be incorporated in national legislations. Nevertheless, in order to verify the legal status of fishery products landed in the ports of the region, practices and procedures for port monitoring and port inspections should be developed to ensure that these meet international standards as well as the aspirations of the ASEAN Community development and the development of the ASEAN Economic Community which envisioned to promote increased trade among the ASEAN countries. Therefore, it is crucial for the Southeast Asian region to have efficient and reliable port monitoring/inspection mechanism that would ensure the sustainability of marine resources and maintain sustainable trade as well as combat IUU fishing.

In establishing and enhancing port monitoring mechanisms, it is necessary to strengthen the cooperation among all relevant sectors and institutions, as well as among neighboring countries. It is important to recognize that during port monitoring, local and foreign vessels are monitored to be able to validate and support the increasing requirements for catch traceability and other documentations. In facilitating the process, support should be provided to countries by building upon their existing well-managed ports to be developed as a model for the country and establish protocols relevant to the laws and regulations of each country. Furthermore, landings by vessels in neighboring ports require special consideration in the process of validation of the legal status of landed catches, especially with regards to artisanal fisheries as indicated in the PSM Agreement. Initially, this could be followed up in relation to cross-boundary relations with regards to areas such as in the Gulf of Thailand between Cambodia and Vietnam, Cambodia and Thailand and in the area between Malaysia and Thailand. Similar efforts should be explored for border areas in the Andaman Sea, such as between Myanmar and Thailand and in the southern part between Indonesia, Malaysia and Thailand. Therefore, close cooperation should be enhanced among the countries in the Southeast Asian region and around sub-regional seas where countries share common interest in sustaining the benefits derived from productive fisheries and eventually effectively combat IUU fishing.

Ideally, port monitoring should include all fishing ports and landing sites, district and provincial, bearing in mind the places where fishery products are landed, which are considered as important and critical control points. Good port monitoring and port inspection is not only important to combat IUU fishing but is needed to control the quality of fishery products passing through the ports. In this regard, control of the socio-environmental standards of the ports is necessary since it is through the catch and landing documents provided at the ports and landing sites that the relevant authorities could appropriately assess the country's earnings in terms of taxes and other revenues. Presently, port monitoring in the Southeast Asian region is basically or primarily done to monitor the management of ports and landing sites without putting much focus on systematic monitoring and validation of catch documents and documents linked to the operation of the fishing vessels (*e.g.* registration, licenses, crew, other relevant documents) as stipulated in the PSM Agreement.

One critical challenge in port monitoring and inspection is to validate the legal status of catches from traditional small-scale fisheries, which becomes even more "challenging" because verifying the origin of landings especially for the small-scale fishing boats in border fishing ports is a very difficult task to undertake in view of the limited monitoring efforts and no records of their catch. One possible solution could be through the application of "cluster arrangements" whereby authorities at the landing sites can verify and validate the combined landings from a "cluster" of small boats in accordance with national laws and ensure that landings have been fished in a sustainable manner. As an option, cluster arrangements could also be used to certify products from small-scale aquaculture. With regards to artisanal landings across boundaries, Article 3, Para Part b of the PSM Agreement provides the necessary guidance viz: "Each Party shall, in its capacity as a port State, apply this Agreement in respect of vessels not entitled to fly its flag that are seeking entry to its ports or are in one of its ports, except for (a) vessels of a neighbouring State that are engaged in artisanal fishing for subsistence, provided that the port State and the flag State cooperate to ensure that such vessels do not engage in IUU fishing or fishing related activities in support of such fishing".

Another challenge is to be able to validate the legal status of catches from areas where fishing vessels have two flags and double registration that would allow them to operate in waters of two countries. Recording of such catch becomes an issue because the catch might have been landed in ports which are most convenient for the best price of the day. Furthermore, institutional structures could actually obstruct all attempts to implement good port monitoring since in most instances, a number of agencies are involved with the fish landing and more often than not, cooperation for sharing of information among such agencies is very limited contributing to the hindrance for adequate enforcement.

4.1.4 Monitoring, Control and Surveillance System and Network

Effective monitoring, control and surveillance (MCS) capability is a fundamental component of fisheries management which could strengthen all efforts to manage fishing capacity and reduce IUU fishing. However, for MCS system to be effective supportive legislation would be necessary. The MCS capacity of the Southeast Asia countries varies depending on the level of technology and on how advanced the systems used in the country could be. While generally monitoring may not be well developed, in some countries, control has been undertaken through the use of Vessel Monitoring Systems (VMS) for monitoring fishing activities within the respective EEZs. Many countries also attempt to strengthen law enforcement in order to improve fisheries management, but the effectiveness of such initiatives varies among the countries. The high maintenance cost of surveillance assets is a critical factor that contributes to the slowing down of the development of MCS in the Southeast Asian region.

Therefore, as a result of the prevalent ineffectiveness of national governance structures and varying MCS capacity to control fishery activities of national and foreign fishing vessels as well as combat IUU fishing, the efficiency of MCS could differ widely especially that regional structures to coordinate data collection and assessments to guide regional management are also lacking (Morgan *et al*., 2007). While structures are being developed and/or improved in the respective countries, the varying legal mandates and/or regulatory systems among the countries make it difficult to harmonize policies and legislations in fisheries. Limited efforts in data collection and compilation, and varying levels and quality of existing research also make it difficult for managers to monitor and discern the real status of the fishery resources. Moreover, relevant government agencies, although not directly concerned with fisheries, *e.g.* environment authorities, national defense, coast guard, customs, and immigration, should take part in dialogues on matters relevant to determining priorities, allocating resources and sharing of information for the development of MCS networks (Awwaluddin *et al*., 2011).

As a regional approach to the development of MCS networks, common understanding should be created including the perspectives on the new "requirements" that highlights the importance of cooperation in MCS activities and efforts to combat IUU fishing. In the Southeast Asian region, establishment of more "sub-regions" could be pursued as these could form basis of cooperation especially in areas where countries have common interests towards the development of MCS networks (SEAFDEC, 2010b). In this connection, the efficiency and effectiveness of fisheries-related MCS activities should be improved through enhanced cooperation and coordination, and improved information collection and exchange among national organizations and institutions responsible for fisheries-related MCS activities. Moreover, cooperation should also be strengthened in the sub-regions involving the ASEAN countries and as applicable, non-ASEAN countries (*e.g.* Arafura-Timor Sea between Indonesia, Timor-Leste, Papua New Guinea, and Australia). A number of regional, sub-regional and bilateral cooperative initiatives on MCS activities already exist in the Southeast Asian region, which could be grouped into two categories, namely: a) joint patrol, and b) sharing of information, which provide clear contribution to capacity-building in MCS. Countries like Indonesia, Malaysia and Philippines, for example, have been involved in sub-regional initiatives or tri-lateral agreements to combat IUU fishing in the Sulu-Sulawesi Sea. Such initiatives include the "Marine Eco-region Program" of WWF, the RPOA to promote responsible fishing, and the Coral Triangle Initiative.

In addition, Indonesia, Malaysia, and Singapore through trilateral agreement, conduct regular collaborative seaborne patrol activities under the MALSINDO program and the joint "eye in the sky" air reconnaissance program to combat IUU fishing in the Malacca Strait (Poernomo *et al*., 2011). However, human and financial resources are critical components of any MCS program. Even the capacity of MCS officers who are highly competent with high degree of integrity and professionalism in the implementation of MCS still needs to be strengthened. Moreover, as another means of enhancing MCS, community-based fisheries monitoring systems could be promoted as carried out in Indonesia, where community groups undertake the observation at sea and land, and report to the proper authorities in their communities any suspected fishers and vessels conducting illegal fishing.

4.1.5 Legal and Institutional Matters

In response to new international and regional instruments, requirements and agreements, *e.g.* FAO PSM Agreement and EC Regulation, safety and working conditions under the IMO and ILO Conventions, and ASEAN "Blueprints" for building the ASEAN Community, it is necessary to review the existing legislations, and the institutional and legal structures of the ASEAN countries as the results could form basis for dialogue and recognition of the opportunities and limitations of such legal structures. Such recognition is an important basis for the enhancement of cooperation among institutions involved in fisheries and maritime-related activities. Since the characteristics of fisheries in Southeast Asia is very complex with commercial, urban-based, a wide range of traditional and small-scale vessels with multi-gear fishing activities considered significant for the regions' economies, it would be a great challenge to look at the legal and institutional implications of the various instruments, requirements and agreements. It is therefore necessary that the countries should review their existing regulatory frameworks and as needed make certain adjustments to be able to improve their respective fisheries management.

During the 2010 Expert Consultation on Managing Fishing Capacity to Combat IUU Fishing, the need to build up personal and institutional capacity in all aspects especially in terms of improving fisheries management and capacity, including port monitoring and MCS related matters had been highlighted (SEAFDEC, 2010b). To improve the effective cooperation on M, C and S, a synthesis should be developed on the common needs for each sub-region as basis for the development of MCS networks. The synthesis should take into consideration the legal and institutional opportunities or limitations embedded in the relevant legislations of each country.

The legal and institutional implications in developing an MCS network and in embarking on a regional cooperation would mean increased emphasis on port state responsibilities and further pressure on flag states as basis for cooperation and information sharing. In the process of facilitating consultative dialogue legal officers should be involved in the process of regional cooperation considering that the countries have different laws and regulations.

Lawyers and legal officers should help in assessing the opportunities and limitations of the legal structure of each country to find out the common elements as basis for cooperation, including technical aspects reflected in national legislations. In order to adapt to rapid changes based on new requirements including those required for the building of the ASEAN Community, countries should learn from each other's experiences and exchange information among countries in the region to facilitate the development of a structure that fits with national regulatory and institutional frameworks that could be adapted to common perspectives. Information-sharing should be enhanced while capacity building should be continuously promoted to improve institutional capacity.

4.1.6 Future Direction

In the Southeast Asian countries, being major producers of fish and fish products, efforts are continuously made to improve various aspects relevant to the management of fishing capacity including efforts to reduce IUU fishing in the region. Countries should now start looking beyond international agreements and conventions on combating IUU fishing, by taking suitable actions in support of improved management of fishing capacity, *e.g.* fishing vessel registration and licensing system, MCS, port monitoring, catch documents for fisheries management, and control of fishing efforts in the region. However, considering national policies and procedures, there is a need for capacity building and strengthening of relevant institutions to enable the countries to implement the abovementioned measures and requirements.

Furthermore, considering the ASEAN Community building which is envisaged to come into force by 2015, it is important to consider appropriate actions to facilitate cooperation among neighboring counties through bilateral and tri-lateral arrangements. Such arrangements could strengthen and provide basis for more effective implementation of international instruments and agreements. To boost the regional approach and to facilitate cooperation, options should be explored in finding common ground for the management of fishing capacity and in enhancing efforts to combat IUU fishing in the region. Moreover, cooperation among such organizations as the Association of Southeast Asian Nations (ASEAN), the Asia-Pacific Fisheries Commission (APFIC), Southeast Asian Fisheries Development Center (SEAFDEC), and the Secretariat of the RPOA to Promote Responsible Fishing Practices (including Combating IUU Fishing), should be enhanced in order to improve the working relationship with the countries based on the respective on-going and planned initiatives that would secure benefits for the countries and ensure the sustainable utilization of the fishery resources in the Southeast Asian region.

4.2 By-catch Reduction and Management

At the international level, the term "discards" is frequently synonymous with "by-catch", even considering that "by-catch" is usually the main source of discarded catch in many fishery activities, especially from industrial fisheries in the temperate countries. Since "discards" are generally regarded as an important result of the negative impact of fisheries, various attempts have been made around the world to minimize "by-catch". Unfortunately, the term "by-catch" as used in tropical areas including the Southeast Asian region, could result in misunderstandings about fisheries of the region. The major part of fisheries in the Southeast Asian region can be categorized as small-scale coastal operations exploiting a large number of tropical species. Therefore, three factors could differentiate the fisheries in the region from those of the temperate zones. These are: (a) most fishery operations in tropical waters are small-scale and conducted from one to few days, taking into account the economic value of the catch; (b) by the characteristics of tropical ecosystem, individual species in tropical waters have relatively small stock size compared with those in temperate areas; and (c) the inherent flexibility of markets in tropical areas traditionally handle a wide range of catch species each of which is relatively in small volumes.

Therefore, the international definition of "by-catch" could be modified for it to be applicable to fisheries in Southeast Asia, but should not be understood as source of discards. Thus, for the Southeast Asian region, "by-catch" could be associated with the target catch although such term is not used in all fisheries in the region and "by-catch" could be used for industrial fisheries. However, a more appropriate working term for by-catch in the region could be "unwanted catch" or "trash fish" which comprised the low- and no-value species, and under-sized commercially valuable species. Another major issue that should be addressed is the estimation of the scale of discards by fisheries in the region. For in general, the amount of discards in Southeast Asia could be relatively small, considering the nature of small-scale fishery operations, but the increasing demand for aquaculture feeds encourages fisheries to land non-edible small-sized catch.

The collection of data to estimate the scale of discards might not be a priority issue for the Southeast Asian region. However, since collection of accurate data on discards requires enormous efforts and still might give unreliable results due to the small volume, more practical and useful approach should be developed through the conduct of appropriate research directed towards the development of management actions to reduce discards. The first important step that could be immediately undertaken by the countries is to identify the fisheries with discards problems through research that focuses on the reduction of "by-catch" or "unwanted catch".

Under the present fishery regime, it may be difficult to convince fishers to be responsible in their operations through the use of selective fishing devices or by-catch reduction devices such as the Turtle Excluder Devices (TEDs), and the Juvenile and Trash Excluder Devices (JTEDs) which have been specifically designed to reduce by-catch. Fishers should also be made aware that such devices are important for the development of practical selective fishing methods which, in conjunction with the implementation of right-based fisheries, will eventually minimize the "unwanted catch".

Considering that reduction of by-catch is a new initiative in the Southeast Asian region, demonstrations on the use of JTEDs have been conducted in the region through the SEAFDEC and FAO collaborative programs on Responsible Fishing Technologies and Practices, and By-catch Reduction Technologies and Change of Management (REBYC) which exhibit the rationale for the adoption of JTEDs as technical tool and as platform to initiate other management measures. In order that the adoption of JTEDs in the region would be sustainable, the Southeast Asian countries are encouraged to develop their respective national policies on the use of JTEDs and other selective fishing devices or by-catch reduction devices.

4.3 Community-based Fishery Management Approach in the Southeast Asian Region

Fisheries in Southeast Asia are complex and any one single community-based fisheries approach may not be applicable, although it has been recorded that co-management approach has been progressing well in Malaysia, Thailand and Cambodia. The experiences of these countries indicate that effective and well-defined partnerships of NGOs and government take some time to establish, while the fisher groups or community organizations need encouragement from the government and NGOs to adapt sustainable fisheries management.

The region's fisheries could be considered as among the most productive and biologically diverse resources in the world, where more than 300 million people depend significantly on fish as source of protein (SEAFDEC, 2001) although approximately 35% of the people live below the poverty line (Pomeroy and Viswanathan, 2008). The region's fishery resources had been known to be depleted due to increased fishing pressure, unregulated fishing efforts, continued use of destructive fishing methods such as mechanized push-net, trawlers, cyanide and dynamite seriously destroying the fish habitats and reducing the fish stocks. It has been reported that over the past 40 years, the standing fish stocks in the Southeast Asian region have been reduced to less than one-fourth of their former levels (Pauly *et al*., 2002; Pauly *et al*., 2005). The current fishery crises therefore pose critical threat to sustainable fisheries and the livelihoods of millions of people who depend on these resources especially those living in the coastal areas.

The fishery management system that has been practiced in this region through the years had been unsuccessful in managing the fishery resources. It has been recognized that fishers must take active part in the fishery management system and the current top-down and centralized system must be reviewed and subsequently changed to better management systems. Co-management has been considered an alternative approach for the management and exploitation of the fishery resources. Specifically, Community-based Co-management (CBCM) is a people centered, community oriented, and resources-based partnership approach in which government agencies, the community of local resource users, NGOs, and other stakeholders share the responsibility and participate in the decision making for the management of the fisheries (Kuperan *et al*., 2003; Berkes *et al*., 2001; Pomeroy, 2001; Pomeroy and Williams, 1994; Sen and Nielsen, 1996; Nik Mustapha *et al*., 1998).

The ultimate goal for co-management is to empower fishers in the expectation of better management (Kuperan *et al*., 2003). Meanwhile, Community-based Fisheries Management (CBFM) is a process by which the substantial role for fishers in management of the resources they depend on is enhanced within a framework of government support. Co-management is not an end point because it is a process by which the relationship among the parties concerned is constantly changing. However, there is a hierarchy of co-management arrangements where the fishers are initially consulted by the government, but later on, when regulations are introduced fishers are involved in designing, implementing, and enforcing laws and regulations with minimum advice and assistance from the government.

Organized fishers groups are the central elements in co-management intervention with local institutions as important prerequisites for effective co-management, because these institutions are to make decisions and undertake collective actions (Kalikoski *et al*., 2002; Noble, 2000). The participation of fishers and other stakeholders reduces the negative economic, social and cultural impacts that are traditionally borne by the fishing communities (Lane, 2001). Pomeroy and Ahmed (2006) cited that the potential benefits of co-management could include a more open, accountable, transparent, and autonomous management process which is more economical as it requires less cost for administration and enforcement. In the process of co-management, community awareness should be enhanced through information, training and education, allowing local communities to share power with political and economic elites and government agencies. The social unity among fishers groups in local communities should be improved in order to minimize social conflicts. Effective co-management framework is usually envisioned to generate benefits for the resource users and local communities' conservation efforts, and subsequently under the co-management arrangement, poverty and resource degradation could be reduced (Brown *et al*., 2005).

Generally, community organizations in the Southeast Asian region are rather weak especially in the aspect of co-management, which could be because co-management started to develop in Southeast Asia only in the early 1990s. Pomeroy (1998) found out that few groups of fishers in the Philippines had opted to either formally organize or seek to implement institutional arrangements on their own. In the village organizations in Lao PDR, there are no specific local organizations that focused on resource management.

4.3.1 Issues and Concerns

Various initiatives on co-management have been undertaken by the Southeast Asian countries, but the scale for co-management arrangements varies a great deal in terms of people, ecology and level of management. Fisheries are considered common pool resources and characterized as open access. Traditional top-down management approach could not provide incentives to the fishers to reduce fishing effort. Therefore, there is a need to address the important issues in co-management which include: unclear property rights, undefined role of NGOs, homogeneity characteristics of communities, poverty in fishing communities, and sustainability of co-management.

The main problem in fisheries management generally lies among the fishers themselves because of unclear property rights over the fishery. Although property rights arrangements exist, these are complex where fishers and community members have generally low motivation to contribute to community fishery. Without seeing any tangible benefits, community members are unwilling to invest time and effort in the management. Even if fishers recognize that community management can reduce illegal fishing which is attributed to the establishment of the community fisheries, but it is still unclear to them whether community-based fisheries could really provide them benefits in terms of increased income from fishing. Although local and municipal level governments could play active role in fisheries management, each country has their own different ways of handling problems related to legal authority of co-management institutions. The government's role in granting legal authority is the basis for the 'constitutional rules' that determine who can exercise legitimate local management functions which include determining access rights to the resources.

The community fishery potentially offers the government a low-cost and effective means of improving compliance with rules and regulations, for example in banning of illegal fishing gears. Considering that individual and community empowerment is a central element of co-management, empowering the communities would free them from many bureaucratic requirements of government agencies. Based on some countries' experience in co-management, NGOs have played very important role in facilitating the establishment local co-management, by focusing on building fisher community organizations that can manage their fisheries through active interaction with the government. Although the involvement of NGOs in establishing an appropriate co-management approach may not always be equal, it is expected that individual NGOs should not also be rigid to adopt their own approach but should make limited modifications to fit with local circumstances. However, several NGOs have different approaches and in some cases, do not want to change their strategies and adjust to the local or project needs.

Based on the experience of the Philippines and other Southeast Asian countries, enhanced capacity building strengthened the confidence and sense of empowerment of the resource users and partners, and NGOs have been the appropriate groups for organizing local communities. In Thailand, some NGOs network emerged and succeeded in organizing the local resource users. However, it has come to a point that co-management in Thailand is heavily dependent on NGOs in terms of organizing local communities and raising the awareness of community members on the aspect of resource management. A similar situation emerged in Bangladesh where the NGOs were most successful in organizing the poor. In the Philippines, a CBFM program started with a small aquaculture project, which had expanded through the help of local NGOs and local government. Similar lessons learned about the importance of NGOs in fisheries co-management have also been documented in Thailand.

It has been observed that communities that are homogeneous are more likely to establish effective community-based fisheries management. There are many communities in Thailand, Indonesia and the Philippines, where successful co-management was dependent on the high level of socio-economic and cultural homogeneity of the communities. However, co-management project could also be successful even in socio-economically and culturally heterogeneous communities, such as in the village of San Salvador in the Philippines where co-management in fisheries has been successful despite marked differences in ethnicity and fishing gears. Fishing is an activity of last resort or as a safety valve for the poor, *i.e.* people who fish for subsistence are already poor. However, at this point in time, it might still be early to determine whether CBFM could really have a strong role in rural poverty reduction, even if food security and poverty reduction had always been the key agenda of the Southeast Asian countries. The easy entry into artisanal fishing by the poor results in the vulnerability of the aquatic resources to biological and economic over-exploitation, making it impossible to use the exploitation of resources as routes for people to get out of poverty.

The sustainability of institutional arrangements under co-management arrangement is still to be determined. Although it has become clear that establishing sustainable co-management in any one fishery requires some time, meanwhile, the locally organized communities should be developed as sustainable organizations with legitimate decision making body to decide on the access and use of the fishery. Eventually, the fishers' feeling of ownership would automatically come through their active participation in the communities' fishery activities. The most important factors that hamper the establishment of CBFM are external forces such as threats and conflicts. Improving the political will and commitment of the fishers groups would be needed to counter the pressure from elite groups, because when local but influential people and politicians are involved with personal gains in mind and control the fishing rights, it would be difficult to solve the problem. In the communities where political elites are not included in the process or are opposed to the project for some reasons or another, all interventions could not be sustained after the completion of any project. Since adequate financial resources is required in order to support the co-management processes, oftentimes co-management projects which are initiated and funded by external financial sources fail when the project is completed due to the inability of the local partners to continue funding the activities.

Co-management in the Southeast Asian Region

In Southeast Asia, co-management and community-based natural resources management has started to develop through the initiatives of people, NGOs, government and international agencies, as ways of involving the resource users in fisheries management. The history of co-management in this region shows a shift from CBFM to co-management (CM). In the Philippines, natural resource management had been top-down and non-participatory for centuries, and with its long history of traditional fisheries rights and allocation, community-based coastal resource management (CBCRM) was initiated in early 1980s. The country is now the only country in the region that has a wide range of experiences in terms of CBCRM and co-management (Pomeroy and Carlos, 1997). Since the late 1970s, the country's fisheries was defacto open access and subjected to overexploitation but in 1975-1998, fisheries management had been implemented in accordance with the Philippine Presidential Decree 704 series of 1975, and in order to reduce fishing effort, licensing system was introduced. Nonetheless, in spite of the number of laws and regulatory frameworks for integrated coastal management that were introduced in the Philippines, none of these were enforced properly (Eisma, Christie and Hershman, 2005).

In 1991, the Philippine Government recognized the need to enhance the stakeholders' participation in management and to devolve control over resource access to local levels through policy and institutional reforms. Such policy reforms included decentralization of authority, strengthening of the enforcement of fisheries laws, and promoting community-based initiatives. Thus, the government transferred the management of natural resources to local fishing communities and municipalities under its Local Government Code (LGC). Thus, good prospects for co-management in the Philippines started largely due to the changes in the political climate of the country, specifically the move to delegate more responsibilities to local governments and NGOs involved actively in community development (Nik Mustapha, 2002). Since then, over 180 CBCRM projects have been implemented by the government, NGOs, fishing communities, as well as by the academic and research institutions.

Evidences of the implementation of co-management have been increasing in Thailand, Malaysia, Cambodia, Lao PDR, and Vietnam. The governments of these countries are exerting efforts in order to sustainably utilize the fisheries and improve the socio-economic conditions of small-scale fishing communities through the CM approach. SEAFDEC for its part has developed regional guidelines for all Member Countries to formulate fisheries policy supportive to co-management or community-based management approach. From 2001 to 2009, co-management pilot projects have been implemented in Thailand, Malaysia and Cambodia under the ASEAN-SEAFDEC collaborative mechanism with support from the Trust Fund of the Government of Japan (JTF). During the implementation of the pilot projects, the participating countries made certain adjustments in the CM approach to ensure its applicability in the concerned countries and sustain its implementation after the completion of the relevant funded projects.

The first pilot community-based fisheries management project was started in Thailand by its Department of Fisheries (DOF) with the involvement of local fishers and other stakeholders. In Thailand, it has become necessary to adopt the CBFM approach because commercial fishing vessels had been encroaching in the prohibited areas 3 km from the shoreline and using destructive fishing gears. The main objective of the pilot project was to improve the livelihoods of coastal fishing communities by reducing the fishing pressure. Many important activities were conducted under the project which centered on enhancing local employment and income through capacity building and improved participation of local fishers in the management of the coastal resources through sustainable utilization and at the same time generate alternative income for sustainable livelihoods. As part of the project activities, fishers groups were organized and had been involved in fisheries conservation such as releasing juveniles, establishing crab banks, installation of artificial reefs, among others. This pilot project has been successful in managing fishing activities, monitoring, and enforcement of regulations to combat illegal fishing.

The centralized fisheries management system provides limited scope for co-management of the fisheries in Malaysia. Thus, the Locally Based Coastal Resource Management (LBCRM) project was implemented in Langkawi Island from 2001 to 2007, where a model Fishermen Economic Group was formed, and later this model group had been adapted in several fishing communities in Peninsular Malaysia. Considering the nature of the functions of the group, it was later renamed in July 2007 as the Fishery Resource Management Community. Therefore, the fisheries management approach has moved towards a more holistic and ecosystem based approach (SEAFDEC, 2009).

During the implementation of the LBCRM in Malaysia, all administrative and technical support was provided by the Department of Fisheries Malaysia (DoFM). Co-management approach was initiated in Kuala Teriang, Langkawi with the active participation of the staff of DoFM and members of the local fishing community.

The local people were actively involved in fisheries conservation activities in the project area such as re-plantation of mangroves, installation of artificial reefs and selling fish-based food products. The institutional arrangement for the project implementation was done with the strong role of SEAFDEC and DoFM, while a fisheries resources management committee was formed under the supervision of the DoFM and Fisheries Development Board. The organized fishers group was able to prepare their own fisheries resource management plan (FRMP). However, there was a problem in the implementation of the planned activities due to inadequate number of DoFM staff in the project site (SEAFDEC, 2009).

A traditional community-based approach had been implemented in Sabah, East Malaysia over the past 20 years. Locally called tagal, the system prohibits fishing by concerned communities in a river for a certain period. Since 2001, the Department of Fisheries Sabah (DoFS) has extended support to promote this approach in order to conserve and protect freshwater riverine fisheries. As a result, more than 240 tagal fisheries groups have been established in various locations in Sabah. The DoFS and local community had worked jointly in this co-management project. Only local people with traditional use rights are included in the tagal fisheries groups, which have established fish sanctuaries and introduced restrictions on using fishing gears such as gill net in particular fishing area in the river. Eco-tourism activities have also been promoted very successfully in many tagal projects. Although in general, the tagal co-management approach is promising, but in some areas this system has not been successful due to weak institutional arrangements and lack of enforcement.

In Cambodia, riverine fisheries are open access especially in the upstream provinces near the Mekong River Basin. In 2000, the Royal Government of Cambodia, through the Fisheries Administration (FiA) reformed the fisheries policy of the whole country by empowering the local communities to manage the resources by themselves, known as the “community fisheries” or CF. However, the process of CF establishment and implementation varies and relies on the supporting organizations and government agencies. A co-management pilot project implemented in 2005-2009 by the FiA with funding support from the Japanese Grassroots Level Aid, focused on community organization, capacity building and empowerment of local fishers in order to ensure their participation in the management of the resources and improve livelihoods through alternative income earning opportunities. In the process, the organized local community groups were able to prepare their own Community Fisheries Area Management Plan (CFAMP) which together with other related documents such as Internal Law, By-Laws, and the community fisheries zoning map were endorsed by the local administration to the Governor with the Community Fishing Area Agreement for approval. Under the co-management project, the Community Fishers (CF) and Local Enforcement Unit (LEU) were established in 2002. Although community management is a very new concept in Cambodia compared with that the other countries in the Southeast Asian region, the country has an excellent opportunity to practice sound community management because the Cambodian Government encourages the fishers to be actively involved in community resource management.

In Vietnam, communities are not yet regulated by the rule of law, which is very important for sustainable resource use. The legal framework is not yet clear on how much the local government can be creative and proactive in the decision-making and planning of the local community. Based on traditional methods and practices along with the lessons learned and experience gaines, Vietnam could have the real chance to implement successful community-based management if the government would only remain highly supportive and would continue to encourage the stakeholders to implement such scheme.

4.3.2 Future Direction

Thus in the Southeast Asian region, community-based management and co-management arrangements in fisheries are considered as feasible options for bringing together the relevant levels of the government and users in pursuing a common set of goals to improve the resource and socio-economic conditions of the communities. More than two decades of research have provided sufficient conclusive support for co-management and community-based management as approaches for effective enforcement and equitable access for the poor and often voiceless fishers (Dey and Kanagaratnam, 2008). Nevertheless, in the context of small-scale fisheries in Southeast Asia which is complex, one single community-based fisheries approach may not be applicable everywhere, considering that community-based co-management approach involves continuous consultation, negotiations, information sharing, and conflict management among stakeholders for the improvement of the existing management systems.

4.4 Habitats Protection and Coastal Fishery Resources Enhancement

4.4.1 Issues and Concerns

The coastal waters of Southeast Asia comprise a rich ecosystem characterized by the existence of areas with extensive coral reefs and seasonal up-welling, as well as the presence of dense mangrove forests enriched with nutrients from land. These areas are critical to a broad range of aquatic organisms during their life cycle from breeding, spawning, nursing and growing, hosting the feeding zones of aquatic species that are economically important, and serving as important source of recruitment of a wide diversity of fish species. In view of the economic benefits that these areas could provide, human settlements have mushroomed in coastal areas leading to the significant deterioration of the quality of the ecosystem as a result of continued and increasing human activities. More specifically, the commercially important fishery resources in the region have declined due to many factors that include overfishing, illegal fishing, use of destructive fishing practices, and environmental degradation. Massive clearance of mangrove forests for aquaculture, urbanization, industrialization, wood fuel, timber and the like, could bring about large temporary economic benefits to certain groups of people or the governments but in the end, the breeding, nursery and feeding areas of many aquatic species such as fishes, crustaceans, and mollusks have been destroyed and lost. For example, sand mining destroys the natural habitats of many commercial fish species while the use of dynamites in fishing could seriously destroy the coral reefs which serve as the natural habitats for the highly economic and commercially important demersal fishes such as groupers, humphead wrasse, snappers and others.

In addressing such concerns, most countries in this region have deployed artificial reefs (ARs) to restore the depleting coastal fisheries resources, prevent encroachment of trawlers, reduce conflict between commercial and traditional fishers, and increase the opportunities for small-scale fishers to improve and sustain their incomes from fishing. Other measures have also been promoted such as the installation of fish enhancing devices, promotion of stock enhancement through re-stocking, development of fish *refugias*, seasonal closure of breeding grounds, and establishment of marine protected areas or marine parks. Fish *refugia* is the spatially and geographically defined inland, marine or coastal areas in which specific management measures are applied to sustain important species (fisheries resources) during the critical stages of their life cycle. The establishment of fish *refugia* had been intensified in Thailand, Vietnam and Cambodia. Other man-made structures including aquaculture facilities, breakwaters, oil platforms, oil and gas pipe lines, stationary fishing gears, and jetties have also enhanced the biodiversity of aquatic organisms including fish. Thus, strengthening the linkages between resource enhancement activities and integrated coastal fisheries management with particular emphasis on decentralized rights-based fisheries has been promoted in the Southeast Asian region for the sustainable development of coastal fisheries for food security.

Fish *refugia* and ARs can be complementary tools for conservation, management and enhancement of fisheries resources. However, note should be taken that the use of ARs can result in positive social and economic benefits if fishing effort is regulated, but it could result in further overfishing if uncontrolled. A combination of integrated programs using ARs, closed season, limited entry, habitat protection and restoration, fish sanctuaries, mangrove reforestation; and increased community awareness of the need to conserve the resources is therefore necessary. AR programs also need proper planning and management at the national and regional levels while the implementation of any AR-related activity must be based on scientific knowledge and multi-discipline expertise. In the process, it is necessary to strike a balance between the objectives and benefits of the AR projects in terms of the environmental, economic and social aspects in fish production for food security.

4.4.2 *Use of Big-size Artificial Reefs: Malaysian Experience*

Focusing on the efforts of Malaysia, its ARs program which was started in 1975, aimed to promote fish sanctuaries, recover seriously depleted coastal fishery resources and prevent the encroachment of trawlers into the prohibited inshore areas. The country's ARs program started with the use of discarded car tires and later, under the Ninth Malaysian Plan in 2006, the Department of Fisheries Malaysia focused on the design and construction of big-sized reinforced concrete ARs suitable for installation in hard and soft bottom sea beds. The structures considered various factors such as the fish behavior, marine engineering aspects, physical oceanography, and the target species. The structures were constructed according to the British Standard 8110, and until the end of 2010, fifteen new designs of concrete ARs weighing about 6-42 MT/module and measuring 1.6 to 3.8 m (length, width and height) were produced. The various ARs had their specific functions, for example the cuboid bio-active ARs, anti-trawling ARs, juvenile ARs, soft bottom ARs (2 designs), tetrapod ARs (2 designs), recreational ARs (2 designs), cube ARs (2 designs), cuboids ARs (2 designs), and lobster ARs (2 designs).

The experience and knowledge gained since 1975 was used to improve the planning and management of the ARs program during the Ninth Malaysia Plan (2006-2010). New objectives were set-up which included the development of new AR sites and deployment of additional AR modules at the existing/present sites for resource enhancement; conduct of research and compilation of information on suitable AR designs, durability of materials, and suitable sites of local fishery resources; development of new AR designs which can deter the encroachment of unfriendly fishing operations especially trawlers into traditional fishing grounds and specific zones; and providing substrates for corals to grow.

During the Ninth Malaysia Plan (2006-2010), ARs program was implemented in all states of Malaysia for the first time since 1975 using funding from the federal and state governments. The research and development program focused on design and construction of big size reinforced concrete ARs for installation in hard and soft bottom seabeds taking into consideration fish behavior, marine engineering, physical oceanography and target species (Zaidil Abdilla *et al*., 2010).

Construction using reinforced concrete grade 30-50 was started in 2006. The structures constructed included soft bottom ARs measuring 3 m x 3 m x 3.6 m (18-22 MT/module); cube and cube juvenile ARs 2.5 m x 2.5 m x 2.5 m (14-14.5 MT/module); cuboid and cuboid juvenile ARs, 2 m x 2 m x 3 m (10-10.5 MT/module); tetrapod ARs, 2.655 m x 2.655 m x 2.385 m (8 MT/module); lobster ARs, 1.65 m x 1.65 m x 1.65 m (5-6 MT/module); recreational and recreational juvenile ARs, 1.85 m x 1.85 m x 1.85 m (6-6.5 MT/module); and juvenile soft bottom ARs and anti-trawler ARs, 3.4 m x 3.4 m x 3.75 m (35-42 MT/module). The construction work followed the British Standard 8110, where concrete covers at least 50 mm, column and beam rebar make use of 4 rod of Y12, link uses R8 @ 200mm c/c and slab reinforcement uses BRC A10. Ready-mix concrete from batching plant grade 40 was used for all designs except for the soft bottom ARs, anti-trawler ARs and juvenile soft bottom ARs. Since these designs were quite big and heavy, ready-mix concrete grade 50 was used. Cube test was conducted 7 and 28 days after construction at the government and private laboratory. Curing was implemented for at least 28 days before deployment. Any module which did not follow the specification as stated in the quotation or tender documents was rejected (Zaidil Abdilla *et al*., 2010).

The newly designed ARs for soft and hard bottom sea bed were deployed in 2006, where a total of 33 modules of soft bottom ARs were deployed in Pulau Payar Marine Park, Kedah for research purposes and another 16 modules in Kuala Langat, Selangor for resource enhancement. Forty tetrapod AR modules were also deployed on sandy bottom in Terengganu and Pahang. A series of visual observations by SCUBA diving was conducted to study the fish behavior especially their interaction to the ARs structures, while information on the bio-fouling on the ARs surface was also recorded. Minor modifications were made from year to year until the most suitable design was materialized in 2010 (Fauzi, 2010).

In 2007, the project was expanded to another 10 new sites, especially making use of the tetrapod ARs to deter the encroachment of illegal trawlers into traditional fishing grounds in Kelantan and Johor, while soft bottom ARs were also deployed in Kedah and Selangor, and ARs for recreational anglers deployed in Terengganu and Pahang.

In 2008, the ARs project was implemented in all states except in Sabah and Sarawak. Another 19 new sites were identified and a new design for lobster ARs was deployed in the Federal Territory of Labuan. The success of big size ARs in enhancing coastal fisheries resources as well as hindering illegal trawlers had encouraged the Federal Government to allocate additional budget for the project in 2009.

Thus, another 38 new sites for ARs were identified in 2009. The project was continued in 2010 with another 35 new sites identified and by the end of 2010 a total of 105 new sites were deployed with the appropriate ARs, where each site had 12-134 modules depending on the available budget. Thus, Sabah had 17 new sites for reinforced concrete ARs while Terengganu had 15, Kedah (12), Federal Territory Labuan (9), Kelantan and Perak (8), Pahang and Selangor (7), Negeri Sembilan and Johor (4), Malacca and Penang (3), and Perlis two sites. From 2009 until the end of 2010, a total of 237 recreational concrete ARs and anti-trawling ARs were deployed at 12 sites in Sabah. Management and monitoring of all AR sites are under a co-management approach between the DoFM and local fishers. Meanwhile, the Department of Fisheries Sabah (DoFS) put up a condition that ARs would be deployed near the fishers' fishing villages only if local fishers are willing to take part in the Local Artificial Reef Committee which functions and commits to protect, monitor and harvest fish in a sustainable manner from the AR sites. The approach introduced by the DoFS has succeeded in protecting the resources in the AR sites from dynamite and cyanide fishing by illegal fishers. In addition, the DoFS also prescribed that only angling is allowed while other gears are prohibited to operate near the AR sites. The Marine Police and the Malaysian Maritime Enforcement Agency also participate in the activities that aim to protect the AR sites from illegal fishing. The local fishers in Sabah that have ARs projects near their villages are now very happy to have such big concrete artificial reefs deployed because the structures function not only as resource enhancement but also prevented trawlers from encroaching into their inshore areas.

Site selection is an important component in the deployment of ARs. Thus, a series of surveys were carried out in the waters of Malaysia using echo-sounder for seabed topography, grab or divers for collecting sediments, and current meters for information on direction and speed of current. Divers also used to explore and film the seabed areas to obtain baseline information especially on the topography, substrate stability, proximity to natural coral reefs, and the biological resources within the immediate vicinity of the site. Bamboo traps, and hooks and lines were also used to gather preliminary indication of the fishery resources of the selected sites.

Considering the heavy weights of the ARs, pontoon or barge was used to transport and deploy the concrete ARs to the selected sites. During the installation processes, free fall deployment method was applied using 44-100 MT crane. Special mechanical device was constructed which worked very successfully during the deployment process. Each module was placed on the sea bed at 2-3 meters apart from each other. After the completing the deployment, several divers inspected the position of each module and all information was recorded by video camera for future reference (Zaidil Abdilla *et al*., 2010).

Monitoring activities are conducted regularly every 3-6 months after deployment to record the changes in fishery resources as well as the physical stability of the reef modules by the Penang-based DoFM staff of the Fisheries Research Institute, staff of SEAFDEC/MFRDMD in Terengganu, and from the Fisheries Research Institute Sarawak Branch. Several survey methodologies were used and this included intersected transect method for sessile, fouling and encrusting organisms, and visual observation via transect, fixed stationary points as well as search pattern for fishes. Information on the encrusting, sessile and fouling organisms, fish assemblages, fish composition, as well as physical, chemical and biological parameters were recorded and analyzed. Several research activities were conducted in collaboration with local universities involving the undergraduate as well as post-graduate students. Mapping of the AR locations were also conducted using side-scan sonar.

Results of the monitoring by SCUBA diving showed fast development of the resources that had been enhanced and various organisms had immediately encrusted the structures while all surface areas have been covered with bio-fouling, sessile and encrusting organisms within six months after deployment especially for ARs deployed on sandy sediments. Generally, the surfaces of most ARs have been covered with mollusks, barnacles and multi-species corals. In Kuala Terengganu, an average of 364 tails of fish was estimated at each module for cuboid ARs after six months of deployment. These included 45 juveniles of high quality grouper (*Epinephelus coioides* and *E. areolatus*). After 11 months, the mean count/module was increased to 1839 tails and mostly dominated by the bigeye snapper, *Lutjanus lutjanus* and yellowtail scad, Atule mate (Mohammed Pauzi *et al*., 2010). Fauzi (2010) reported that big size ARs deployed in the coastal waters of Peninsular Malaysia in 2006 has become a nursery and breeding ground for lobsters and crabs, especially the fully gravid animals which were found within the AR structures during the series of visual observations conducted by DoFM researchers. The structures also function as substrate for many marine fauna and flora to grow, and also proved successful in hindering illegal trawlers especially because the cod-end of a trawler could be entangled with the AR structures.

In the latest findings in 2010, more than 100 species of fish were recorded at the AR sites in Terengganu, Kedah, Sabah, Sarawak and Federal Territory of Labuan. Among the species found were the highly commercial species such as groupers, red snappers, sweetlips, lobsters, and coral fishes such as banner fish, anemone fish, lion fish, bat fish, chromis, among others. Tetrapod ARs deployed near the Mak Daerah turtle nesting beach in 2006 has become a safe resting place for green turtles during their inter-nesting period. Adult green turtle *Chelonia mydas* was observed resting closed to the ARs in July 2010. This place is now a safe temporary habitat for this reptile away from trawling activities. A study in May-June 2010 by the DoFS on ARs deployed in Tempurong and Lok Nunuk in 2009 recorded 22 species and among them are high grade snappers (*Lutjanus* spp.), groupers (*Epinephelus* spp. and *Cephalopholis* spp.), Carangoides (*Caranx* spp.), stingrays, and spiny lobster (*Panulirus* spp.).

The DoFM has imposed prohibitions against fishing in the immediate vicinity of up to a radius of 0.5 nm of the ARs, the locations of which had been suitably indicated by marker buoys (Jothy, 1986; Wong1991; Abdul Razak and Mohamed Pauzi, 1991). However, all marker buoys were lost due to vandalism and from forces of nature. In Sabah, the DoFS enforced a policy or condition that only local fishers who are committed to take active part in the Local Artificial Reef Committee to protect and monitor the AR sites from dynamite and cyanide fishing, overfishing, from net and trap fishing with only angling allowed, will be considered as ARs project beneficiaries and where ARs would be deployed near their fishing villages.

Generally, the ARs program of Malaysia in 2006-2010 has achieved its objectives of deterring illegal trawling activities into the coastal waters. Moreover, the involvement and commitment of local fishers in protecting, monitoring and managing the ARs from illegal fishing and overfishing had been the most effective form of management in the AR sites. The DoFM also gathered valuable experiences that will serve as guide through its future undertakings in habitat enhancement as well as on the suitable materials, appropriate designs, size and strength that will provide the best performance of the ARs.

For example, the large concrete artificial reef modules currently being promoted by DoFM have the strength, design and size which are most suitable in terms of creating new habitat, resisting environmental conditions and also withstanding the onslaught of the illegal trawlers' malpractices. The DoFM is continuing its efforts to find new designs for concrete ARs that will be able to closely imitate the natural reefs, preferably those that could protect young juveniles of marine organisms and at the same time provide niche for a host of marine organisms. Nevertheless, various issues have also arisen during the implementation of the ARs project in Malaysia in 2006-2010. These include: (a) perceptions of most people and policy makers that ARs are constructed for fishing, and as a consequence AR sites outside Marine Park areas are fished without control; (b) fishers' management responsibility of the ARs is unclear because many government agencies are directly involved in the construction and deployment of ARs; (c) conflict of interest among user groups especially between drift net and anglers in the AR areas, especially that drift nets are always entangled with the AR modules and are left unrecovered; (d) inadequate technical knowledge among officers involved in ARs project especially in marine engineering construction and physical oceanography; (e) insufficient facilities and infrastructures such as jetty, pontoon, crane and concrete batching plan; and (f) limited funding for the scheduled monitoring activities.

4.5 Responsible Fishing and Practices in Southeast Asia

Promotion of the concept of responsible fishing is not new in global fisheries as it can be traced back to the Convention on Fishing and Conservation of the Living Resources of the High Seas in United Nation Law of the Sea (UNCLOS) 1958 which explains the global concern of sustainable utilization of the marine fishery resources. Similar message was reemphasized in the articles of UNCLOS 1982 which concerned more on the conservation and utilization of the living resources, and especially the stocks occurring in the exclusive economic zones of two or more coastal States or transboundary or highly migratory species. However, the fishery resources had gradually declined year by year and in order to address the problems on stock decline, the Committee on Fisheries (COFI) organized the International Conference on Responsible Fishing in 1992 (The Cancun Declaration 1992) to consider the draft of the Code of Conduct for Responsible Fisheries (CCRF). Finally, the global CCRF was adopted in 1995, providing general principles and international standards for responsible fishery practices worldwide. Recognizing that the implementation of the CCRF is very important in ensuring sustainable fisheries in Southeast Asia, SEAFDEC also sustained its campaign for the implementation of the CCRF in the region. In order to encourage the Southeast Asian countries to adopt the CCRF, it was necessary for SEAFDEC to provide clarification on the requirements spelled out in the CCRF taking into consideration the specific situation of the Southeast Asian region.

The different fishing scenarios and issues that exist within the region, especially those related to multi-species, multi-gear and small-scale nature of fisheries are rather dominant and unique, but it is unfortunate that these issues were only superficially covered by the global CCRF. Thus, it was deemed important for SEAFDEC to address the specificity of fisheries in the region through its program on the Regionalization of the Code of Conduct for Responsible Fisheries (RCCRF) starting in 1998. RCCRF aimed to: clarify the requirements of the CCRF; identify and prioritize the required actions; identify the issues that require special consideration from the regional point of view; formulate regional policies that would help the ASEAN Member Countries in implementing the global Code of Conduct for Responsible Fisheries; and facilitate the formulation and implementation by the ASEAN Member Countries of national codes of practices for responsible fishing operations, fisheries management, aquaculture, and post-harvest practices and trade. While the RCCRF focused on the Southeast Asian region's specific context, encompassing its culture, its fisheries structure, and the region's fishery ecosystems, the result was a compilation of regional guidelines accommodating the specific regional concerns that the global CCRF failed to highlight, and where the issues of particular importance to Southeast Asia have been amplified and elaborated on under the framework of the global CCRF.

4.5.1 Key Issues Related to Responsible Fisheries

In order to sustain the marine fishery resources and maintain marine capture fisheries in the Southeast Asian region, the RCCRF attempted to put more emphasis and strengthen Chapter 8 of the CCRF, while the hindrances confronting the development of sustainable fishing were identified. Two main issues were then focused, *i.e.* depleting fishery resources coupled with environmental deterioration, and climate change that impacts on fishing operations and safety of fishers at sea. Since the impacts of fishing operations and practices both legal and illegal had been identified as the main causes of the depletion of fishery resources and deterioration of the environment, these issues were discussed thoroughly during the Regional Workshop on the Reduction of the Impacts of Fishing on Coastal and Marine Environments in the Southeast Asian Waters organized in Thailand in January 2009, and scoped into specific issues that include: over-fishing; destructive gear; on-selective gear and practice, IUU fishing; ghost fishing; and use of fossil fuel. In addition, the 2009 Workshop also identified major fishing practices that could bring negative impacts on the coastal and marine environments hindering all efforts to achieve sustainable fishing especially in the Southeast Asian waters. These included: light fishing; use of stationary gears (*e.g.*, tidal traps, stow-net, fyke net, Japanese set net, Muro-ami, Choko-ami); use of active gears (*e.g.*, trawls, dredge, push net); use of semi-passive gear and small-scale fishing gear (*e.g.*, pot, gill net); longline fisheries; and purse seine operations associated with fish aggregating devices (FADs).

Moreover, considering that the impacts of climate change and the consequences of unpredictable weather conditions had been the main hindrances in sustaining responsible fishing activities and safety of fishers at sea, efforts are being made by the Southeast Asian countries to mitigate the impacts of fishing operations to the environment. The SEAFDEC Fishery Statistical Bulletin 2007 reported that the number of fishing boats in Southeast Asia both powered and non-powered could reach about 1,500,000 units, reflecting the fact that the fishing sector is rapidly growing and could be a major source of greenhouse gas emission and thus, should be addressed as part of the international climate change mitigation framework. Furthermore, reports have also shown that some 2.5 million out of 4.3 million vessels used in fisheries worldwide are powered by fossil fuel burning engines that consume some 42-45 million MT of fuel per year. The increasing use of fossil fuels by fishing boats led to increased emission of CO_2 providing the information on carbon footprints of fishing boats. Since the boat's carbon footprint is directly proportional to the amount of fuel burned, it is therefore necessary to reduce the use of fossil fuel to minimize the fishing boat's carbon footprint and subsequently reduce the emission of CO_2, a major greenhouse gas (GHG) that contributes heavily to global warming.

SEAFDEC recognizes that strengthening responsible fishing and practices is an approach that could sustain marine fisheries in the Southeast Asia region. In this regard, three main issues have been considered which should be addressed in future R&D activities, *i.e.* investigating the destructive manners of fishing gear and practices, optimizing energy use in fisheries, and enhancing safety at sea for small-scale fishing boats. The 2009 Workshop noted that destructive fishing gears and practices are being operated in the Southeast Asian region and thus, countries were asked to mitigate the impact to fisheries resources and ecosystem. On light fishing for example, research on appropriate use of lights in fishing (optimizing and saving), fish behavior in response to the light, visual physiology and impact on socio-economic as well as alternate light source technology should be undertaken. The outcome of such effort could be a draft policy on the use of lights in fishing.

For active fishing gears (trawl net, dredge, push net), action plans for the development of strategy on the promotion of JTEDs in trawl fishing in Southeast Asia should be strengthened, while observers program for trawls, dredgers, and push nets should be initiated. Assessment of the impact of dredge, push net and other active gears should be conducted, the results of which could be used in the development of appropriate policies. Action plans for longline fisheries should be developed to include the development of strategy for adoption of the circle hook in longline fishery and secure reliable supply of appropriate hooks, promotion of best practices for longline fisheries, onboard observers programs as well as assessment of by-catch in pelagic longline fisheries.

Moreover for stationary fishing gear (tidal trap, stow net, Japanese set net), the action plan could include assessment of the impact of stationary gear, establishment of regional expert network to promote further extension of set net technology in the region, and dissemination and promotion the manual on good practice. For small-scale gear (gillnet, pot/trap), future R&D activities should aim to enhance sustainable fisheries, and could include: assessment of the impact of small-scale gear to marine fishery resources, mortality risk assessment of small-scale fishing activities to marine mammals, development of mitigation measures for ghost-fishing and use of non-selective fishing gears, development of management model for small-scale gears, and development of awareness building materials to mitigate by-catch in small-scale gears. As for purse seine in association with FADs, activities that had been initiated in the region should be enhanced, *e.g.* survey on the use of drifting FADs and fixed FADs in Southeast Asian countries, assessment of the impact of fixed FADs on tuna stock, materials and designs for eco-friendly FADs, and awareness building on the impacts of abandoned drifting FADs and on the use of fixed FADs in purse seine fishing. In addition, the development of best practices for drifting FADs and fixed FADs should also be pursued.

In line with the efforts of the Southeast Asian countries to reduce the impact of fishing practices to the coastal and marine environments, the establishment of the *Network for Reduction of Impact of Fishing on Coastal and Marine Environment in Southeast Asian Waters (IFCOME-Network)* has been initiated by SEAFDEC to facilitate the sharing and dissemination of information on programs and initiatives related to the reduction of the impact of fishing, and monitor the developments to be used as basis in improving the design of fishing gears and promotion of responsible fishing practices. The main role of the Network is to provide information and recommendations that could contribute to improving the current fishing gear technology and practices to reduce the impacts from fishing activities; enhancing inter-agency and inter-sectoral coordination at the national, regional and international levels for achieving sustainable fisheries management and development in the Southeast Asian region through proper development of fishing gear technologies and practices; strengthening regional cooperation on R&D, technology transfer, and resources capacity building on the issues related to reduction of impact of fishing practices; and widening the network of people, government, organizations for reducing the impact of fishing practices to the coastal and marine environments.

4.6 Optimizing Energy Use in Fisheries

Considering the large number of powered fishing boats in the Southeast Asian region, it has become imperative to reduce fuel consumption in order to contribute to savings on operations costs as well as reduce CO_2 emission to the environment. In the capture fishery sector, introduction of good engine maintenance including the use of alternative energy source for example the use of sails for small fishing vessels, natural gas such as the liquefied petroleum gas (LPG) or compressed natural gas (CNG) or the liquefied natural gas (LNG) commonly used in natural gas vehicle (NGV) has been promoted to reduce pollution and CO_2 emission from boats' engine. Modification of fishing gear construction and design should be pursued to reduce resistance during fishing operations or reduce travel time from shore to fishing grounds.

Furthermore, it is also vital for the Southeast Asian countries to advance the production of fish and fishery products in terms of safe and good quality standards in order to promote the region's fish and fishery products in the world market, and eventually boost the flow of foreign currency into the region's economies, as well as increasing the availability of fish and fish products for human consumption. Therefore, sustainable development in fisheries post-harvest technology could also be enhanced by minimizing the fuel consumption for refrigeration or that of the boat's auxiliary engine through good fish handling processes and preservation onboard, and proper local knowledge practices. The use of ice and chilled sea water, practicing traditional method of fish processing such as the use of solar energy, should also be advanced to reduce the use of charcoal and fuel in processing.

4.7 Safety at Sea and Standards for Fishers in Southeast Asia

The global Code of Conduct for Responsible Fisheries has prescribed in 8.1.5 that: "States should ensure that health and safety standards are adopted for everyone employed in fishing operations. Such standards should not be less than the minimum requirements of relevant international agreements on conditions of work and services". Taking into consideration the situation in the Southeast Asian countries, the Regional Guidelines for Responsible Fishing Operations in Southeast Asia (SEAFDEC, 2000) specifically stipulated in (8.1.5 (1)) that: "*Since the minimum requirement in relevant international agreements including SOLAS and IMO is only applicable to vessels larger than 24 m LOA, and considering that majority of fishing boats in the region is smaller than this size, States should be encouraged to elaborate special safety standards and policies with emphasis on smaller boats*".

Taking into consideration the small-sized fishing boats in the Southeast Asian region, the Regional Workshop on Safety at Sea for Small Scale Fishing Boats in Southeast Asia held in 2003 and 2010 (SEAFDEC, 2010c), recommended that "*Since safety at sea is a serious problem in developing countries, the initiatives of respective Southeast Asian countries in improving safety at sea for small fishing boats should be reviewed taking into account the international and regional initiatives on safety at sea*". The 2010 Workshop also made special focus on the establishment of a mechanism for recording the accidents at sea for fishing boats, and on the need to improve the fishers living conditions onboard fishing boats (**Box 3**).

Moreover, even if the Southeast Asian countries have been implementing measures to improve safety of fishing boats and fishers, there is still a need to generate political will in order that such efforts could be further enhanced. Thus, the 2010 Workshop called upon the governments to mainstream the safety issues into national policies in order that safety at sea could be integrated in the overall fisheries management with the recommendations during the 2010 Workshop (SEAFDEC, 2010c) as the overall framework, and that appropriate programs on Safety at Sea should also be pursued by the Southeast Asian countries.

Note should also be taken that in order to promote and address safety at sea including working condition onboard fishing boats to ensure that the consideration that appeared in **Box 3** are addressed, a series of activities have been initiated and implemented in the region. These include, among others, development of regionally harmonized format for recording accident at sea of small fishing boats; production of awareness building materials for promoting safety at sea of small fishing boats; development of the regional guidelines on safety at sea and working standard for small fishing boats; establishment of the regional network to strengthen inter-agency coordination on safety at sea and working standard of fishing boats in the Southeast Asia.

5. AQUACULTURE

Aquaculture contributed 38% to the world's total fisheries production of 145 million MT in 2009, and has become the fastest growing food producing activity in the world with an average annual growth rate of more than 8% from 1970 to 2008 (FAO, 2010). Aquaculture has also grown to be a robust and vital industry providing about 46% of the fish consumed globally, and with its ancillary industries, engaging about 11 million people and spurring global trade of fish and fishery products.

While global accounts show remarkable milestones for aquaculture, the scenario in Southeast Asia suggests a

Box 3. Recommendations on Safety at Sea for Small Fishing Boats in Southeast Asian Region

- Develop appropriate incident reporting and investigation systems for the purpose of improving safety at sea, taking into account the following considerations:
  - The draft Guidelines to Competent Authorities in Implementing an Accident Reporting and Analysis System for Small Fishing Vessels currently being developed by FAO;
  - The possible establishment of incentives for fishers, indemnity programs, registration systems for fishing vessels, MCS systems and subsidies to the fishing industry; and
  - The objective of the systems which should be appropriate to the size of vessels and types of fishing operations or facilities onboard.
- Promote the registration of small fishing boats.
- Promote and ensure that safety aspects, including considerations on the working conditions and socio-economic development, are incorporated and addressed by concerned authorities while improving monitoring and control of the status and use of small scale fishing vessels.
- Strengthen local authorities and local organizations and promote the application of safety at sea standards among the coastal communities.
- Promote technical and financial support from authorities, including subsidies, at all levels for issues of safety at sea, including considerations on working conditions and socio-economic development.
- Identify and promote the basic requirements for safety at sea in the following areas:
  - Research on the design and construction of small fishing boats including the modification of traditional types of boats;
  - Safety equipment including fire fighting and live-saving appliances, regular maintenance and repair of boats, gear and equipment; and
  - Development of regular boat inspection systems.
- Implement training and education programs for all stakeholders including the fishers, family members, boat builders and others, for basic requirements of:
  - Boat design and construction;
  - Equipment and its correct use (including avoidance of dangerous fishing practices);
  - Search and rescue operations;
  - Occupational health, working conditions and safety awareness; and
  - Awareness of the environmental factors.
- Promote awareness among policy makers, central authorities and the broader public on the safety hazards facing people involved in fisheries in order to:
  - Attract more attention and resources to be allocated to safety at sea aspects;
  - Provide knowledge on the working conditions and hardships faced by fishers (which are increasing following the impacts of climate change); and
  - Raise political will to address safety at sea and in strengthening the local organizations.
- Develop and promote the use of appropriate communication systems for:
  - Weather forecasting information; and
  - Search and rescue systems.

more challenging appraisal. Aquaculture in the region has undeniably eased the supply and demand gap for fish for domestic consumption, and has also benefited the export sector that revved up economic development in the region. Of the world's aquaculture production of 55 million MT in 2009, about 91% came from Asia, of which 17% was produced by the Southeast Asian countries (SEAFDEC, 2010). While direct engagement in aquaculture is not the only indicator of its contribution to the economic development, aquaculture in the Southeast Asian region is expected to contribute towards the holistic development of rural communities.

5.1 Integrating Aquaculture in Rural Development in Southeast Asia

The incidence of poverty remains high in the rural areas of many Southeast Asian countries (**Table 58**). Thus, most rural development programs are generally envisioned to address poverty, food insecurity, nutritional deficiencies, insufficient livelihood alternatives, limited human skills and environmental degradation that drag economic growth and hinder improvement of the societal welfare in rural communities. Therefore, the role of aquaculture in contributing towards rural development needs critical analysis while relevant strategies for integrating aquaculture in rural development should be determined and implemented.

Considering the scientific and technological breakthrough attained in aquaculture for the past three decades, the sub-sector is being challenged on its role in uplifting the welfare, and in particular, securing food and the livelihoods of rural folks. The most common questions being asked these days are: *Has aquaculture benefited the marginalized fisherfolk who depends on the aquatic resources for their food and livelihood? Are there specific policies that address the issues of environmental degradation and social inequities in rural communities resulting from the rapid development of aquaculture? How is the impact of climate change in rural aquatic communities being addressed by R&D institutions and government policy makers?* Nonetheless, there seems to be more questions than answers considering that data and information remain limited and yet to be organized for most countries in the region.

5.1.1 Aquaculture and Rural Development in Southeast Asia

Why is aquaculture being challenged to pay attention to rural development in Southeast Asia after decades of remarkable production growth rates and profitability? What has transpired in the sector? FAO (2010) noted that the level of development of aquaculture has varied widely across nations, with positive bias towards countries and localities where private entrepreneurs have been successful or where growth was driven by the capital-rich private sector. A review of literature in aquaculture conducted through a commissioned study by FAO in 1997 "Aquaculture Economics in Developing Countries: Regional Assessments and an Annotated Bibliography"

Table 58. Incidence of poverty in selected economies in Southeast Asia, 1997-2002 (%)

Country	Year	Incidence of poverty (%) using national poverty line			
		Total	Urban	Rural	Contribution of rural poverty to total poverty
Cambodia	1999	35.9	18.2	40.1	93.8
Indonesia	2002	18.2	14.5	21.1	70.3
Lao PDR	1997	38.6	26.9	41.0	80.7
Malaysia	1999	7.5	3.4	12.4	69.3
Myanmar	1997	22.9	23.9	22.4	70.4
Philippines	2000	34.0	20.4	47.4	72.4
Thailand	2002	9.8	4.0	12.6	91.3
Vietnam	2002	28.9	6.6	35.6	92.3

Source: *Asian Development Bank (2004)*

(Charles *et al*., 1997) revealed that majority of the studies focused on the evaluation of aquaculture production systems or farm-level economics that aimed to find the most efficient techniques to culture fish. Various culture techniques have been developed and verified either in paddies, fresh and brackishwater ponds, reservoirs, irrigation canals, tanks, cage nets and pens in freshwater and marine water bodies. Various species combination and agri-aquaculture integration have also been studied. The most economically efficient methods under different culture scenarios have been determined and promoted through aggressive extension methods. Credit packages have been offered to national governments down to local entrepreneurs to boost aquaculture investments and development. Rural areas have been host to various aquaculture systems and have witnessed the conversion of its landscape to suit the most technologically suitable and economically viable aquaculture operations.

Despite the increase in world aquaculture production, the benefit distribution from aquaculture was not a prominent consideration in rural development planning not until the onset of the new millennium. The human dimension of aquaculture has since then became a focus of policy and government programs to concurrently address the food security and poverty question more upfront than in previous years. Most governments in Southeast Asia began providing institutional and infrastructure support to rural communities to enable access to resources such as land and water, integration of production systems (fish breeding, nursery and grow-out). Governments in the region also got involved in the development of input markets and post-harvest and value-adding facilities that are accessible for resource poor households in rural areas (Ahmed and Lorica, 2002). The issues of environmental degradation and the resource use conflicts of the late 1980s and early 1990s had governments reviewing their policies and taking steps to address such issues.

Possibly arising from this redirected attention, a more recent study noted some contradictions to what has been suggested in earlier literatures about the inequalities brought about by aquaculture. Irz, *et al*. (2007) noted that aquaculture demands a large number of relatively unskilled labor which in the context of rural communities offer opportunities for employment, either directly or indirectly in fish farming and post-harvest activities. Poor households engaged in aquaculture obtain larger portion of their income from fish farming than the non-poor and those doing other forms of farming. Since aquaculture is suggested to be inequality-reducing, policy-makers and local government units in inland aquatic and coastal communities who aim to counter poverty should give attention to the effects of adopting new policies and aquaculture technologies. Nevertheless, these results could be limited to situations where aquaculture is done without compromising the environment, as this will change the impact of evaluation outcomes.

Furthermore, recent gender studies in the mid-1970s to early 1990s showed evidences aquaculture provided avenues to enhance the role of women in rural areas as owners and managers of aquaculture enterprises as well as active participants in community-management of fishery resources aside from being homemakers. Although issues on environmental degradation and resource use conflicts of the late 1980s and early 1990s had been reviewed by the governments, valuation assessment of natural resources that could influence policies on sustainable use of fishery and aquatic resources in rural setting remain insufficient. Issues on how climate change will impact people and aquaculture in rural development should also be studied, requiring equal attention considering the very fragile but important connections between people and the environment in rural communities.

5.1.2 Integrating Aquaculture in Rural Development: Issues and Opportunities

Expressed in gross domestic product (GDP), the economic growth in Southeast Asia during the past decades has been remarkable, with GDP in 2002 of 4.7% compared to the whole of Asia (3.2%) and the world (2.4%). In 2000-2002, the average contribution of agriculture including fisheries to GDP was 13.8% which was much higher than the whole of Asia (7.9%) and the world (5.1%). Empirical data show that although economic growth reduces poverty, however, poverty still persists in rural Southeast Asia, where about 70-90% of the poor come from the rural areas. Moreover, in most fishing communities in Southeast Asia, the rural poor have limited access to land and water resources, technology, services, capital, markets, and centers of governance.

Aquaculture has big potentials in alleviating poverty and attaining food security, as it can provide food of high nutritional value especially for women and children, livelihood and "own-enterprise" employment opportunities, and incomes from sale of relatively high-value species. The sustained promotion and wider adoption of aquaculture among fishing families will result in positive impacts especially improving household food security. Thus, aquaculture as a supplier food and tradable goods has the potential of improving the food and nutritional security of people in three ways, namely: (1) adoption-income linkage; (2) adoption-employment linkage; and (3) adoption-consumption linkage (Ahmed and Lorica, 2002).

Although adoption of appropriate aquaculture technologies may be slow among the rural folks, empirical evidence in Vietnam, Philippines, and Lao PDR shows that aquaculture has been providing additional income to the poor. The impact of aquaculture on employment including wages is not well documented except for some aquaculture economic analysis that indicates a ratio of one technician for every 5 ha of ponds. In one Mariculture Park in southern Philippines, one technician is hired for every 1-5 units of fish cages. Self-employment in seaweeds farming has also demonstrated a big potential, especially considering that almost all seaweed farms in the Philippines and Indonesia are family-operated. Abundant labor in rural areas can therefore be tapped to supply the needs of aquaculture, but the wages for hired labor in aquaculture enterprises should be documented.

The consumption effects of aquaculture depend on many factors such as price, and consumer taste and preferences. High-value species such as crustaceans is more price elastic and has high rate of substitutability compared to low value species like tilapia. The consumers, especially in developed western countries have become health conscious in their eating habits. Fish is considered as a health food and consumption is expected to increase in both fish producing and fish importing countries. Home consumption of aquaculture production is estimated to be 30-40% in Bangladesh (Gupta in Ahmed and Lorica, 2002), while in Tonle Sap in Cambodia, small-scale aquaculture provides food for families and incomes from excess production for sale.

Traditions and practices associated with aquaculture in rural areas generate some important nutritional benefits for households that engage in various ways in aquaculture. The practice of allowing the collection of "free fish" or residual and non-target species after harvest by the young and the poor in the communities happen to provide fish food and nourishment. These benefits are highly appreciated by many rural residents in the Philippines, although occasional and limited (Irz *et al*., 2007). This shows an example of non-market mechanisms in the practice of aquaculture in rural communities making fish available and improving the nutrition of poor households.

Many of the developing countries have moved away from the centralized strategic approach to development that received heavy emphasis in the 1950s and 1960s. Since government services and control have not reached remote areas especially the fishing communities, such situation led to mismanagement and destruction of the fishery resources. As a result, paradigm shift from central governance to a decentralized form of resource management has been adopted by many Southeast Asian countries (*e.g.* Philippines, Indonesia, Thailand, and Cambodia). The shift to devolve government control of fishery resources is a responsive act towards addressing the issues regarding property rights arrangements over bodies of waters for fishing and aquaculture.

Since marine and freshwater bodies are technically state-owned, they become an "open access" property where any individual or entity can undertake personal and enterprise activities. The open access nature of the fishery resources does not augur well for the security of small-holder fish farmers. With devolution and decentralization, local government units are now in better position to provide policy support in the management the coastal waters and inland bodies of water through enactment of ordinances indicating the zone for exclusive use of fisherfolk for aquaculture livelihood. In addition to policy support, government should provide technical and extension services, market accessing and guides to micro-financing schemes, and disaster-preparedness mechanisms because of the vulnerability of coastal dwellers to the impacts of climate change. As a matter of fact, one of the key reasons for the flourishing aquaculture industry driven by the private sector in one jurisdiction but not in the others is governance (FAO, 2010) because in the past two decades considerable progress has been made in addressing aquaculture governance issues. This progress has been made possible by an international corporate effort and by several nations that have pushed for the aquaculture agenda forwards in an orderly and sustainable manner through good governance.

One of the major impediments in promoting aquaculture for food and livelihood in rural Southeast Asia is the inaccessible and unaffordable financial packages for small-scale fish farmers. Some governments in the region have provided subsidies such as interest-free loans to farmers to boost adoption of agricultural technologies. However, many such programs are not self-sustaining and subsequently failed because of poor repayment rates. The traditional collateral-based lending schemes of banks also do not meet the financing needs of rural farmers, especially the fishers in island communities without material and financial assets (Farrington *et al*., 1997). A relatively recent development is the entry of NGOs in the lending of cheap and accessible loans to break the barriers faced by the rural poor in accessing formal financing packages. The micro-financing innovations introduced by some NGOs appear to be more promising than previous attempts to induce lenders to serve this clientele group, where the scheme heavily relies on the social assets of individual borrowers and the community. Such micro-financing scheme engages a group of 5 to 15 individuals, each of them accountable to the loan repayment failure of any member of the group. This scheme has generally worked and has induced collective action among the group of borrowers in protecting the group's interest. The loan is usually short-term which covers the production cost for one production run where its utilization is often supervised by the lending agency. For example, to avoid misuse of loans, some NGOs supply the inputs (seed and feeds) needed by small fish farmers the costs of which are charged to the loan, which is payable upon harvest. This way, loans are used for fish farming livelihood activities instead of other non-productive purposes which could result to non-payment of the loans. Nevertheless, one big challenge is for the government and private sector to invest in infrastructure and ancillary services, *e.g.* cold storage, processing plants and other downstream investment to support the marketing of the produce of aquaculture farms, big and small. Public-private partnership investment modalities should be encouraged for long-term capital investments to upgrade production and processing facilities to meet the growing global fish market.

Mainstreaming the rural communities into the aquaculture industry will require building their capacities to adopt appropriate aquaculture technologies. However, most countries in the Southeast Asian region are constrained by many factors, which include: ineffective government extension programs; lack of facilities and logistical support; inadequate and ill-prepared extension workers because of the lack of skills and knowledge on new aquaculture technologies; lack of "easy-to-understand" information materials on aquaculture and ineffective delivery systems to the rural folk; and remoteness of rural areas from knowledge centers such as government and private facilities.

In 2008, SEAFDEC with support from the ASEAN Foundation initiated and implemented a project on "Human Resources Development (HRD) for Poverty Alleviation and Food Security by Fisheries Intervention in the ASEAN Region", which had rural aquaculture as one of the thematic areas. Under the rural aquaculture portion, training was conducted on two phases, with the first phase focusing on "Trainers' Training" conducted at the Tigbauan Main Station of AQD in Iloilo, Philippines for selected senior fishery extensions workers representing the Southeast Asian countries.

The second phase involved on-site training courses in eight countries, which had been facilitated by the Senior Extension Officers who participated in the Trainers' Training with experts from AQD providing the technical assistance. Moreover, AQD also implemented a project on "Institutional Capacity Development for Sustainable Aquaculture (ICDSA)" to promote appropriate aquaculture technologies for improving the livelihoods of fishing communities through strategic partnership with "on-the-ground" institutions such as local government units, fisherfolk organizations, NGOs, micro-finance companies, and schools of fisheries. A "Season-long Training" approach was adopted in order that the fisherfolk could experience the full aquaculture production cycle including post-harvest and simple value-adding techniques. An important component of the training program is the establishment of demonstration set-ups (*e.g.* fish culture in cages, ponds and other systems) where the aquaculture system to be introduced to communities could be demonstrated for its technical and financial viabilities. Impact assessments are then conducted to determine the effectiveness of technology transfer strategy to rural folks in adopting aquaculture as a sustainable livelihood alternative and source of food.

Climate Change

Sea level rise is expected to reach 1.0 m or more by 2100 due to global warming, glacier melting, and accelerated decline in polar ice sheet mass. The resulting disastrous impacts on low elevation coastal zones are certain, but the ability of society to cope via adaptation remains uncertain. Moreover, observations on climate change show that rapid environmental change has coincided with shifts in the food web from its base to the apex. This complicates the management and protection of marine resources that have direct negative impacts on coastal communities. The climate change phenomena have been observed in many Southeast Asian countries through flash floods, increase in sea levels and temperature, stronger waves, and longer dry season. Therefore, there is a need to conduct social research on the vulnerability and resiliency of the small-scale fish farmers on the impacts of climate change which will not only affect their aquaculture livelihood but may endanger the safety of their families. In order to know the adaptive mechanisms for reducing or mitigating the effects of climate change, technical research should also look into the aquaculture systems and species that have better chances of withstanding the negative impacts of climate change.

5.1.3 *Perspectives in Integrating Aquaculture in Rural Development*

Taking into consideration the issues and constraints faced by the aquaculture industry, especially on the need to enhance the role of aquaculture in securing food and income which is critical in rural development in the region, the *ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment"* in June 2011 in Bangkok, Thailand adopted the new *Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020*. Included in the new Plan of Action is a provision on aquaculture which stipulates the guideline for the development of programs, projects and activities for the implementation of the new Resolution. The provisions in the Plan of Action specific for aquaculture are expected to compliment and update existing technical guidelines, policies and regulations in the practice and promotion of aquaculture in the Southeast Asian region (SEAFDEC, 2011b). Thus, the relevant future directions in the new Plan of Action could broadly be classified into: enhancing support for sustainable aquaculture in national through to local programs and policies; motivating governments to mainstream aquaculture in rural development; and applying precautionary and ecosystems approach in aquaculture. The new Plan of Action also enjoins that national programs and policies on aquaculture in the Southeast Asian countries should address the pressing social, economic and environmental aspects of sustainable aquaculture that directly impact rural development, *i.e.* that aquaculture programs should contribute to improved food security, livelihoods, employment and poverty alleviation. Such programs should envision to: provide the mechanisms and enabling environment for good aquaculture practices, efficient markets and fair trade; strengthen the capacity of small-holder farmers; and promote inter-agency collaboration.

Meanwhile, measures to manage the sustainability of aquaculture will include the implementation of strategies at the national and local levels to monitor and regulate aquaculture operations, prevent its over-development, and ensure that aquaculture practices are conducted in a manner that will not compromise the environment (BFAR-PHILMINAQ, 2007). In particular, governments at all levels have been encouraged to integrate aquaculture into rural development planning within the context of multiple uses of land and water resources, as well as the strengthening of inter-agency coordination in policy formulation, project planning and implementation, stakeholders consultation, extension services and technology transfer. Mainstreaming aquaculture in rural development requires the participation and support of the governments to regional initiatives that will assess the role of aquaculture in poverty alleviation for better policy formulation. In addition, in order to realistically integrate aquaculture activities in community development plans, compliance to national employment practices, facilitation of financial incentives and credit schemes, and promotion of investments in ancillary and other support structures to motivate aquaculture enterprises are also stipulated in the new Plan of Action. Moreover, public-private modalities to catalyze integration of aquaculture in rural development are also encouraged.

Recently, the FAO together with regional and national partner agencies has been promoting the precautionary approach through the ecosystems approach to fisheries management (Christie *et al*., 2007). This principle in effect applies a preventative approach to safeguard the environment from rapid development of offshore aquaculture, and likewise consider development of regional guidelines on responsible marine (inshore and offshore) aquaculture. In rural development scenarios, a precautionary and ecosystems principle will benefit protective and conservation measures that are critical in the practice of aquaculture in fragile environments. Natural resources are very critical and often fragile, assets being used for generating economic benefits in rural communities. Ecosystems approach therefore beneficially magnifies the interconnectedness between the human and ecological dimensions in the utilization of natural resources in aquaculture in rural areas.

The fundamental way forward in integrating aquaculture in rural development in the Southeast Asian countries is to collaborate through organizational networks in the promotion and implementation of the new Plan of Action. The technological breakthroughs and economic benefits from the growth and success of aquaculture in the region cannot be emphasized if aquaculture cannot significantly contribute to rural development. For several decades now, aquaculture technology has been introduced in many communities in inland aquatic resources and coastal areas in the region. However, the social dimension of aquaculture in improving the welfare of the poor in rural communities has been below par. Thus, while CCRF which stipulates sustainable aquaculture development in Article 9, remains to seek voluntary compliance, where governments at the national through to local levels would benefit from referring and adhering to the recommended aquaculture practices (SEAFDEC, 2005).

For most countries in Southeast Asia where rural development in inland aquatic and coastal areas is hampered by overfishing and lack of livelihood opportunities, the options could be diverse but should be coordinated. Since there is a need for aquaculture to be mainstreamed in the rural development planning, governments and development planners at the national through the local level should harmoniously ensure that their fisheries and aquaculture development policies include the need to: encourage optimal use of harvest from capture fisheries; reduce post-harvest losses; and enhance aquaculture benefits by engaging and supporting rural communities in farming and processing fish to generate local nutritional and economic gains. Support from governments should also include: cohesive and comprehensive policies and guidance to promote responsible aquaculture including generous measures for mitigating impacts of climate change to small-holder aquaculture livelihoods initiatives; development and implementation of supervised micro-financing schemes for small-holder aquaculture entrepreneurs; and aggregation of small-scale producers to facilitate participation in market and trade.

5.2 Good Quality Seeds for Aquaculture

World fisheries production was estimated to have reached 145.1 million MT in 2009 of which 55.1 million MT came from aquaculture (FAO, 2010). In addition to China, the major contributors to global aquaculture production from Southeast Asia are Vietnam, Indonesia, Thailand, Philippines, and Myanmar. Production from Asian aquaculture accounted for about 89% of world's production from aquaculture. Although noted to be a relatively young food production sector, annual aquaculture production has rapidly increased from 1.0 million MT to 50.2 million MT after six decades (FAO, 2010). Aquaculture production covers not only freshwater and marine fishes, crustacean and molluscan species but also includes aquatic plants, mostly seaweeds. Breeding and culture requirements for most of the commercially important aquaculture species especially those found in freshwater environments have been well studied (Siriwardena, 2007) thus accounting for a steady growth in production. Ironically though, in many Asian countries, several species that are economically valuable are not indigenous. Tilapia for instance, is a major national aquaculture product in the Philippines, Indonesia, Thailand, Malaysia, and China. In the last five years, apart from tilapia, the whiteleg shrimp (*Penaeus vannamei*) from the U.S.A. became a major culture species in Southeast Asia replacing the black tiger shrimp (*P. monodon*). The interest in whiteleg shrimp can be attributed to the fact that the shrimp industry was in need of a species which when cultured, can earn profits that may be enough to compensate for the losses in tiger shrimp production brought about by disease problems.

5.2.1 Status of Seed Production

Aquaculture production is mainly reliant on seed availability. Seedstocks for the aquaculture of different species could be obtained from the wild or from captive stocks in hatcheries (**Appendix 2**). For species with undetermined or no established breeding technologies, and possibly low seed production capabilities, the source of seedstock will be a limiting factor as commercial production would depend entirely on wild seeds. Seed production is primarily affected by several factors, from genetic to non-genetic or extrinsic causes such as the presence of diseases and sub-optimal hatchery and nursery methods or extreme changes in the environment. However, low seed production in the hatchery can be improved particularly if appropriate interventions are made. For some species such as catfish in Cambodia, milkfish and grouper in Indonesia, tilapia in the Philippines and Malaysia, grouper and sea bass in Thailand as well as in Vietnam, and shrimp in Malaysia, Myanmar and Vietnam, aquaculture production is constrained by seed supply and quality (Hishamunda *et al*,. 2009).

5.2.2 Issues and Concerns

A logical solution to the issue of decreasing aquaculture yield caused by poor survival and slow growth is to use good quality seedstocks. Quality seeds are fish fingerlings, crustacean post-larvae, molluscan spats or aquatic plantlets that are robust or hardy apart from having the same beneficial traits such as the capacity to grow fast, tolerate stress and feed efficiently as the case may be. Good quality seeds can be intentionally produced through the use of good quality spawners; suitable broodstock maturation diets; appropriate broodstock management methods that can minimize inbreeding; conventional selection such as hybridization, mass selection, within family and family selection, or combined selection; genetic manipulation methods; and improved hatchery and nursery rearing protocols.

For aquaculture in the Southeast Asian region, genetic methods have been employed through major selective breeding programs and several of these technologies have been known to generate improved stocks that are either in the process of field testing or have already been disseminated. For example, the Nile and red tilapias, some carps, Clariid catfishes, penaied shrimps, abalone and seaweed species have been the subject of genetic improvement research in Asia although in varying levels of development and adoption (**Appendix 3**).

Nevertheless, some countries have considered genetics as an important component in improving quality of seeds and as such have designated national genetic improvement centers to undertake research to further improve aquatic breeds. Indonesia for one, has assigned institutes specific to species, *e.g.* Sukabumi Aquaculture Development Center and Bogor Research Institute for Freshwater Aquaculture are designated to do genetics research on tilapia, catfish, carp and gourami, and other centers to engage in grouper, seaweeds and tiger shrimp improvement. Apart from these research centers, broodstock multiplication centers and a nucleus breeding center especially for non-indigenous species such as the whiteleg shrimp have also been established mainly to reduce dependence on imported broodstock (Sugama, 2011). Except for tilapia, the impact of the numerous genetic programs that aimed to develop growth-enhanced, stress tolerant and/or disease resistant species have yet to be evaluated in terms of their direct impact on increased aquaculture production and the gains derived from using the improved seedstocks on commercial farming need to be quantified.

It is recognized that improved reproduction and consequently, good quality seedstock are likewise achieved by nutritional intervention. SEAFDEC/AQD through its numerous research and verification studies involving fish and shrimp feed development, has determined the nutritional requirements in the formulation of fish/crustacean broodstock diets that promote enhanced reproduction. This also contributes further to the fact that apart from genetics, appropriate or best management protocols or the adoption of optimal husbandry techniques for rearing potential broodstock as well as for hatchery and nursery operations also help improve seed yield and quality.

5.2.3 Challenges and Future Direction

Aquaculture seedstock are produced by both public and private hatcheries. In many Southeast Asian countries, fish and prawn hatcheries are normally based on small- and backyard- scale operations (Tayamen, 2007). Traders serve as the link between farmers and hatchery operators where often when the seedstocks available from one hatchery do not meet the requirements or demand from prospective grow-out farmers, the trader procures seedstocks from various sources. This arrangement inevitably affects seed quality as seeds would come from different farms and subsequently on-farm performance and yield would not be what the farmer would expect. To ensure quality of seeds that would be in compliance with industry standards, seed certification standards should be defined and imposed, a concern which some governments in Southeast Asia are now trying to address. Countries like the Philippines, still need to formulate and implement seed certification standards while Vietnam and Indonesia, have been imposing regulations to ensure seed quality. Hatcheries such as those operated by large-scale investors, implement strict seed quality standards and dissemination schemes as required by genetically enhanced stocks. In addition to seed standards, these farms follow biosecurity measures on-farm, and this is especially true for disease-resistant and disease-free shrimp seedstock. Ideally, to protect the genetic integrity of premium seedstocks developed through known genetic improvement programs, grow-out farms which receive the improved seedstock would need to ensure that there would be no other unselected stocks on-farm to avoid unintentional mixing of seedstocks for culture. One of the main challenges in the production and distribution of quality seedstocks would be keeping the genetic quality and integrity of the seeds used in aquaculture (Romana-Eguia and de Jesus-Ayson, 2011) and addressing most of the problems in the development and production of quality seedstocks in the Southeast Asian region (**Appendix 4**).

As reported, an estimated 10% of the seedstocks used in aquaculture technically come from known genetically enhanced stocks. The lack of better seeds or lack of access to the same could either be due to flaws in the distribution chain in that farmers still have limited access to genetically improved seedstocks. It is also possible that knowledge about potential sources of good stocks or strains, optimal breeding, hatchery and nursery methods, selective breeding techniques or simply efficient broodstock management schemes to maintain genetic integrity in farm stocks, has not reached the farmers who are the ultimate end users. One way of addressing these issues would be to build and/or further strengthen public-private sector partnerships. Establishing and maintaining links among all the major players in the seed production and distribution chain would basically be part of the responsibility of national governments.

Grow-out operators who can afford the better seeds which are sold at premium prices can choose to get them from private/commercial hatcheries that are able to adopt advanced genetic technologies. Meanwhile, both small-scale farmers and hatchery operators can seek the assistance of the government for capacity building to facilitate farmers' adoption of new simple technologies, access to quality broodstock and seeds produced through farmer-friendly broodstock management methods, and establishment of effective distribution links or channels to enable continuous production and profitable dissemination of better seeds (Mair, 2002).

Finally, the best way to proceed would be for scientists to pursue research on existing genetic resources, particularly on how to improve the seeds to be used in aquaculture. For all the key players, from researchers, individual farmers and farmer clusters, academic organizations, industry and governments, there is a need to establish links to collectively address genetic issues, support sound policies and promote the implementation of better farm management practices to improve the supply of quality seeds and sustain aquatic food production in the region (Little *et al*., 2004; Little *et al*., 2007; Siriwardena 2007).

5.3 Disease Diagnosis, Control, Monitoring and Surveillance of Aquatic Animals

Aquaculture has always been a major part of the economic strategy adopted by many Southeast Asian countries for reducing poverty in view of its great potentials to fill the gap between supply and demand for fish and fish products especially the role that it has maintained as an important producer of high quality protein for domestic consumption as well as a major generator of export earnings. However, the continuing population growth, the decline in marine fish catch, and the widespread poverty in the rural areas of the region make it imperative that sustainable aquaculture be promoted to ensure food security. In fact, aquaculture in Southeast Asia has grown very rapidly especially during the last two decades, but due to irresponsible introduction of aquatic species that allegedly carried pathogens, a large number of infectious diseases have emerged threatening the sustainability of aquaculture in the region. The occurrence of aquatic diseases has not only led to low production but has also threatened food security and raised alarming environmental concerns (Ogata, 2009). In a brave attempt to address the issues, a regional project on fish disease was implemented at SEAFDEC/AQD in Iloilo, Philippines since 2000 with funding support from the Trust Fund Program of the Government of Japan's Fisheries Agency (JTF). Phases included in the Project are the Development of Fish Disease Inspection Methodologies for Artificially-bred Seeds which focused on the development of diagnostic methods for important viral diseases of aquatic animals in the region and Development of Fish Disease Surveillance System which aimed on the development of surveillance system for diseases of aquatic animals. Also, another phase of the project which is still on-going is the Food Safety of Aquaculture Products. Through this Regional Fish Disease Project, trading of healthy and wholesome aquaculture products has been promoted in the Southeast Asian region (SEAFDEC, 2008a).

5.3.1. Status, Issues and Concerns

Important findings from the Project have been disseminated to the countries in the region through hands-on training and information dissemination. Meanwhile, the countries in the region are also exerting efforts in controlling aquatic diseases to safeguard the quality of their products which are meant not only for domestic consumption but also for the export markets. For its part, SEAFDEC would continue to provide the means in order that the objectives of the countries are attained and to ensure that the requirements for safety and quality of the customers especially the international markets are being complied with. However, this would depend much on the available resources at SEAFDEC.

Development of Diagnostic Methods for Important Viral Diseases of Aquatic Animals

Through the SEAFDEC Regional Fish Disease Project, diagnostic methods have been developed to ensure healthy and wholesome trading of aquaculture products in the Southeast Asian region. Generally, there are 3 levels of diagnostics: Level I, which provides the foundation and is the basis of higher diagnostic levels. It includes production site observations, record-keeping and health management; Level II includes the specialization of parasitology, histopathology, bacteriology and mycology; and Level III includes advanced specialization like immunology and molecular techniques (Bontad-Reantaso *et al*., 2001). The SEAFDEC Regional Fish Disease Project focused more on Level III diagnostics. As a matter of fact, the implementation of the Project was also an opportune time to prevent the spread and control of an emerging viral disease of common carps known as koi herpesvirus (KHV) which almost devastated carp production in the region. The timely efforts of SEAFDEC to address such concern had ensured the sustainability of carp culture, a major economic livelihood in many Southeast Asian countries.

The main activities of the Project aimed to address the concerns related to the reported viral diseases including emerging ones in cultured shrimp and fish in Southeast Asia, such as the white spot syndrome virus (WSSV), monodon baculovirus (MBV) of the black tiger shrimp (*Penaeus monodon*), the taura syndrome virus (TSV) and infectious myonecrosis virus (IMNV) of the whiteleg shrimp (*Penaeus vannamei*) (Nagazawa, 2004). WSSV was in fact one of the root causes of the devastation of the shrimp culture industry that brought acute economic slow-down in Southeast Asia in the 1990s and even until now. This epizootic probably began in China then subsequently spread to Japan, Taiwan and the rest of Asia. Outbreak will cause a high and rapid mortality which may reach 100% within 10 days from the onset of clinical signs. Host range extends widely into other marine and freshwater crustacean species, including annelids, copepods and even aquatic insect larvae. This persistence in wild crustacean species in the vicinity of shrimp farms may make the disease difficult to eradicate from affected aquaculture areas. Through the Project, Level III diagnostic method such as the polymerase chain reaction (PCR) was optimized and standardized for WSSV (de la Peña *et al*., 2007). MBV is exemplified by problems related to infection that is usually encountered in hatchery and grow-out operations because its outbreak can slow the growth of the cultured animals. Level III diagnostic methods have also been optimized and standardized for MBV and hepatopancreatic parvovirus (HPV) in shrimp (Catap *et al*., 2003; Catap and de la Peña, 2005; de la Peña *et al*., 2008). TSV was first recognized in Ecuador in early 1990s where the disease caused heavy losses with a very high cumulative mortality rate of affected cultured *P. vannamei*. It was not reported in Asia until after introduction of *P. vannamei* in Taiwan in the late 1990s and was subsequently reported from most Asian countries where *P. vannamei* were imported for aquaculture. IMNV is considered as an emerging viral disease and its outbreak was initially documented in Brazilian *P. vannamei* farms in 2002. The virus caused low but steady mortality leading to accumulated losses up to 70%. In mid-2006, IMNV outbreak was reported in Indonesia (Flegel, 2009; Taukhid and Nur'aini, 2009). The legalization of the importation of *P. vannamei* in several Asian countries including the Philippines for aquaculture hastened the efforts for the establishment of Level III diagnostic methods such as RT-PCR for both TSV and IMNV. These diagnostic methods are very useful in the pre- and post-border screening of imported stocks.

In marine fish, well known viral diseases that severely affect the aquaculture industry in the region are the viral nervous necrosis (VNN) and iridovirus and also the koi herpesvirus (KHV) for the freshwater fish. VNN is considered as one of the most devastating diseases of marine fish. Larvae and juveniles are the most affected stages wherein outbreaks may cause up to 100% mortality. Iridovirus may also cause infections in many marine fish such as red seabream and groupers wherein mortalities may reach 60% among fingerlings and market-sized fish. Methods to detect, prevent and control VNN infection in marine fish hatchery have also been developed and established (Pakingking *et al*., 2009 and 2010; de la Peña, 2010). Level III diagnostics such as PCR was also optimized and standardized for iridovirus.

The first outbreak of the viral disease in koi and common carp (*Cyprinus carpio*) known as the koi herpesvirus disease (KHVD) was reported to have caused mortalities in carps in Indonesia in early 2002 and in Japan in 2003. With potential threats of spreading in other Southeast Asian countries, SEAFDEC through the Regional Fish Disease Project initiated strategies for the prevention and control of the KHVD. Kanazawa (2005) cited that in 2003, the losses incurred by Indonesia due to the KHVD was more than US$ 15 million, and considering that common carp is an important source of protein in the rural areas in Southeast Asia, it has become necessary for AQD to conduct studies on KHVD taking into account its high virulence and devastating impact on the freshwater aquaculture sector. Lio-Po *et al*. (2009) cited that the results of the studies on KHVD conducted at AQD that targeted five Asian countries had provided basic data on the status of the disease in the region and led to the prevention of the transboundary movement of KHVD in Southeast Asia. In addition, husbandry techniques (*e.g.* use of live bacteria or probiotics and "green water" culture system) to control the luminous vibrosis caused by *Vibrio* spp. such as *Vibrio harveyi*, a common bacterial disease that has also heavily affected shrimp aquaculture in the Southeast Asian region, were also developed as alternatives for chemotherapy (de Castro-Mallare *et al*., 2005). Results from the standardized diagnostic and husbandry methods for disease control have been disseminated to the region through hands-on training and massive information dissemination.

E-learning on Principles of Health Management in Aquaculture

Since 1988, AQD has been conducting classroom-based face-to-face training courses on health management in aquaculture on a regular basis at its main station in Tigbauan, Iloilo, Philippines. Later in the early 2000s, the teacher-student face-to-face setting had been changed into a distance-learning mode, which AQD considered more convenient and practical for a learner to acquire knowledge and skills in health management at his own place and at his own time. This new learning experience via information technology was developed for the AQD AquaHealth Online, which covers up-to-date knowledge on fish and crustacean diseases, the causal organisms and the methods of disease prevention and control (Lavilla-Pitogo and Torres, 2004). Targeting full-time working professionals, AquaHealth Online aims to introduce the principles of health management in aquaculture, and is envisaged that by the end of the course, online participants should be able to recognize diseased shrimps and fish, identify the cause(s) of the diseases, explain how the diseases develop, apply preventive and control measures to lessen the risks posed by the diseases, and use appropriate techniques for the preparation of samples for disease diagnosis. The AquaHealth Online was developed to train a large pool of geographically dispersed participants at minimum costs. Since its first session in 2002, AquaHealth Online has trained more than 150 e-learners not only from Southeast Asia but also from other regions in the world. Based on the feedbacks from the e-learners, AquaHealth Online has proved that a state-of-the-art online course can be as effective as the face-to-face training. However, AquaHealth Online requires that participants should have basic knowledge of written English and competency in using the computers and browsing the Internet.

Fish Disease Surveillance System

The Regional Fish Disease Project also focused on the development of Fish Disease Surveillance System in Southeast Asia to assist its Member Countries in their efforts in fish health management. Both general and targeted surveillance were implemented; thus, a network of the region's resources and facilities for fish health diagnosis has been established while human capacity building has been enhanced. During the implementation of the Project, AQD has continued to refine the diagnostic methods to be able to develop new prevention methods for aquatic animal diseases. More importantly, a surveillance system for important viral diseases for shrimps in the region has been instituted. As a result, the countries have developed a well-coordinated network for the timely and efficient reporting on any outbreak of any aquatic disease in the region as exemplified in the reporting of KHVD which spared the region's freshwater aquaculture sector from total economic collapse. As one of the most significant outcomes of this Project, the countries in the region can now boast of its regionally-recognized reference laboratory for specific aquatic diseases.

In order to review the emerging fish diseases and to keep the region abreast on the advances in pathogenesis, diagnosis, epidemiology, and surveillance of emerging diseases of aquatic animals the International Workshop on Emerging Fish Diseases in Asia was convened by SEAFDEC in December 2007 in Bangkok, Thailand. Attended by more than 70 participants from 17 countries including the Southeast Asian region, the information obtained from the Workshop has largely contributed to the promotion of responsible aquaculture in the region. Moreover, the knowledge gained by Southeast Asian countries on newly emerging aquatic diseases could boost their efforts in preventing the occurrence and spread of any aquatic diseases. Moreover, AQD has also updated information related to fish disease management based on considerable research findings achieved through the implementation of the Project (Lio-Po and Inui, 2010). This would then ensure that aquaculture products from the region are safe and wholesome for human consumption.

Monitoring Residual Chemicals in Aquaculture Products

The expansion of aquaculture farming activities over the years has made the health of the culture animals under constant threat from bioagressors such as viruses, bacteria, parasites and fungi. In an effort to control the occurrence of such bioagressors, many farmers use antibiotics and other chemicals without knowing that some could be toxic to humans and pose danger to the wellness of the environment. Improper use could also induce the development of resistant pathogens in the cultured aquatic species, the human consumers and the environment (Platon *et al*., 2007). Considering that the presence of chemical residues in aquaculture products poses threats to human health, SEAFDEC through the Regional Fish Disease Project has developed and standardized detection methods for residual chemicals such as pesticides and antibiotics in aquaculture products. This is aimed at securing safe and healthy aquaculture products from the Southeast Asian region.

With the cooperation of the Singapore-based SEAFDEC Marine Fisheries Research Department (MFRD), studies have been conducted to develop detection methods of residual antibiotics in aquaculture products. Oxolinic acid (OXA) and tetracycline (TC) are the most extensively used antibiotics in aquaculture and in order to determine the residue levels of OXA and TC in aquaculture products, high performance liquid chromatography methods had been developed (Tan *et al*., 2005). Moreover, a compilation of the methods for chloramphenicol and nitrofuran residue testing were prepared by MFRD and AQD and disseminated to the region's fish disease laboratories (Ruangpan and Tendencia, 2004; Borlongan and Ng, 2004). Furthermore, evaluation methods for residual chemicals in aquaculture products have been established to secure the safety of aquaculture products while the use of antibiotics in the region's aquaculture industry has been closely monitored (Borlongan, 2005; Ruangpan and Pradit, 2005).

5.3.2 Challenges and Future Direction

Recognizing that aquaculture which is an important contributor to food security in the region has been severely threatened, efforts have been made by SEAFDEC in collaboration with the Member Countries towards its sustainable development through the effective control of diseases by developing technology and techniques for disease identification, quick and reliable field-side diagnosis and harmonized diagnostic procedures specifically on Level III diagnostic methods; establishing regional and inter-regional referral systems including designation of reference laboratories; reducing risks of negative environmental impacts, loss of biodiversity, and disease transfer by regulating the introduction and transfer of aquatic organisms; and establishing quality standards and take measures to reduce or eliminate the use of harmful chemicals.

Considering that the occurrence of diseases in aquaculture is attributed to irresponsible management practices that bring about deteriorated culture conditions, some innovations have been adopted by many countries in the region that aimed to prevent disease outbreak. This includes the installation of effluent reservoirs which has been found effective in controlling viral diseases (Platon *et al*., 2007). Also included is the concept of total biosecurity system which comprises the installation of disinfection baths, dedicated paraphernalia per pond, screening of postlarvae for diseases, presence of reservoir ponds, water filtration and treatment for incoming and outgoing water and proactive monitoring of the animals and rearing water during the culture. In addition, strategies have been formulated to control fish diseases in aquaculture systems (Platon *et al*., 2007) as well as address the issues on healthy and wholesome aquaculture (Toledo *et al*., 2011) which should be considered specifically in the further development and refinement of the various methods and techniques for fish disease prevention and control, taking into account the various preventive measures that are now being advanced that could inhibit the use of chemical inputs in aquaculture.

More importantly, AQD would continue to focus its activities in addressing the areas of concern of responsible aquaculture development guided by the priorities especially on the development of responsible aquaculture technologies and practices, responsible use of genetic resources for the purpose of aquaculture, adoption of measures to avoid environmental degradation, and promotion of environmentally sound culture methods and commodities. There is certainty that if uncontrolled, irresponsible practices in aquaculture would continue to threaten food safety and create negative impacts on the ecosystem. It is for this reason that AQD has been promoting the concept of healthy and wholesome aquaculture, which is a holistic approach to fish disease management for food safety and security. This concept also promotes the use of efficient feeds which are cost effective and low-polluting in order to optimize production and healthy famed aquatic animals with the least negative impact to the environment (Toledo *et al*., 2011).

5.4 Development of Sustainable Aquaculture Feeds

Southeast Asia is a major producer of aquaculture products and aquaculture production has been steadily increasing with concomitant increase in the demand for aquafeeds in the region. Fishmeal (FM) and fish derived products (FPs) such as fish oil (FO), fish hydrolysates, fish protein concentrates, fish processing by-products, and fish soluble, are the major components of aquafeeds that would satisfy nutrient requirements and acceptability. However, FM and FPs are not always available and market prices could be unstable. Hence, these have big impacts on aquaculture activity and its sustainability.

Aquaculture feeds with lesser dependence on these feedstuffs are being developed to sustain growth of aquaculture in the Southeast Asian region. Decreasing the levels of FM and FPs in aquafeeds has been the objective of many feed formulators and feed millers. Therefore, research effort should emphasize on determining the lowest levels of FM and FPs in feeds formulated for specific aquaculture species in their stages of growth without loss in efficacy and on protein production. This has been achieved to a certain extent, for example in the compounded feeds for some species using alternative protein sources and nutritional interventions. Improvement and refinement of formulations, however, should be continued together with technologies that make alternative protein sources commercially available and cheap. Moreover, the culture of species with low requirement for FM and FPs such as the low value with high volume aquaculture species should be encouraged and to a certain extent environment regulations should be put in place. In addition, there is a need for greater involvement of governments to expand the market and promote consumer acceptance of low value species.

5.4.1 Use of Fishmeals and Fish-based Products for Aquafeeds

Production from fed aquaculture is 54% of total production in Asia (FAO, 2008). In 2009, the Southeast Asian region which is a major producer of aquaculture products, the volume of production was 12.5 million MT valued at US$ 14.8 billion (FAO, 2010). The amount of raw materials that goes into aquafeed production in the region is significant and the impact is tremendous on non-renewable resources or on the raw materials with limited supply. The collective impact of market forces, research results, and pressures of environmental issues lowered the inclusion levels of FM as a source of high quality protein and minerals as well as that of FO as a source of omega fatty acids, the second most valuable among the FPs in compounded feeds for aquaculture. Global reported data showed that these ingredients are expected to decline from 1995 to 2010 in the levels of FM and FO in compounded feed of milkfish (*Chanos chanos*) from 15% to 3% and 3% to 1%, respectively.

Except for catfish, a similar trend is also reported for shrimps, marine fish and tilapia. The compounded feeds for these species have become less dependent on FM and FO as lesser amounts are used, and are also increasingly efficient as shown by lower average FCR values from 1995 to 2010. The decreased levels of FM and FO in aquafeed imply that there is now less pressure on the manufacture of FM and FO. However, fish production from aquaculture in the Southeast Asian region has increased and more fish farmers are using efficient compounded feeds in aquaculture, increasing the demand for aquafeed production and thus, increasing also the total requirements for FM and FPs. For instance, the volume of aquafeeds used in the culture of milkfish between 1995 and 2007 has more than doubled while that for the other species groups has quadrupled (**Table 59**). In 2010, the estimated volumes of total feeds for the culture of these species also increased. Thus, with increased aquafeed use in aquaculture production in the Southeast Asian region, the demand for FM and FPs will continue to increase.

5.4.2 Issues and Concerns

Aquaculture production in the Southeast Asian region has been increasingly dependent on aquafeeds and this trend will continue as long as resources for the feed poduction are available. However, FM and FPs which are significant components of aquafeeds are finite resources, and as such feed producers and feed formulators are optimizing the use of these feedstuffs in aquafeeds. There is a lower limit to the inclusion of these feedstuffs in compounded feeds for specific species for culture without loss of efficiency. The pressure on FM and FPs would be greatly alleviated by finding the right resources as alternatives for protein and oils in aquafeeds. These alternative resources should come in adequate supply, cheap, effective, and acceptable to consumers. The use of alternative protein sources in aquafeeds has been done successfully to a certain percentage of the protein coming from FM. The common sources are those coming from plants which are high in fiber and contain some anti-nutrients. Soybean which is the most important plant protein source in aquafeed is highly digestible to most species for culture. However, its use in aquafeeds is constrained by its application in the livestock industry, for human consumption, and for the production of ethanol and biodiesel. The importance and acceptability of soybean meal, however, as a major plant protein source (also a source of lecithin and oil) has long been recognized.

As a result, products with soybean as the base component are coming out in the market with enhanced protein level and amino acid profile. These enhanced products are not cheap and so their utilization is constrained by the economics of aquafeed manufacturing. The use of genetically modified soya and corn in aquafeed is also a concern for some sectors of the industry. Plant protein sources such as corn, peas, Leucaena leaf meal, the leguminous meals, and copra meal are commonly found in the region and these have been increasingly used in fish diets, thus, decreasing reliance on the use of protein from FM. The other plant sources such as rice bran, wheat, palm kernel meal, ground nut cake which are used mainly as sources of carbohydrates in aquafeed contains small amounts of proteins and thus, FM protein is substituted to a lesser extent. Through fermentation processes, the nutrients in these plant sources can be made more available, however, constraints in the use of these feedstuffs could include keeping their quality and acceptance by fish.

Agricultural by-products including rendered products of terrestrial animal origin and dried grains as by-products of fermentation and distilleries have also been effectively

Table 59. Fishmeal (FM) and fish oil (FO) uses and efficiencies (1995), and estimates based on expected growth (2007-2010) in milkfish and four species groups

Species/ Group	Percentage on feed[a]	Average Feed Conversion Ratio (FCR)	Average FM level in feed (%)	Average FO level in feed (%)	Total feeds used[b] (Thousand Tonnes)
Milkfish					
1995	30	2	15	3	220
2007	41	2	3	1	499
2010	44	1.9	3	1	572
Shrimp					
1995	75	2	28	2	1,392
2007	93	1.7	18	2	5,603
2010	95	1.6	12	2	7,170
Marine fish					
1995	50	2	50	15	498
2007	72	1.9	30	7	2,311
2010	73	1.8	24	6	2,797
Tilapia					
1995	70	2	14	1	984
2007	82	1.7	5	0	3,590
2010	85	1.7	3	0	4,953
Catfish					
1995	85	2	5	1	345
2007	72	1.5	8	1.7	2,080
2010	73	1.5	6	1.7	2,923

Source: *Data from Tacon and Metian, 2008.*
[a] *Estimated percentage of milkfish and total species group fed on aquafeeds*
[b] *Estimated total aquafeed used*

used in aquafeed formulations but the inclusion level is limited. Rendered by-products are cheaper and those that have been successfully used in aquafeeds production as protein sources are blood meal, meat and bone meal, feather meal, and poultry by-product meal. Furthermore, dried grains have high fiber content but may not be always palatable to fish. Many studies have shown the use of these by-products in aquafeeds, but the reduced digestibility of these products in fish is a constraint. In addition, poor market acceptance has limited the use of rendered products.

Plant-based oil which is cheaper than marine fish oils have also been used in aquafeeds. The sources of plant oils are sunflower, olive, coconut, corn, and palm, but the use of these oils is limited by their fatty acid profiles and degree of un-saturation. Nevertheless, these characteristics benefit most freshwater species for culture. The combination of plant-based oils with marine oils has been known to improve feed utilization by cultivable marine species. Other feed ingredients that can be used as FM and FPs substitutes include fermented plant protein, single cell protein, krill, and by-products of seafood processing (Naylor *et al*., 2009). These are good and suitable substitutes but they are not yet produced in commercial quantities and, in the case of krill, the adverse ecosystem impacts. Numerous fishery products are used as feed ingredients in aquafeed and probably not all can be substituted by alternative sources. The most important ones are FM and FO, and these are the focus of much research effort for many species. These investigations also include other rich sources of DHA and EPA such as marine algal resources.

Research had also been done on the use of leaf meals as alternative protein sources in commonly cultured fish in the region. Although substitution of FM is possible to a certain level but processing leaf meals would be expensive and, in addition, contain anti-nutritional factors. In the continuing efforts to develop new formulations using non-traditional feed ingredients, the use of beneficial microorganisms in the gut of aquaculture species have been explored to ferment common feedstuffs to increase their suitability for use in aquafeeds, while other fermentation methods such as solid state fermentation, are also being explored to process non-traditional feed ingredients.

The cultivation of low-value with high-volume fish species is being promoted because they require lesser amount of FM and FPs in the feeds compared with the high-value with low-volume species which are mostly marine carnivores. In this case, farmers prefer to grow such species because of the profitability of farm operations or incentives given by the government. However, the use of high amounts of FM can be limited to the larval feeds and lesser amounts can be included in the feed for later stages of aquaculture. The fast growth of aquaculture sector has spurred a great demand for aquafeed and most importantly on FPs as important ingredients in aquafeed production. This has resulted in some cases in the adulteration and indiscriminate addition of chemicals in these commodities to avoid spoilage, increase bulk weight, retain freshness, and to improve fish health and growth. Adulterations in fishmeal had been reported and governments of the Southeast Asian countries should take important steps to curtail this activity since it undermines the use of FM, the efficiency of the aquafeeds, and the safety of aquaculture products.

The use or application of basic nutritional information in the formulation of aquafeeds by formulators in the aquafeed industry is critical in improving the efficiency of the feeds and sustaining aquaculture. However, more research still needs to be done to improve the understanding of fish nutrition and feeding management, as for example in the use of enzyme complexes to reduce FM required in aquafeeds to give the same or even improved performance in fishes which seems to be feasible. Much research efforts on FM and FPs substitutions in aquafeed have been done and presently being done, where valuable results should be made accessible to people who are responsible for the adaptation and use of such information.

5.4.3 Challenges and Future Direction

More efficient compounded feeds with lesser inclusion of FM and FPs are presently produced compared with the situation a decade ago. Therefore, efforts to continue such initiatives should be sustained through the involvement of other sectors of the industry. For the sustainability of the industry in the region, a more aggressive and multidisciplinary effort in finding adequate substitutes in aquaculture feeds should be pursued, while the various challenges should be addressed. The major challenge in the use of conventional feed ingredients for aquafeed formulations are commercial availability, quality, and the adequacy of nutrients to meet the requirements of specific species. In addition to cost, there is competition for these resources from other users such as the food producing sector. Government subsidies and incentives will help bring down the cost, but, stringent regulations should be in place to safeguard quality. Furthermore, for effective FM and FPs substitution in aquafeeds, research should be conducted on feedstuff digestibility for important species for culture, as well as intervention should be in place in order to achieve nutrient balance, palatability, and stability in compounded feeds to enhance the FCR.

Commercial quantity is also a constraint for the non-traditional feed ingredients. However, it is crucial to establish efficacy through research to enable the other sectors of the industry to follow with the commercial production of these feed ingredients. Aquaculture products grown on non-traditional feedstuffs should also be assessed for acceptable sensory characteristics such as odor, color, taste, and texture. Traceability, effect on human health, and impact on the environment are significant issues to be addressed in the use of non-traditional ingredients. Databases are available on feed ingredients that include their nutrition composition, usage in industrially- and farm-made aquafeeds, quality criteria, limitation of use, as well as documented feeding studies (Tacon *et al*., 2009; Hertrampf and Pascual, 2000). Databases should be updated to contain the current information on feed ingredient including those on non-traditional feed ingredients, and should be made available to feed manufacturers, researchers, fish farmers, policy makers, and other stakeholders.

The use of alternative substitutes for FM and FPs has some setbacks such as poor palatability, poor digestibility, essential amino acids deficiency, high fiber content, and limited inclusion level. Technological innovations are therefore needed to effectively use these in aquafeeds. Genetic engineering can improve amino acid profile in legumes and increase DHA/EPA levels of plant-derived oils. In addition, with technological innovations, concentrated and hydrolyzed protein products can be made cheaper and bone content in meat and bone meal can be adjusted to reduce calcium levels. In addition, genetic selection can be done for strains/stocks that can efficiently utilize plant derived non-traditional ingredients. It is apparent that the demand for aquafeed will continue to increase in the region as more aquaculture operations will be producing fish through fed aquaculture. The development of efficient aquafeeds with less dependence on FM and FPs should be pursued aggressively and with more multidisciplinary research efforts. Some feed ingredients with potentials for use as substitutes for these resources are already found in the market. Their efficacy to substitute FM and FPs in aquafeed including those of non-traditional feed ingredients can be increased through technological innovations.

5.5 Minimizing Impacts of Aquaculture on the Environment

Aquaculture is the fastest-growing food production system globally, with about 9% increase in production per year since 1985 (Diana, 2009). On the average, Asia which is known as the birthplace of aquaculture (Tacon *et al*., 1995) provides 83% (range: 59-91%) of the total world aquaculture production, 14% of which comes from Southeast Asia (**Fig. 38**). Indonesia and the Philippines contribute the most to aquaculture production in Southeast Asia at 23-42% and 20-45% of the total production from aquaculture, respectively (**Fig. 39**). With the increasing demand for fish and fishery products coupled with the dwindling supply of wild aquatic resources, aquaculture has been projected to compensate the declining fishery production and considered a reliable solution to food security problems. However, as aquaculture production intensifies, a lot 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 broodstocks 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 (Chua *et al*., 1989; Iwama 1991; Beveridge *et al*., 1994; Naylor *et al*., 2000; Primavera, 2006). Efforts have been done by the countries in the region to increase production and at the same time minimize impacts of aquaculture on the environment.

5.5.1 *Status, Issues and Concerns*

The many advantages of aquaculture provide a strong and credible argument for its continued implementation. Aquaculture continues to provide valuable food supply and economic support for many countries. However, the industry has its own share of problems that need to be addressed, the most important of which is its impact on the environment. In order to limit the potential negative

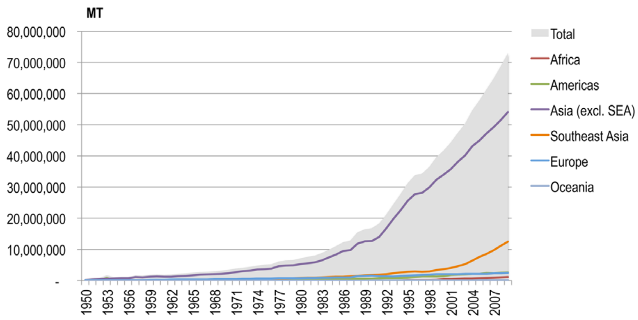


Figure 38. Aquaculture production from 1950 to 2009
*(**Source:** FAO database)*

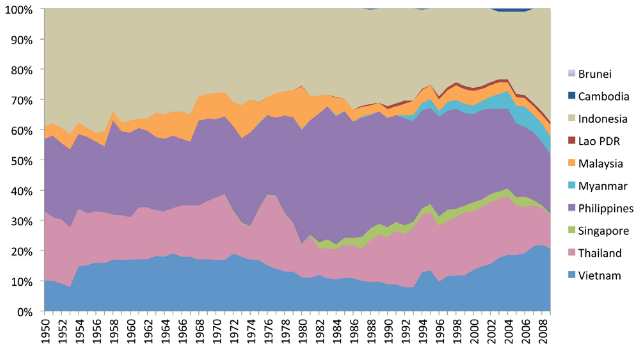


Figure 39. Contribution (%) of Southeast Asian countries to aquaculture production of the region from 1950 to 2009
*(**Source:** FAO database)*

environmental impacts of aquaculture effluents, studies are being conducted, policies and laws are being formulated, and there is a concerted effort of the scientific community, academe, policy makers, farm owners, and government authorities to come up with approaches that could 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 basic approaches 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). In addition, treating farm effluents prior to discharge; limiting the concentration of specific dissolved/suspended inorganic/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 time period; 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 time period; 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; banning the use of certain chemicals and antibiotics; prescribing minimum feed performance criteria; requiring the use of specific Codes of Conduct, including appropriate Best Management Practices (BMPs) for farm operations; requiring the development of suitable farm/pond sediment management strategies for the storage and disposal of sediments; and/or requiring the implementation of an environmental monitoring program have been suggested by Tacon and Forster (2003). However, most fish farmers still do not follow these approaches at present, and thus, continuing implementation of only some but not most, would mean that the environment continues to suffer.

Coastal aquaculture is a traditional practice in Southeast Asia, and prior to the establishment of SEAFDEC/AQD in 1973, Indonesia has been the top aquaculture producing country in the region (**Fig 40**). Five years after SEAFDEC/AQD was established until 2004, Philippines led the Southeast Asian countries in terms of aquaculture production. However, as aquaculture development in the region accelerated, it has created negative environmental impacts. As one of the leading institutions for aquaculture research and development in Southeast Asia, SEAFDEC/AQD needs to continue developing management measures to mitigate deteriorating coastal water quality and the adverse environmental impacts of aquaculture development, important issues that have become a matter of urgency to the Southeast Asian region.

Among the coastal ecosystems, mangroves are the most greatly affected by aquaculture. The positive feedback of aquaculture in boosting production and compensating losses from capture fisheries is usually coupled with negative feedback of converting mangroves to aquaculture ponds. Southeast Asia used to have the widest and the most diverse mangroves in the world but between 1980 and 2005 it suffered a decline of more than 26% (Spalding *et al*., 2010), where most of the losses were due to conversion of mangrove areas into milkfish and shrimp ponds (Naylor *et al*., 2000). Looking at the countries as major contributors to aquaculture production in Southeast Asia, Indonesia which had the widest mangrove cover worldwide (Giri *et al*., 2010; Spalding *et al*., 2010), began large-scale mangrove conversions for extensive milkfish ponds called tambaks, as early as the 1950's (Fast and Menasveta, 2003). The country reportedly converted 269,000 ha of mangroves to shrimp ponds between 1960 and 1990 (Harrison and Pearce, 2000 in Thornton *et al*., 2003) and which remains a major threat to its mangroves (Spalding *et al*., 1997).

From 1951 to 1988, almost half of the 279,000 ha of Philippine mangroves were developed into culture ponds with 95% of brackishwater ponds in 1952–1987 derived from mangroves (Primavera, 2000). From 1975 to 1993, the mangrove area in Thailand was halved from 312,700 to 168,683 ha. Mangrove conversion for shrimp aquaculture began in 1974 but accelerated in 1985 when shrimp farm areas expanded from 31,906 to 66,027 ha and number of farms increased from 3,779 to 21,917 in 1983-1996 (Barbier, 2003). Vietnam has reportedly lost more than 80% of its mangrove forests over the last 50 years and shrimp aquaculture is considered to be the greatest threat to the remaining mangroves (Thornton *et al*., 2003). These conversions result in loss of goods and ecosystem services generated by mangroves including plant and wood products, provision of nursery habitat, coastal protection,

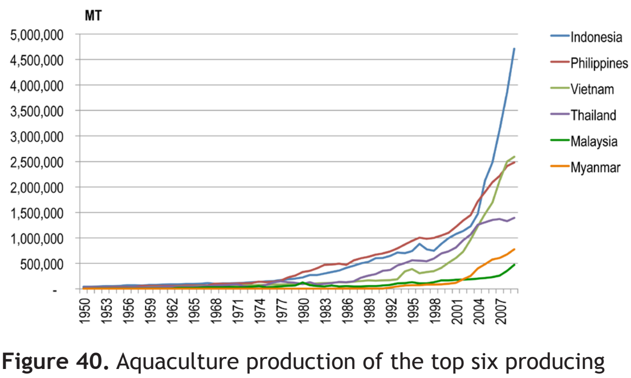


Figure 40. Aquaculture production of the top six producing countries in Southeast Asia from 1950 to 2009
*(**Source:** FAO database)*

flood control, sediment trapping and water treatment (Macnae, 1968; Bandaranayake, 1998; Ewel *et al*., 1998). In Southeast Asia, mangrove-dependent species account for roughly one-third of yearly wild fish landings excluding trash fish (Naylor *et al*., 2000). A positive relationship between fish and shrimp landings and mangrove area has been documented in Indonesia (Martosubroto and Naamin, 1977), Philippines (Camacho and Bagarinao, 1986) and Thailand (Barbier, 2003). 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.

The impacts of aquaculture on biodiversity are rarely positive, sometimes neutral, but usually negative to certain 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 of 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 (Macnae, 1968; Alongi, 2002). The interdependence of mangroves with sea grass beds and coral reefs is apparent in the movement of fish and other organisms observed between these three adjacent systems (Gillanders *et al*., 2003; Sheridan and Hays, 2003). Losing one of these habitats will affect all three ecosystems and everything that dwells in them. Aside from habitat modification, unregulated collection of broodstock and wild seeds for use in aquaculture facilities may eventually threaten the wild population. The same could also happen to fish species harvested for use in fishmeal and fish oil production. Regardless of purpose, indiscriminate harvesting of wild stocks has negative impact on biodiversity.

As the world's fastest growing agriculture industry, 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 systems employed and aquatic environment utilized (Tacon and Forster, 2003). Aquaculture wastes are mostly derived from excess feeds and fecal matter, and continuous discharge of wastewater without treatment could result in a chain of undesirable events, that include 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; and sometimes disease outbreak. Moreover, inadequate handling of wastewater has serious consequences for human health, the environment and economic development (Cao *et al*., 2007). This past decade, fish kills have been a recurring phenomenon in the Philippines. The most serious among the recent ones was in Taal Lake, Batangas last 28 May 2011 which resulted in the death of about 752.6 MT of fish with an estimated value of US$1.3 million. Fish kills in the country have been attributed to eutrophic waters and algal bloom (Azanza *et al*., 2005; San Diego-McGlone *et al*., 2008) which could be linked to uncontrolled proliferation of fish pens and cages to more than double the allowable limit (Yap *et al*., 2004; San Diego-McGlone *et al*., 2008).

Aside from wastes, 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. The excessive 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 such as tetracycline, oxytetracycline, oxolinic acid, furazolidone, and chloramphenicol have also been used excessively the result of which could lead to the development of bacteria-resistant populations (Tendencia and de la Peña, 2001; Hoa *et al*., 2011).

5.5.2 Challenges and Future Direction

There is an urgent need to change the present aquaculture practices in order to minimize its environmental impact and preserve the remaining habitats which may eventually be affected as aquaculture continues to intensify. Aquaculture had intensified because of diminishing wild stocks, but there are other ways of replenishing depleted stocks, such as regulating the fishing effort; restoring degraded nursery and spawning habitats; or enhancing the stocks (Blankenship and Leber, 1995).

In the case of aquaculture, habitat rehabilitation or restoration should be more focused on mangroves which suffered most because of pond construction. The review paper of Ellison (2000) suggested that although most of the objectives of restoration projects were for forest products, coastal protection and stabilization, two Southeast Asian countries have set their goals for maintenance or sustainability of fisheries (Malaysia) and provision of habitat for wildlife (Vietnam). Rehabilitating nursery habitats is 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 in the Philippines (Walton *et al*., 2007) and mangrove recolonized abandoned pond in Dumangas, Iloilo also in the Philippines (Lebata-Ramos, unpublished data).

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, which are the augmentation of scallop fishery in Hokkaido, Japan causing a four-fold increase in annual harvests; and the 20-year shrimp release program in China which achieved a 7 to 10-fold return of investment. The success in stock enhancement depends on setting the management goals and identifying the right species for release. Once these are determined the ten essential components of a "responsible" enhancement program suggested by Blankenship and Leber (1995) can be distilled into three critical issues, namely: 1) understanding the nature of the system or the habitat for release; 2) producing robust, compatible individuals for release; and 3) evaluating the effects of releases (Blaylock *et al*., 2000).

Most stock enhancement activities have failed because of lack of proper habitat for released juveniles. Stock enhancement can be very effective if accompanied with habitat restoration because it will be of no effect in situations where recruitment is limited by the 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 fisheries resources due to overfishing, the impact of adding juveniles which is aimed at improving production of the 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). Contrary to most beliefs, mangroves and aquaculture are not necessarily incompatible (Primavera, 2006). Marginal coastal sites such as denuded and over-exploited mangrove areas and unproductive or abandoned fishponds can be made productive and economically profitable through aquasilviculture, the integration of aquaculture with silviculture or 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 (Triño and Rodriguez, 2002; Primavera *et al*., 2010) in the Philippines; mariculture in Taiwan (Su *et al*., 2011); shrimp-mangrove farms in Vietnam (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. A forestry program was initiated in Indonesia by the state forest enterprise in 1976 integrating forest management with fish production. Popularly known as the 'tumpang sari', the program allows for crops to be grown while protecting the forest and optimizing land use, filling 80% of the ponds with trees and leaving 20% for fish production (Adger and Luttrell, 2000). Aside from integrating aquaculture into the mangroves, culture species, *i.e.* seaweeds, mussels and oysters, and fish can also be reared in mangrove waterways.

The concept and practice of integrated aquaculture is well-known in inland environments in Asia, but much less reported in the marine environments. In the recent years, the idea of integrated aquaculture has been often considered a mitigation approach against the excess nutrients/organic matter generated by intensive aquaculture activities particularly in marine waters. Integrated marine aquaculture can cover a diverse range of co-culture/farming practices, including the integrated multitrophic 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, improved water quality, prevention of diseases, habitat conservation, or increased allowable 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 MT of fish, 50 MT of bivalves and 30 MT fresh weight of seaweeds or 55 MT of sea bream or 92 MT of salmon, with 385 or 500 fresh weight of seaweeds, respectively, without pollution. 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 which appears to be economically and environmentally sustainable.

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 impacts 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 farmers and also minimize aquaculture wastes (Kolsäter, 1995). Among the best management practices (BMPs) related to feeding management, Boyd (2003) suggested that fertilizers should be used only as needed especially to maintain phytoplankton blooms. Moreover, it is also important to use high quality and water stable feeds that contain only the required amount of nitrogen and phosphorus than necessary; and apply feeds conservatively to avoid overfeeding and to assure that as much of the feed is consumed as possible. Feeding may be also improved through the use of automatic feeder and by employing compensatory feeding. An experiment involving three automated feeding systems gave FCRs of 0.94, 0.93, and 1.05, providing good control of feeding and helping in the improvement of feeding efficiency (Myrseth, 2000).

In a feeding experiment on *Pangasius bocourti*, there was no significant difference in the final weight among the five groups tested indicating complete compensation in the fish experiencing restricted feeding. Improved feed conversion efficiency was experienced in the juveniles of *P. bocourti* when restricted feeding was conducted (Jiwyam, 2010). Atlantic halibut reared on a repeated 5/10 week starvation/re-fed regime for 3 years led to full growth compensation, higher feed conversion efficiency, lower male maturation, and improved flesh quality (Foss *et al*., 2009). In one of the compensatory feeding experiments conducted by SEAFDEC/AQD, biomass of milkfish reared in brackishwater ponds and fed every other day was comparable to stocks fed daily resulting to one-half of the usual FCR and 50% savings on feed inputs (de Jesus-Ayson, unpublished data). Based on these results, feeding regimes may be manipulated in such a way that feed inputs to the environment may be minimized without sacrificing production.

Aquaculture may be the ultimate solution to the problem of dwindling fishery production. Since most of the time, aquaculture does nothing good to the environment, and in order to compensate the diminishing fishery production and meet the demands of fishery products for the human population which continue to grow, aquaculture must be redesigned to minimize its impact on the environment and make it more environmentally and at the same time economically sustainable. Scientific studies on how aquaculture has destroyed habitats, polluted the waters, threatened non-target species, and a long list of other impacts; and how aquaculture should be done to make it sustainable and environment friendly are readily accessible. However, despite the easy access to such information, aquaculture continues to pollute the environment. Therefore, 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 and enforced in order to achieve the goal of having a better and cleaner environment in the future.

6. ADAPTATION AND MITIGATION OF THE IMPACTS OF CLIMATE CHANGE

Capture fisheries and aquaculture are the most beneficial livelihood sources in coastal communities. However, the sustainability of these sources is being subjected to various threats and pressures especially during the past decades. In the advent of these serious fisheries and aquaculture concerns coupled with environmental changes, the people's dependence on fisheries in the Southeast Asian region for economic growth is in question. Considering that nowadays, extreme meteorological events have increasingly occurred with frequent and more severe manifestations. Therefore, it is valid to analyze how people involved in fisheries react and adapt to existing climate fluctuations (Daw *et al*., 2009). It is noteworthy that climate change affects fisheries and aquaculture directly by influencing the fish stock and the global supply of fish consumption, or indirectly by influencing fish prices or the cost of goods and services required by fishers and fish farmers (WFC, 2007).

In particular, strategies and interventions to mitigate the effects of climate change to the fisheries industry should be established. In aquaculture for example, the impacts of climate change to the various culture, and its effect to the cultured species and their vulnerability to the environmental changes as well as to the wild stocks targeted by capture fisheries, should be assessed. Environment friendly strategies to lessen the sectors' impacts to the environment should also be developed, which also pertains to the efforts to reduce the carbon footprint of fisheries. These efforts should be taken with serious consideration considering that many peoples in the Southeast Asian region are increasingly dependent on the fishery resources as evidenced in the per capita consumption that reached a new all time high (FAO, 2010a).

Since these resources come mostly from our vulnerable coastal areas, it is therefore important and urgent to integrate fisheries management in resource exploitation with the objective of ensuring sustainable utilization of the very important resources, protecting vulnerable areas and species, and eventually mitigating the effects and ensuring the stakeholders' adaptation to climate change.

6.1 Vulnerability of Coastal Habitats

It is most certain and widely recognized that the effects of climate change are (but not limited to) sea-level rise, seasonal monsoon/rainfall variations, increased and stronger incidence of storms and typhoons, increased land-based run-offs, and sea-surface temperature (SST) rise. These effects highly influence the productivity of the coastal habitats where most of the fishery resources are confined. The Southeast Asian region has been considered as one of the most vulnerable areas to environmental variations caused by climate change because of its long coastlines and dependence in seasonal monsoon patterns, and where most coastal dwellers depends on fisheries for sustenance (IPCC, 2007 as cited Santos *et al*., 2011). In addition, poverty is still recognized as widespread in the Southeast Asian region especially along coastal communities (FAO, 2010a) where the people in these communities are most vulnerable to environmental changes brought about by climate change. At certain degree, habitats exhibit minimal natural recovery responses to climate change, but constant pressure from other anthropogenic activities and natural calamities hardly presses their integrity and recovery.

In coral reef ecosystem, SST 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, *e.g.* Andaman Sea and Aceh, Indonesia in 2010. The level of recovery in the coral bleaching events varies depending on the subsequent water physical conditions, availability of spats and food resources for corals to feed. 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 the most direct impact to these habitats and will dictate mangrove landward migration (Gilman *et al*., 2007). Likewise sea grass beds are affected by SST rise particularly impinging on the plant growth and other physiological functions. Distribution pattern of aquatic species would most likely shift due to temperature variations and sea-depth. Changes in terms of productivity in deeper areas will also be manifested (Short and Neckels, 1999).

6.2 Impacts of Climate Change on Capture Fisheries

Climate change is modifying the distribution and productivity of marine and freshwater aquatic species (**Appendix 5**) and is already affecting biological processes and altering food webs (FAO, 2009). Since fish are cold blooded animals, their adaptive capacity to the environment is highly affected by changes of 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 by Santos *et al*., 2011). Fish may tend to move to cooler tolerable waters thus changing their migratory patterns and known availability. This has been observed on migration of skipjack tuna, an economically important tuna species in the Coral Triangle area, which move to cooler Central Pacific region thus making a decline of stocks in this region (Alcala, 2010 as cited Santos *et al*., 2011).

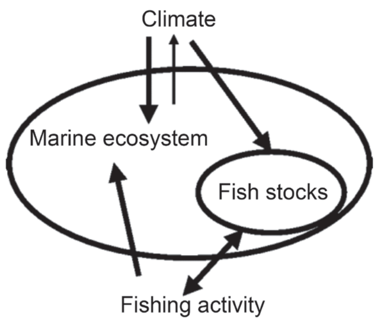


Fig. 41. Schematic representation of the impacts of climate change and fishing activity on the marine ecosystem and its fish component
(***Source:*** *http://www.pnas.org/content/104/50/19709.full)*

Changes in the distribution through migration (either spawning and/or feeding) of stocks will ultimately affect the ability of fishing to detect target species at certain place and time. Other profound effect to stocks is the availability of food which could already affected by climate change. Warming of sea surface deepens the thermocline layer and disrupts the upwelling due to SST, and warming could likely influence primary productivity. In addition, ocean acidification affects the formation of calcium-carbonate phytoplankton shells and skeleton which are primary elements of the ocean's food chain.

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. Salinity changes in the coastal waters also encourage species re-distribution but the net effects on fisheries yields are unlikely to be significant as shown in **Fig. 41** indicating the representation of impacts of climate change and fishing activity on the marine ecosystem and its fish components.

6.3 Impacts of Climate Change on Aquaculture Development

As aquaculture requires water as culture media for its operation, any climate change however short term will have an impact to the overall operation. In particular, changes in water temperature could influence stocks growth rate and metabolism prolonging period of culture and increase production inputs. The variability of weather conditions, prolonged hot conditions, intense/stronger storm surges are just but a few that would most likely influence fish stocks vulnerability. 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. Rising sea level poses great threat to the pond production system in the estuarine environment by flooding the land. Among the possible effect is water would have low carrying capacity which means lower productivity for aquaculture operation. Higher temperature will reduce oxygen solubility in water but raise the oxygen and food demand of fish following increased metabolism. Associated rise in gill ventilation rates can lead to increased uptake of aquatic pollutants, rendering the fish unfit for human consumption. Higher water temperatures can also favor the multiplication and survival of bacteria and parasites. 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.

6.4 Adaptation Strategies

SEAFDEC has been implementing programs for adaptation and mitigation of the effects of climate change in the Southeast Asian region, while the SEAFDEC Member Countries have also initiated individual efforts to lessen the impacts of climate change. 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 Member Countries through ASEAN Fisheries Consultation Forum (AFCF) has consolidated all activities to be implemented that are aimed at mitigating the impacts of climate change. The countries in the region have also widely recognized the concept of Climate Change Adaptation and that development of mitigation strategies should at all time be integrated in every fishery related programs and frameworks. Participatory approach in vulnerability assessment of climate change in coastal communities should be considered a simple device yet practical technology in the conduct of vulnerability assessment and simulations. Since environmental changes and seasonal variations are best observed at the people's level, local knowledge would come handy and helpful in formulating strategies for adaptation.

Furthermore, awareness programs on the short- 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 fisherfolks should also be considered. Provision of other means of income among artisanal/subsistence fishers gives them opportunities and lessen their dependence on fishing, thus, lessen their vulnerability to environmental changes. Risk reduction among fishers working in harsh offshore conditions as well as the small-scale fishers in coastal waters is crucial. Likewise, governments should exert efforts to strengthen adaptive measures and provide safety at sea tools to fishers. Thus, wide range, reliable, accessible and up to date meteorological services should be in place in the Southeast Asian countries. Resource enhancement and rehabilitation activities should also be continued and appropriate strategies should be widely promoted in the Southeast Asian region.

In aquaculture, research and development initiatives should respond to the impact of climate change. In particular, assessment of culture media to the effect of climate change and development of adaptation strategies should be encouraged. Current researches should also gear towards culture stocks/strain development focusing on wider tolerance stocks to environmental changes. Alternative feed sources for aquaculture should be sought to lessen dependence to fishmeal. In particular, to lessen the impact of climate change on aquaculture activities, countries could implement appropriate action plans to safeguard the respective national aquaculture industry. Such action plans could include: a) regular monitoring of water quality parameters within aquaculture zones; b) study the impact of water parameter change to dynamic of growth and survival of traditional aquaculture organisms; c) conduct programs on domestication and selective breeding for aquaculture species; d) highlight and encourage land-based and indoor-closed system aquaculture operations; and e) implement surveillance and coordinating with meteorological department on weather changes for early warning adaptation and improve safety at sea standards for fishing operations.

6.5 Reducing Carbon Footprints from Fisheries

It has been a global consensus and concern that dependence on fossil fuels/non-renewable energy sources should be significantly reduced in the coming decades by tapping alternative and renewable energy sources. In addition, it has been widely and universally recognized that emerging climate change issues need immediate actions. At the global scene, technologies in fishing operations as well as reliance to fossil fuel had advanced in leaps and bounds, thus it may be deemed necessary to consider the impacts of climate change and the mitigation structures/strategies in the context of the fisheries sector. Through SEAFDEC, the fisheries and aquaculture sectors could strengthen their efforts to reduce carbon footprints to mitigate environmental impacts which lead to climate change. As reported, there are various ways of reducing fishing boats' carbon footprints: reduce fossil fuel consumption and/or offset footprint by compensating with other fishing activities (Bundit, 2011). Moreover, it is as 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, 2011b).

Specifically, several projects have already been initiated in the Southeast Asian region concerning measures to reduce fossil energy dependence in capture fisheries. The project of SEAFDEC on Responsible Fishing Technologies and Practices or "Fishing in Harmony in Nature" has been promoting the use of sails in fishing operations. Moreover, SEAFDEC/TD has been conducting studies to determine the ways and means of reducing the use of fossil fuel in fisheries which include improvement of designs of boats/vessels, and increasing engine efficiency which also entails gear modifications. In terms of alternative/less inflicting energy sources, the use of biofuels which have lesser impact than other fossil fuel has also been considered for promotion in the region's capture fisheries.

Concerns related to energy use in fisheries had become critical in the region, thus, policy intervention at the regional level would be necessary to address common interests in sustaining the fisheries industry in the midst of environmental challenges. In an attempt to address these concerns, the ASEAN developed the Plan of Action in Regional Energy Policy and Planning (APAREPP): 2010-2015, which aims to enhance national policy and planning activities of the ASEAN countries for integration into a cohesive and effective regional policy analysis and planning towards sustainable development. Moreover, SEAFDEC on its part would continue to promote alternative energy sources for both capture fisheries and aquaculture, support the use of energy savings and environment-friendly fishing technologies and sustain its projects on the reduction of the use of fossil fuel in fisheries (SEAFDEC, 2010d). Involvement of and awareness raising in the private sector should also be enhanced which will ultimately reduce the impacts while relevant programs should be promoted in collaboration with other institutions including the academe, NGOs, research institutions, especially in developing advocacies relative to minimizing the contribution of fisheries to climate change. To list a few, some specific strategies that could be adopted to address climate change could include: 1) reduce heavy dependence on oil by tapping alternative energy sources; 2) promote energy efficiency among industries and the private sector; 3) implement public awareness programs by government agencies and NGOs towards promoting energy efficiency, recycling and use of public transport; and 4) maintenance effective forest management and conservation.

7. HUMAN RESOURCES IN FISHERIES

7.1 Status of Human Resources in Fisheries

While moving towards global competitiveness, countries in the Southeast Asian region have confronted with issues and challenges that threatened sustainable development of fisheries. In view of such challenges, the availability of qualified human resources in relevant subjects and disciplines is envisaged to be one of the very crucial prerequisites for sustainable development and management of fisheries. In order to obtain information on the current status and gaps in human resources of countries in the region particularly in the government sector, a survey on the "Existing Human Resources and Expertise in Fisheries in the ASEAN Member Countries" was undertaken by SEAFDEC in early 2010. The questionnaire used during this survey primarily sought information on the availability of expertise in the areas of fisheries biology, capture fisheries, fisheries management, aquaculture, fisheries post-harvest, laws and legislations, cross-cutting issues, etc., in different gender and age groups. The inputs from countries, although doesn't cover the whole dimension of human resources profile, indicated the tendency in inadequate human resources in several subject areas (**Box 4**).

It could be said that during the past decade, human resource expertise in fisheries in most countries have been moving towards those that provide higher economic benefits, such as aquaculture, post-harvest and processing enterprises, etc.; as well as subjects that caught attention from policy makers/planners such as fisheries management and governance. In contrary, there are tendencies in shortage of human resources in some fundamental subjects, such as fisheries biology, laws and legislation, as well as the cross-cutting and emerging issues/challenges. It is therefore necessary for countries in the region to further review and form a clear picture of the current availability and gaps of relevant expertise and human resources, and come up with strategies to balance the availability of human resources in wide ranges of disciplines in responding to their respective future requirement.

In addition to the tendency in shortage of expertise in some fundamental fisheries-related subjects, many countries in the region also faced the problem that most of the young generations had shown no interest to engage in the activities, particularly capture operations. The situation is specifically more serious under the situation where fishery production and catch has continuously declined with the degradation of fishery resources, and the drastic increase in fuel price. In some localities, only those that have no better job opportunity choose to become fishers, resulting in a tendency in increasing average age of fishers. These

Box 4. Fisheries Human Resource: Gaps and Requirements of Southeast Asia

From the survey conducted by SEAFDEC in 2010, based on the information provided by countries, namely Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines Singapore and Thailand, the available human resources in fisheries in the region and the gaps and areas where expertise were limited had been identified. In general, observation could be made that the available expertise in fisheries was higher for men than women in all countries; and there are only few areas where expertise was higher for women, specifically on post-harvest and trade. However, this was mainly due to the nature of most of the tasks that may suit more for men, particularly those on capture fisheries, aquaculture and fisheries biology.

In most countries, the areas where very high number of human resources with expertise was observed were aquaculture, fisheries management and capture fisheries; while the areas where scarcity of expertise was clearly found especially in the government sector were fish taxonomy, population dynamics, ecology, limnology, etc. Other important areas where expertise is available at certain levels but inadequate were laws and legislation, particularly on international cooperation and marine affairs and fisheries laws/regulation, especially for the less developed countries such as Cambodia and Lao PDR; and the cross-cutting issues, such as those on fisheries information and statistics, fisheries and food security and poverty alleviation, and climate change. The limited availability of human resources in these areas is envisaged to create impact to the development of fisheries in a long-term basis, especially under the situation where several issues and challenges have emerged from the global arena.

Under the same survey, countries also provided recommendations on actions that should be taken in order to enhance the capacity of existing human resources and ensure the availability of human resources in fisheries in the future.

The recommendations could be summarized as follows:

At national level, governments should:

- Establish clear policy and plans in ensuring long-term sustainability of human resources;
- Encourage officials to be involved in relevant national/ international workshops, conferences to enhance their knowledge and expertise;
- Carry out measures to acquire expertise in areas where there are currently gaps, by supporting the existing staff in building up their knowledge and capacity in the areas outside their current expertise; and consider recruiting new staff with relevant expertise; and
- Ensure the future availability of qualified human resources particularly for the areas where shortages of expertise are envisaged, through the development of appropriate curriculum in collaboration with fisheries-related academe, and provision of scholarship or research funds on the required scopes.

At the regional level, organizations relevant to fisheries should:

- Conduct regional training programs to support human resources development activities for the existing fisheries-related officials of countries based on their priorities and needs;
- Convene technical events such as consultations, workshops, symposia and conferences to provide opportunities for officials from countries to exchange views and expertise;
- Develop and facilitate exchange programs for the region's researchers and national/regional experts;
- Conduct research activities of mutual interest in collaboration with Member Countries; and
- Arrange study visits for government/non-governmental sectors and other related stakeholders to enhance their experiences and knowledge in the required disciplines.

Sources: *SEAFDEC, 2011*

insufficient human resources situation if continued are envisaged to eventually create extensive impacts to the capacity of the fisheries sector in providing food supply and sustaining the future food security requirement.

7.2 Strategy for Human Resource Development in Fisheries in the ASEAN Region

In order to clarify the role of human resource development for sustainable fisheries development, the ASEAN Member Countries in 2004 in the midst of the implementation of the Resolution and Plan of Action adopted in 2001, also approved the "Strategy for Human Resource Development in Fisheries in the ASEAN Region" (**Box 5**). The development of the "HRD Strategy" was based on principles that: 1) the promotion of HRD in fisheries

Box 5. Strategy for Human Resource Development in Fisheries in the ASEAN Region

To ensure long-term support to human resource development (HRD) in fisheries in the ASEAN region, recommendations were made as follows:

1) Regional collaboration should be strengthened to improve HRD activities at the national level;
2) Scope of HRD requirements including objectives, target groups/areas and levels will be identified in accordance with the Resolution and Plan of Action;
3) The development of human resource capacity should not only be on technical issues but also integrate social, environmental, legal, and other issues as identified in the Resolution and Plan of Action;
4) The ASEAN Member States should conduct awareness building activities to obtain cooperation/compliance of private sector on the issues, including national requirements for sustainable fisheries;
5) The ASEAN Member States may conduct HRD activities to introduce new technology to private sector, through consultation/collaboration with the intended beneficiaries;
6) HRD activities directed towards competency/skill-based training relevant to the current fisheries situation and demands of industry can be promoted where resources and mechanisms are available;
7) Each ASEAN-SEAFDEC Member Country should conduct an inventory of programs for HRD in fisheries that contain essential and usable information from fisheries-related agencies and HRD programs operated by relevant institutions, including universities. Based on this inventory, a regional database can be established and regularly updated to provide a basis for networking in HRD in fisheries;
8) The ASEAN-SEAFDEC Member Countries and international/ regional organizations should use the inventory and networking to identify gaps, avoid duplication of effort and ensure complementarity of HRD activities;
9) Partnership and regional cooperation, including South-South Cooperation, exchange of expertise at national and regional levels, international/regional organizations, among external funding agencies, government authorities and academe, should be developed by fully mobilizing the inventory and networking;
10) Cost-sharing mechanisms (either cost-recovery or cost-sharing) should be encouraged to enhance the ownership and effectives of HRD programs in the ASEAN Member States; and
11) Regular monitoring and assessment of regional HRD activities should be conducted as part of the implementation of programs under the ASEAN-SEAFDEC Fisheries Consultative Group (FCG) mechanism.

is primarily a national concern, and national capacity and resources are mobilized for maximum impact; 2) where there is insufficient capacity and/or resources available at the national level, bilateral and regional, and/or external supports should be sought; and 3) Regional HRD activities could be conducted on common needs to maximize the use of resources and benefits of the countries.

Along the line with the "HRD Strategy", and recognizing that disparity of the social and economic well-being among/within the most of the Member Countries can be the one of the serious constraints to further promote the countries' development; SEAFDEC during 2008-2010 undertook a project on "Human Resources Development on Poverty Alleviation and Food Security by Fisheries Intervention in the ASEAN Region". The project aimed to enhance human capacity of fishers of selected rural fishery communities as well as relevant fisheries government officials and those working at the local level in support of fishery communities in order to alleviate the identified poverty status through fisheries intervention.

Under different thematic areas, *i.e.* Local/indigenous institution and co-management; Responsible fishing technologies; Backyard fishery post-harvest and processing; Rural aquaculture; and Inland fisheries development, activities were undertaken to identify technical issues that were critical for the poverty alleviation, develop HRD modules/materials, and conduct train-the-trainers as well as on-site training activities. Through the implementation of these activities, the post-training observations and recommendations were made to ensure success in extending future HRD program as shown in **Box 6.**

Box 6. Observation and recommendations from the Project on HRD on Fisheries for Poverty Alleviation

Recommendations were made to ensure success in extending HRD program at the local/national levels as follows:

- Training materials should be simplified and translated into national languages (or local languages), and the successful participants should be invited as resource persons to share their experiences with others;
- Close communication among resource persons and participants should be encouraged to ensure that the training topics and arrangements would address the problems and predicaments;
- Sufficient time should be allocated for both lecture and hands-on sessions;
- On-site training course should be followed-up by a series of training courses facilitated by extension officers in the fishing community;
- Fishery extension officers should strive to improve their knowledge and skills, not only in the technical fisheries aspects but also in extension techniques and strategies;
- National fishery agencies should have a vibrant extension program that include all aspects of responsible fishing and aquaculture, post-harvest and fish processing, fishery resources management, market development and trends, environmental issues, and socio-economic attributes of rural fishery development;
- National fishery agencies should coordinate with the provincial and local government units in disseminating up-to-date information related to aquaculture technology, market, environment especially on climate change, and government policies; and
- HRD initiative should be expanded into institutional capacity building activity where the staff of local institutions is regularly trained on the latest technologies.

7.3 Way Forward

In order to ensure the long-term sustainability of fisheries development initiatives, it is recognized that the availability of human resources in wide ranges of fisheries-related subjects and disciplines is very crucial. Taking into account the recommendations made during the survey conducted by SEAFDEC, countries in the region should therefore consider establishing clear policy and plans in ensuring long-term sustainability of human resources, and exerting efforts to ensure the future availability of qualified human resources particularly for the areas where shortages of expertise are envisaged. These could be done through the development of appropriate curriculum and training modules in collaboration with fisheries-related academes, and provision of scholarships or research funds specifically on the required scopes, etc.

In addition to the initiatives at national levels, in the regional perspective, regional training programs, consultations, workshops, etc., should also be initiated to support human resources development activities and facilitate the exchange of views and expertise, based on the countries' priorities and needs. Exchange program or collaborative researches could also be promoted to facilitate the collaboration and exchange of expertise, particularly in the areas where expertise may be strong and available in some, but insufficient and weak in other countries.

Human resources development in fisheries is an important area that every country and relevant organization should not overlook. It is very crucial that cooperation and concerted efforts are made to ensure the availability of capable and knowledgeable people, and the long-term sustainability of fisheries in the region.

PART III
Outlook of Fisheries and Aquaculture for the Southeast Asian Region

The launching of an ambitious task to build the ASEAN Community by 2015 had been supported jointly by the Southeast Asian countries. Being aware of the consequences and advantages that could emanate from the integration of the fisheries sector into the three pillars of the ASEAN Community, the ASEAN countries should have to ensure that socio-economic considerations are being dealt with accordingly within the fisheries sector. Moreover, policy mechanisms for national institution building should also be put in place considering that by 2015 the ASEAN would be transformed into a region with free movement of goods, services, investments, and skilled labor as well as free flow of capital. In so-doing, the countries should be able to address the prevailing issues which could include social, economic, environmental, and political considerations through the implementation of programs and activities guided by the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020.

1. Rising to the Challenges and Opportunities from the Establishment of the ASEAN Community: Fisheries and the People Involved

Management of the natural resources including aquatic resources, fisheries management and the importance of properly managing important coastal and inland environments/habitats as well as maintaining protective geographical features remain key important concerns that should be addressed now and in the foreseeable future, especially in the Southeast Asia region and among the ASEAN countries. These concerns should be considered from the perspective of poverty reduction and the need to maintain a socially sound, economically balanced and sustainable development, based on a healthy and productive environment in the ASEAN region while living up to the expectations of an ASEAN Community by 2015. This would mean reversing the present trend of environmental degradation and depletion of aquatic resources, and enhancing the social well-being and working conditions of people involved in fisheries and related activities, where specific attention should be given to management of fishing capacity (large- and small-scale operations) including labor and safety aspects as well as the status of migratory fishworkers comprising both men and women.

Equally, this also implies the need to maintain a resources-based equilibrium between the growing demand for fisheries and aquatic products with the available supply, in other words, to balance conservation needs with sustainable exploitation levels of the fishery resources. It is very important consider the contribution of fisheries to economic growth and to food security and livelihood of the people. Attaining food security is tantamount to ensuring sustainability in fisheries, which requires that countries in the region should put together their efforts in improving fisheries governance and sustained endeavors in conservation and rehabilitation of the natural resources, where people will not go hungry if they know how to fish responsibly.

Looking towards the establishment of the ASEAN Community by 2015, the ASEAN countries should strengthen national institutional and policy mechanisms to be able to incorporate the requirements of the three “pillars” as indicated in the three “Blueprints” developed by Member States which are meant to facilitate the efforts needed to establish the ASEAN Community by 2015. These three pillars are the ASEAN Political-Security Community, ASEAN Economic Community, and the ASEAN Socio-Cultural Community. The requirements for Member States, and information to the “global community”, are further defined in three “Blueprints”, namely ASEAN Political-Security Community Blueprint, the ASEAN Economic Community Blueprint, and the ASEAN Socio-Cultural Community Blueprint.

As anticipated, by 2015 the ASEAN region would be characterized by having a single market and production base with free flow of goods, services, capital investment, and skilled labor; being a highly competitive economic region with equitable economic development; and being fully integrated into the global economy. This is therefore an opportune time for the countries of the region to boost the performance of their respective fishery sector by enhancing connectivity in terms of physical infrastructures such as land and marine transportation systems in order to facilitate the flow of goods like fishery products within and outside the region, and promote cross border trade thereby improving their respective economies. However, some of the adverse impacts of the integration of fisheries into the ASEAN Community should be taken into account, which could include increased competition of fishery products, trans-boundary transfer of aquatic resources, and increased pressure to the fishery resources. The countries should therefore take a closer look at these issues in order to mitigate the possible impacts that could take place in the fisheries sector in the coming decades.

2. Growing Demands of Fisheries that Challenge Food Security

In June 2011, the ASEAN and SEAFDEC organized the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment" with the main objective of paving the way for the sustainable development of fisheries and enhance the contribution of fisheries to food security of the Southeast Asian region towards the coming decade. During the Conference, the ASEAN-SEAFDEC Ministers responsible for fisheries adopted the "Resolution" and "Plan of Action" on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020", as important direction in formulating and implementing programs, projects, and activities through the appropriate ASEAN-SEAFDEC mechanisms. These two instruments, the "Resolution" and "Plan of Action", therefore serve as policy guidance for the countries in the region in developing priority actions aimed at attaining sustainability of the fisheries sector in support of international demands.

The tendency of the fisheries sector to maximize the exploitation of resources should be perceived as means of increasing the supply of fish to cater to the rising global demand for food fish and other aquatic products brought about by the increasing global population and enhanced capacity of more people to purchase high value and quality food including food fish. As a result, the sector has gone through a very fast pace of development risking its ability to continue providing stable livelihood to fishing communities while at same increasingly over-fishing the important resources with increasing difficulties to, in sustainable way, supply the requirements of the fishing industry and post-harvest sector. These concerns should be mitigated in order to achieve food security in the Southeast Asian region.

As defined by FAO, food security is attained and is in place when food is available for everybody's access, when people do not go hungry or do not fear of possible starvation, and when all people have physical and economic access to sufficient and safe food at all times. The main aspects of food security could therefore be associated with the availability of nutritionally adequate and safe food including food fish, and the accessibility to such foods through socially acceptable means. Fisheries in the Southeast Asian region had always played the major role of accelerating economic development and generating livelihood opportunities, and in many ways, contributing to the region's food security, considering that

Table 60. Population, fish production and consumption of the Southeast Asian countries

Countries	Population (millions)				GNI PPP [4] Per capita (US$: 2009)	Ave per capita fish consumption [5] (kg/person/year)	2009 Fish Production [6] (metric tons)	% Population below US$2/day [7] PPP 2000/2009
	2009[1]	Mid-2011[2]	2025[3]	2050[3]				
Brunei Darussalam	0.5	0.4	0.5	0.6	-	44.04	2,418	-
Cambodia	14.8	14.7	18.0	22.3	1,820	32.97	515,000	57.0
Indonesia	240.3	238.2	273.2	309.4	3,720	31.43	10,064,140	51.0
Lao PDR	6.3	6.3	7.9	10.3	2,200	24.86	105,000	66.0
Malaysia	28.3	28.9	35.3	43.6	13,710	54.40	1,729,002	2.0
Myanmar	50.0	54.0	61.7	70.8	-	42.75	3,491,103	-
Philippines	92.0	95.7	120.2	150.1	3,540	53.49	5,084,674	45.0
Singapore	*5.0* [8]	5.2	5.8	6.1	49,780	*23.0* [8]	5,687	-
Thailand	65.0	69.5	72.9	71.0	7,640	37.97	3,137,672	27.0
Vietnam	88.1	87.9	100.4	109.3	2,790	41.47	4,782,400	38.0
Southeast Asia	**590.6**	**600.8**	**696.3**	**793.2**	**4,490**	**27.00**	**26,917,096**	**42.0**
World	**6,705**	**6,987**	**8,084**	**9,587**	**10,240**		**145,000,000** [9]	**48.0**

Sources:

1 2009 World Population Data Sheet, Population Reference Bureau, Washington DC, USA

2 Mid-2011 Populations: estimates are based on recent census and official national data. The effects of refugee movements, large numbers of foreign workers, and population shifts due to contemporary political events are taken into account to the extent possible

3 Projected Populations 2025 and 2050: Based on reasonable assumptions on the future course of fertility, mortality and migration

4 GNI PPP per capita 2009 US$: Gross national income (GNI) in purchasing power parity (PPP) divided by mid-year population. GNI PPP refers to gross national income converted to "international" dollars using a PPP conversion factor. Based on World Bank data

5 Fishery Statistical Bulletins for the South China Sea Area (SEAFDEC, 2010); Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)

6 Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2011)

7 Percent of population below US$2 per day: Percentage of population living in less than US$2 per day at 2005 international prices. Based on World Bank data

8 Agri-Food & Veterinary Authority of Singapore

9 The State of World Fisheries and Aquaculture 2010 (FAO, 2010a) the peoples in the region are fish eating by tradition and habits. However, pressure from the growing population and demand for food together with the shifting paradigm in food consumption (fish and other products) could lead to food insecurity in the future. When such situation is not improved, food insecurity in the Southeast Asian region could get worse considering that the region's average per capita gross national income of below US$ 5,000 falls short by about one-half of the world's average of more than US$ 10,000.

Table 60 shows that the world's population increased from 6,705 million in mid-2008 to 6,987 million in mid-2011 and is expected to hit more than 8,000 million in mid-2025 and about 9,590 million in mid-2050. For the Southeast Asian region, the total population increased from 590 million in mid-2008 to 600 million in mid-2011, and by mid-2025 the region's population could reach 700 million and about 800 million by mid-2050. These figures seem to suggest that the demand for food would increase in the next five or so decades with subsequent increasing pressure on most food items, including fisheries and other aquatic products. Considering also the increased capability of more people to spend more on food fish and for health concerns as well as the availability of fish supply, consumption pattern for food fish worldwide has already shifted where more people are now consuming more fish protein than other animal protein – the negative side of this is that poorer groups of people would have less access to fish and aquatic products to sustain food security and their well-being.

From the point of view of the Southeast Asian region, the rapid growth of its population and increasing demand for food is expected to add pressure on the natural resources and increase the dynamism and competitiveness of the multiple uses of water and terrestrial resources. Thus, it will be increasingly necessary for the countries in Southeast Asia to maintain a resources-based equilibrium between fish and aquatic resources and the available resources in order to attain food security. Therefore, the need to balance conservation and exploitation of the aquatic resources through sustainable development of habitat and fisheries should be continued. In addition, in the development and management of fisheries and aquatic resources there is also a need for countries to strike a balance between the contribution of improved fisheries to national economic growth and to food security and improved livelihood among coastal and inland groups of people throughout the Southeast Asian region.

3. Increasing Demands for Environmentally and Socially Sustainable Development of Fisheries and Aquatic Resources in Southeast Asia

Fisheries, marine and coastal habitats, and inland flood plains and wetlands are recognized priority areas for socially just and sustainable development, for the ASEAN and Southeast Asian countries. The common objective of such development is for fisheries and aquatic resources to continue to cater to the needs and requirements of the rapidly growing population including the need to provide broad and diversified income and livelihood opportunities while ensuring future food security for the people. For more than a decade, initiatives have been undertaken to promote the FAO Code of Conduct for Responsible Fisheries (CCRF), a global voluntary instrument that provides a broad framework and guidance for national and international efforts towards sustainability of the fisheries sector. The importance of the CCRF in promoting food security and fisheries sustainability is well recognized by all countries in the Southeast Asian region.

In the 2011 Resolution and Plan of Action which is heavily hinged on the CCRF and in the ASEAN Community Blueprints, several aspects have been identified as priority areas to be promoted in the region. These include sustainable use of fishery and aquatic resources with specific attention which should be given to the importance of integrating or coordinating fisheries management and habitat management. In the process, the importance of managing fishing capacity (large- and small-scale) should be recognized as top priority since this could result in reduced over-capacity, curtailed destructive and illegal fishing, and eventually no IUU fishing.

Many development actions recommended for the coming decade clearly point towards increased attention to social matters and aspects related to poverty reduction, and maintaining a healthy and productive environment. Efforts to mitigate the impacts of climate change and to build up adaptive capacity are cutting across all activities in the region and relate to all sectors. Therefore, all sectors and all segments of society in the region should work together in reversing the trends of environmental degradation and loss of biodiversity, and in securing the means of maintained livelihood for rural (coastal and inland) communities. In addition, improving the working conditions and status of migratory workers/fishers should be addressed with emphasis on the important role of women in local and national development perspectives, the latter being one of the key priorities in the ASEAN Blueprints.

In the entirety of the 2011 Resolution and Plan of Action, and the ASEAN Economic Community Blueprint, it is necessary to enhance governance in fisheries, promote sustainable aquaculture development, and improve the utilization, and safety and quality of fish while at the same time also promote trade and compliance with international trade requirements (quality, equity, traceability, legal status). In other words, all these sum up to the need to undertake initiatives that would reduce practices that impede the sustainable development of fisheries and the aquatic environment, in order that in the coming decades food security could be achieved.

Sustainability of Marine and Aquatic Resources

Marine capture fisheries in the Southeast Asian region have been the major contributor to total fishery production in the region where contributions come from both the larger and smaller scale segments of the sector. The larger vessels which are more urban-based are landing at fishing harbors while the smaller vessels predominantly land at smaller coastal landing sites or on the shore. The smaller scale fishing efforts contribute to the basic livelihood, food security and job opportunities along coasts throughout the region, while contributing a vital part of the rural/coastal social and livelihood structure. Fisheries and the fishing industry are major contributors to income generation, job opportunities and economic development. The larger vessels employ large groups of migratory crewmembers including migrants from other countries. In a similar way, the processing industry in Southeast Asian countries is a major employer with a majority of them constitutes the female workers.

However, sustainability which at present necessitates high level of involvement of people along the coasts and in urban areas is being questioned due to diminishing fishery resources and degradation of stocks coupled with the deterioration of natural habitats which had led to decreased total production from marine capture fisheries in many countries of the region over the past decade. As a consequence, some countries like Thailand for example, imports large quantities of fish and aquatic products to keep canneries and other processing industries going at high capacity.

Under the circumstance where deterioration of fishery resources has taken place, attempts have been made by several countries and relevant organizations in the region to explore new potential fishery resources including demersal and deep-sea resources in order to cope up with the ever-increasing demand for fish. Careful consideration should be given on the fact that fishery resources in these areas could be very scarce in nature. Without adequate information on the status of these resources, effective management mechanism could not be put in place for the sustainable utilization of the resources. In addition, since these new fishing areas may not be easily accessible, the returns that could be derived from exploiting these resources might not be able to cover the operations costs, not even to mention the cost for undertaking the research and exploration activities in the first place.

Improving Governance and Management for Sustainable Fisheries

The rapid and largely uncontrolled development of fisheries throughout the region during the past decades where especially the larger scale fishing operations have increased their share of production, are often in conflict with the needs and rights of smaller fishing communities to fish and maintain their livelihoods as well as their share of the aquatic resources. There is now a substantial over-capacity among larger fishing vessels as a result of the uncontrolled expansion in the sector. Moreover, an increasing number of people are getting involved in coastal small-scale fisheries and the number of vessels also increased which in turn lead to over-capacity in many coastal areas. Increased fishing efforts, including encroachment of larger vessels in coastal waters, comprise threats to the sustainability of the fisheries in coastal areas.

Fishery resources are common property and belong to no one and no country, unless caught. This signifies special challenge for government agencies in each country and the region as a whole, to adopt sustainable fisheries management measures with clear mandates on their roles and responsibilities, including the proclamation of restricted areas, conservation zones which should be complied with by those involved in fishing operations (large-, as well as small-scale). One of the big challenges that lie ahead is to manage fishing capacity (reduce over-fishing), combat IUU fishing, and curb resource degradation, where the latter is a special challenge as it requires cooperation across sectors including non-fisheries activities that are equally damaging the environment and coastal habitats. In Southeast Asia, there is a growing recognition that in order to have good chances to succeed, the countries in the region should cooperate either as part of the whole region or as part of sub-regional arrangements.

A growing concern has been made known at global level and regional levels such as in Southeast Asia, on the need to manage fishing capacity to reduce over-fishing and to combat illegal and destructive fishing to ensure sustainable utilization of the fishery resources. In responding to such concern, countries in the region have increased their efforts in the promotion of responsible fishing technologies and practices in order to improve fisheries management and to manage fishing capacity.

There is also an increasing strong consensus in the region on the need to strengthen measures to combat Illegal, Unreported and Unregulated (IUU) fishing, particularly through port state measures, flag state measures and other measures as practical. The FAO Legally-binding Instrument on Port State Measures to Prevent, Deter and Eliminate IUU Fishing and the European Commission Regulation to Establish a Community System to Prevent, Deter and Eliminate IUU Fishing are indications that increased emphasis is being given to strengthen the role of port states in monitoring fish and fishery products, check the validity of catch documents, vessel records, crew lists and any other documents that could verify the legal status of the catch. In order to provide proper documentations, flag states should improve their records as the port states are carefully inspecting the documents issued by the flag states to verify that fish and fishery products are derived from legal fishing operations.

Further efforts to manage fisheries to combat IUU fishing, as indicated above, should also be pursued by flag states, particularly through the intensification of vessel registration and record systems, development of appropriate catch documentation system and mechanism, and strengthening of monitoring, control and surveillance measures to improve management of fishing capacity and to combat IUU fishing. Local communities, fishing industry and relevant stakeholders should, as relevant in each area, be involved throughout the processes. The need to develop the harmonized catch certification system for countries in the Southeast Asian region has recently been recognized and will continue to be on the agenda, not only to enhance the competitiveness of countries in trading their fish and fishery products to the international markets, but also to ensure the sustainable utilization of fishery resources in the region. Concerted actions are therefore growing among the Southeast Asian countries with the objective of enhancing capacity to develop the legal framework for fisheries management that could address among others, such concerns as excess fleet capacity; significant amount of by-catch and discards; monitoring, control and surveillance (MCS) networks for fishing operations; and collection of fishery data and information.

Governance: It is important to have different approaches in improving governance with regards to large-scale fishing and coastal fishing operations, considering that the large-scale or commercial fishing is to a large extent urban-based, while the coastal fisheries which are considered to be the "traditional" fisheries sector are available all over the region in coastal/rural areas. For the large-scale segment, stricter rules for registration of vessels, rules to issue licenses to fish and regulations with regards to the working conditions of crew members including proper documents for all (including migratory workers) should be imposed. On the other hand, improving governance in coastal fishing operations and the well-being of communities, could be achieved by enhancing the participation of the communities in fisheries and environmental management, and promoting effective accountability of the resources by the users.

Improving local organizations based on "rights" as specified in local regulations, is increasingly recognized as a key element in strengthening the communities not only within fisheries but also to a broader aspect, the livelihood base which includes other sectors. This implies that initiatives should be undertaken to strengthen local institutions and enhance the roles and functions of community members, including those of women, in rural development as well as in fisheries and habitat management. This approach is expected to strengthen the position of coastal communities in ensuring their continued existence and the sustainable utilization of fisheries products and other resources, especially in situations where there is increasing pressure from other resource users including encroachment of other sectors in coastal areas. Another important impact when communities are strengthened would be their improved adaptive capacity and resilience to respond to the effects of climate change.

Fisheries cannot be managed in isolation but through the integration of fisheries and habitat management considered from the broader point of view in terms of improved governance and sustained efforts to combat illegal and destructive fishing. In an effort to improve management and social well-being in a broader context, FAO has launched the Ecosystems Approach to Fisheries (EAF), which in general refers to efforts to increase the contribution of fisheries to sustainable development, the promotion of ecological pursuits such as habitat protection and conservation, and the ways of maximizing socio-economic benefits including increased and equitably distributed wealth and sustainable livelihoods. Looking at the socio-economic benefits, the adoption of EAF should be pursued by the countries in the region.

Habitat Conservation, Restoration and Rehabilitation: There is an increasing commitment among fisheries agencies in the Southeast Asian region to give more attention to initiatives that support the management of habitats and important ecosystems in order to sustain fisheries production and conserve aquatic resources in coastal areas. Several initiatives had been put into practice in the region, including the establishment of conservation zones such as Marine Protected Areas, fisheries *refugia*, wildlife sanctuaries and other "fisheries resource conservation areas". These initiatives are going to increase and thus, should be promoted giving due considerations to the linkage between specific locations and critical life-cycle of important aquatic species, and eventually improve cooperation among countries and relevant agencies. In addition to habitat conservation and restoration, resources enhancement should be carried out, particularly in areas where the fishery resources/stocks have fallen below the ecosystems' carrying capacity. This could also include deployment of artificial reefs (ARs) as means of addressing the concern on fish habitat degradation and overfishing, taking into consideration the real purpose of ARs whether these are for fisheries or for coastal resource enhancement, which should be clarified.

Sustainability of Inland Fisheries

Although coastal marine capture fisheries have been providing very significant portion of the region's total fisheries production, the substantial importance of inland fisheries in Southeast Asia in terms of its contribution to livelihood and food security should be recognized. Very large groups of people depend on the availability of natural resources such as freshwater resources, for their livelihood. In Cambodia alone, more than eight million people are dependent on the country's freshwater aquatic resources. Even if statistics on inland fisheries production are available in most countries in this region, but it has been generally recognized that such figures could be very much under-reported as large portion of the catch from inland fisheries goes directly to local or household consumption, since there are not many stations near inland water bodies that do the information gathering.

The unavailability of accurate data on inland capture fisheries make it difficult to value its importance as well as those of related ecosystems (wetlands), and hence, it is quite improbable to point out that the inland fishery resources have been exploited above the maximum sustainable yields. Countries in the region should therefore strengthen their efforts to improve data collection on inland fisheries as the information could serve as basis for evaluating the extent of exploitation of their respective inland fishery/aquatic resources, and for enhancing the awareness of stakeholders on the importance of inland fisheries, especially the planners, policy makers and other resource users in order to minimize cross-sectoral conflicts.

The largest threat to inland aquatic resources and wetlands includes the numerous construction activities and infrastructure developments that are prominent in the region. Structures being developed such as dams and reservoirs, weirs among others, could endanger the aquatic resources due to the disrupted inter-connectivity of inland habitats and threaten the extinction of certain aquatic species, particularly those whose life cycles depend on upstream/downstream migration. In the like manner, other structures and developments such as roads, urban and industrial estates, and filling up of flood-plains, rice fields and wetlands, also create impacts to the aquatic resources. In this regard, mitigation measures appropriate for the region which could include as appropriate, the development of fish pass models and installation of culverts under road systems that could provide channels for the migration of inland aquatic species should also be explored.

Sustainability of Aquaculture Development

Over the past decade, reduction of fishery resources/ stocks and deterioration of habitats in many countries had led to declining trend in the total production from capture fisheries. On the contrary, the contribution of the aquaculture sub-sector to the sustainability of fish production in the Southeast Asian region has significantly increasing. Such development has been brought about by the fast development of culture technologies and introduction of new or genetically improved aquaculture species with promising future. As a result, production from aquaculture has almost doubled over the past decade.

In order to support the sustainable development of aquaculture in the region, research and development (R&D) on appropriate culture technologies for all culture stages of important aquatic species should be undertaken. Specifically, R&D to improve technologies that ensure steady supply of good quality seeds should be backed by necessary supportive national policies that aim to promote better hatchery management practices as well as responsible collection and use of wild broodstocks and seeds.

In addition, priority should be given on the development of technologies that minimize the dependent of culture activities on fishmeal and fish oils as ingredients for fish feeds, *e.g.* by exploring appropriate plant-based meal substitution and enhancing the digestibility of plant-based feeds. In controlling the occurrence of new and emerging aquatic diseases, surveillance of disease transfer into wild populations should be enhanced by embarking on regional initiatives that aim to harmonize disease control standards and implementing contingency plans to handle the incidence of diseases. In this regard, the concept of healthy and wholesome aquaculture, which includes curtailing irresponsible culture practices that threaten food safety and create negative impacts on the ecosystem, should be promoted. More particularly, the use of efficient feeds to optimize production of quality farmed aquatic species with the least negative impact on the environment should also be pursued.

During the past decade, a growing number of certification requirements (quality, health, hygiene) including those developed by the private sector for the trading of aquaculture products in the international markets had emerged. This has created additional constraints to most aquaculture farms in the region in complying with all the requirements. With the recent development of the FAO Technical Guidelines on Aquaculture Certification, requirements for certification could be harmonized by making these more straightforward, to ease any unnecessary burden on the part of aquafarmers. Although the FAO Technical Guidelines is voluntary in nature, countries in the region should explore the possibility of developing their respective national certification systems which should be harmonized with the FAO Guidelines, to facilitate trade and to make the countries more proactively prepared for any new requirements on trading of aquaculture products that could come to light in the future.

Improving Safety of Fish and Fisheries Products: ASEAN Requirements

The importance of improving the safety of fishery products for regional utilization is rapidly gaining recognition especially with respect to the integrated economic status which is being established under the ASEAN Community framework. In spite of the difficulties encountered in enhancing the safety of fish and fishery products due to scarce resources, considerable efforts had been gradually carried out in the region especially on the development of HACCP plans for fish and fishery products, adoption of GMP/SSOP plans for SMEs producing traditional products, establishment of regional methodologies for analyzing chemical residues in fish products, harmonization and validation of laboratory methods, and implementation of proficiency testing. Given all these means, the countries in the region should be able to enhance their capacity to monitor food safety and food quality, although efforts should also be re-focused to take into consideration additional requirements that could arise in the next decades.

Initiatives have also been undertaken by the countries in the region to enhance their capacities especially in validating analytical methods of detecting important chemical and drug residues in aquaculture products, which together with the promotion of appropriate aquaculture technologies, aim to minimize chemical residues and prevent possible technical barriers to trade of the region's fish and fishery products. In addition, efforts to assure the quality and safety of fish and fishery products for domestic and local consumption, particularly the traditional fish products that are widely produced and consumed by local populace, should be sustained.

Furthermore, significant improvements in terms of improving and developing post-harvest facilities, have also taken place in the region over the past decades, which involved the construction of more cold storage and ice plant facilities as well as infrastructures for fish handling, distribution and marketing, and the development and adoption of techniques to improve fish handling onboard fishing vessels in order to maintain the quality of catch. Modern fish processing factories have also been established in many countries for generating high-value and high-quality fish and other fishery products.

In the midst of the increasing demand for fish for human consumption in the region, the present supply and the pressures from the markets lead to more quantity of fish being diverted for non-human use. It is feared that over the next decade, more low-value fish would be diverted from direct human consumption due to the rapid expansion of the aquaculture sub-sector. Meanwhile, catch of the so-called low-value fish could include juveniles of high-value species, while high-value species could be transformed into low-value fish due to poor handling onboard fishing vessels, particularly in the case of small fishing vessels. Onboard fish handling technologies that are appropriate for small fishing boats should therefore be developed to improve the quality of catch and minimize discards. Parallel to proper onboard handling, onshore technologies should also be promoted for efficient handling and maximizing the utilization of catch so that more fish and fishery products could be used for human consumption.

Moreover, the development of value-added products from low-value fish should also be pursued with much intensity. Considering that technological innovations in transforming low-value fish into value-added products are already available, for example in the development of the surimi industry, assessment of such innovations throughout the entire supply chain should be continued, with the objective of developing more appropriate technologies that are aimed at producing higher quality fishery products to improve economic returns, reduce wastage, and enhance processing by-product utilization.

Enhancing Trade in Fish and Fishery Products

In 2007, the Southeast Asian countries exported 7.4 million metric tons of fish and fishery products valued at US$ 14.4 billion (SEAFDEC, 2010), accounting for about 30% of the region's total fish production in terms of quantity and 60% in terms of value, with Thailand and Vietnam among the top ten exporting countries. The annual growth rate of food fish exported from Southeast Asia was recorded at 7% as of 2009 (WTO, 2010). With this record, it could be gathered that export of fish and fishery products from the region continued to increase, implying further that the fisheries sector has been producing more fish and thus, has continued to provide employment opportunities for more peoples in the region.

The demand for fish and fishery products has increased together with the increased concerns of consumers for good quality and safety of the products, prompting the call for sustainable utilization and harvesting as well as proper management of the fishery resources. Exporting countries have to comply with the demand, requirements and other trade-related measures in order to maintain their niche in the markets and boost their respective economies. Meanwhile, importing countries continue to enforce several measures as conditions for trading of fish and fishery products, which include voluntary instruments and non-voluntary agreements. In particular, important measures and requirements imposed by importing countries include those on traceability, certification, labeling, fisheries subsidies, and welfare of fishing crew and fishing labor. In order to strengthen the export of fish and fishery products from the Southeast Asian region, countries should examine carefully and consider complying with the relevant measures and instruments which are now commonly practiced in international trade and has also been increasingly becoming part of the basic requirements for trade among the ASEAN countries.

The drive towards sustainability has also taken an important angle in the ambitions to protect and conserve the aquatic biodiversity. Increasing attention had already been given on specific species such as cetaceans, several tuna species, marine turtles, and sharks among others. Therefore, conservation and management measures had been put in place to protect the endangered species while trade regulations had been imposed under the UN Conventions to ensure sustainable exploitation of the species. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is one of the conventions that regulate international trading of species that are threatened to extinction. While the regulations imposed by CITES had been under debate in many countries in the Southeast Asian region, countries should continue to undertake measures to ensure the sustainable exploitation of endangered aquatic species.

Addressing Emerging Challenges and Cross-cutting Issues

Data and information: The growing requirements for sustainable development and management of fisheries require the availability of adequate, improved and reliable data and information. To keep up with the fast pace of development in fisheries, real-time fisheries data will increasingly be required, especially for providing better understanding of the status of fishery resources/stocks, including information on species that are considered to be endangered and receiving special international attention. Identifying the data required and strengthening the capacity of countries in the collection, analysis and utilization of fisheries data and information for science-based policy formulation and management of fisheries, constitute additional areas of concern for countries in the region. More particularly, in order to obtain time-series data for understanding the status and trend of fisheries and for the sustainable management of fisheries, collection of fishery information and statistics should be improved and strengthened at the national and district levels since such information could also serve as basis for national planning and management, and eventually for compilation and analysis at regional and global levels. Considering however, that collection of sufficient statistics requires sufficient human resources and budget, appropriate non-conventional methodologies should be explored and applied, since the results could also be used by the countries in deriving better statistical data in the future. In addition to scientific and statistical data, the importance of traditional/local knowledge should also be recognized and appropriately compiled and utilized.

Climate Change: Considerable attention has now been focused on the potential impacts of climate change and on the need for countries to take up measures to adapt and mitigate such impacts to fisheries and aquaculture, and the people involved in and dependent on the aquatic resources and wetlands. While scientific ability to predict changes in weather, climate and water circulation remains limited, the magnitude of the potential impacts of such changes on fish stocks and the ecosystem is even more difficult to foresee. The nature of impacts which is fairly well-known could be used in building up adaptive capacity in coastal and inland communities, which are already well adapted to respond to any "climate variability". Since seasonal patterns never look the same to the extent that people now need to cope with longer the dry season and large amount of rainfall in the wet season including large accumulation of water in various areas, countries would need to develop appropriate adaptation and mitigating initiatives, and establish precautionary approach which should be built upon their capability to cope with the changes. Research and inventory of relevant data and information especially focusing on local/traditional knowledge should be pursued, since the results could provide better understanding on the extent of climate change and the potential impacts. Furthermore, the fact that the impacts of climate change are very much area specific should be well recognized as there could be no common approach applicable for each and every area of the region. Furthermore, measures on safety at sea (and on land) including improved working conditions should also be adhered to. In addition, fisheries and aquaculture sectors should also exert efforts in reducing carbon footprints to mitigate environmental impacts from the sectors which lead to climate change.

Working Conditions of Fishers Including Migratory Work Force: The ASEAN Community Blueprints give high priority to the improvement of working conditions and the status of migratory workforce, especially applicable to vessel crew members and fishers as well as those working in processing industries. Recommendations from countries in the ASEAN region dovetail towards the development of a regional standard which should be in accordance with international requirements, especially on health and safety standards for crew members on fishing vessels as well as for safety at sea of small fishing boats. In the like manner, improved standards should also be applied in the fish processing industry. While initiatives have been undertaken by the Southeast Asian countries to comply with the health and safety standards, consideration should be given to ensuring good employment practices in fishery-related activities in line with respective domestic laws and regulations, while adhering to regional and international requirements. Efforts should therefore be exerted to mainstream and integrate the safety issues into the respective national policies on management of fisheries and post-harvest industries, taking into account the fact that in the Southeast Asian region, coastal and inland fisheries are mainly small-scale and artisanal that include subsistence activities, and involve children and women, particularly in the post-harvest activities and trading of fish and fishery products. Similarly for the larger-scale segment of the fisheries and related activities in the region, where large numbers of migrant laborers could be involved, possibly reaching several millions although the official/accurate data are not available. This could also mean that there could be several millions of workers specifically in the processing industry which comprise mostly women.

Human Resources Development: While progressing towards global and regional competitiveness, countries in the region should ensure that qualified human resources are available in relevant disciplines (fisheries and non-fisheries). This concern has increasingly become crucial with the approaching establishment of the ASEAN Community in 2015. During the past decade, the areas of human resource expertise in fisheries of most countries are moving towards those that provide higher economic benefits, such as capture fisheries and aquaculture, as well as in post-harvest and processing enterprises. While attention is now shifting towards economics and areas that could generate higher returns (for fewer people), the scarcity of expertise in several fundamental subjects has become very noticeable, particularly in fisheries biology, laws and legislation, as well as in emerging concerns such as social and migration aspects. The countries should therefore review the availability of expertise in order to establish a clear picture of their respective current available human resources and be able to nail the important gaps in the existing expertise. This also implies the need to match the existing available human resources in wide-ranging disciplines and the demand to fill up future requirements.

4. Future Direction and Way Forward

There is no doubt that the fisheries sector of the Southeast Asian region could continue to play the vital role of ensuring food security and improving the economies of the region. However, this goal can only be achieved if the prevailing issues in the fisheries sector are addressed, while the possible adverse impacts of emerging issues that come to light in the coming decade are mitigated. This requires that the countries should continue to muster their collective efforts for the next decade in accordance with the region's mission of achieving Fish for the People 2020.

It could therefore be foreseen that by 2020 and beyond, the region would attain the age of golden fish harvest, and with much optimism, fish produced from the region would be among the high value food commodities of the world or even the best of its kind. What is necessary to boost such confidence is to maintain a level of equilibrium where in the fish demand and supply equation, the exploitation and utilization of the fishery resources should not outweigh the increasing demand for food fish as enhanced by capacity of consumers to buy fish for health reasons, notwithstanding the fair benefits that could be reaped by the fishers to sustain their livelihoods.

Meanwhile, it is very likely that in the midst of a very competitive fish market, the number of international and even regional instruments would continue to increase for the sustainable development and management of fisheries worldwide. Such situation makes it necessary for the countries in the region to get together and come up with common means of complying with such instruments, taking into consideration the uniqueness of fisheries in the region which remain small-scale and exploiting the multi-species resources, by beefing up fisheries governance and measures to conserve and rehabilitate the natural resources. While requirements for safety, welfare and sound working conditions of fishers would prevail in the international arena, countries in the region should adopt good employment practices in line with their respective domestic laws and regulations, which also complying with the international requirements.

Therefore, in the perspective of achieving the goal for regional economic integration by 2015, countries in the region should also consider the adoption of resource audit schemes to make the resource users accountable for the natural resources that they have been exploiting. This also implies that the countries should educate the stakeholders on how to fish responsibly and adopt traceability of fish and fishery products. Considering that the peoples in the region are fish-eating, countries should ensure that food fish which is nutritionally adequate in terms of quantity, quality and variety, is available for all peoples at all times, which in turn also addresses poverty especially in rural areas. In a broader sense, a well-balanced demand and supply of food fish should be set as the ultimate goal to reach the age of golden harvest in fisheries. After all, when all factors come into reality, it could be surmised that the region's fisheries would be one sector which could take care of food security for the future generations of the Southeast Asian region.

PART IV
Appendices

APPENDIX 1. SEAFDEC PROGRAMS ON SEA TURTLES IN SOUTHEAST ASIA

Project Activities/Objectives	Accomplishments
1998-2004: Conservation and Management of Sea Turtles in Southeast Asia	
Sea Turtle Hatchery Management To develop a common tool in conserving sea turtles through sustainable hatchery management focusing on the green turtle, *Chelonia mydas*	*"A guide to Set and Manage Sea Turtle Hatcheries in the Southeast Asian Region"* was published. The book provides useful information and guidelines in setting up and management of sea turtle hatcheries based on knowledge established on-site in Malaysia and experiences of other countries. Using this book as guide, turtle hatcheries in the region would be able to continuously produce hatchlings in order to enhance sea turtle conservation activities.
Tagging Survey To gather information on migration pattern, growth and mortality rates, reproduction and population estimates, among others.	*"Conservation and Enhancement of Sea Turtles in the Southeast Asian Region"* was published. The book highlights on the measures undertaken by the ASEAN countries in conserving and managing sea turtles including laws and enforcements on conservation, establishment of sea turtle training and public awareness. *"A Guide for Tagging Sea Turtles in the Southeast Asian Region"* was also published to help the countries in the region in standardizing their own turtle tagging activities.
Development of Turtle Excluder Devices To develop Turtle Exclude Devices (TEDs) suitable for the ASEAN countries in response to the US embargo on shrimps caught by gear not equipped with means to prevent sea turtle by-catch, which was also imposed on the Southeast Asian countries posing threat to the livelihood of fishers in the region.	Awareness of the region's fishers on TEDs was promoted through a series of demonstrations conducted in Thailand, Malaysia, Philippines, Brunei Darussalam, Indonesia, Myanmar, Cambodia, and Vietnam. The use of TEDs has already been advanced by many countries in the region.
Collaboration and Partnerships To enhance regional collaboration and partnerships in sea turtle conservation and management	MOU on ASEAN Turtles Conservation and Protection was adopted at the AMAF Meeting in 1997. The ASEAN Network on Sea turtles was established as a regional taskforce to promote the conservation and management of sea turtles in the region. Development of Turtle Research Database System was promoted by the Western Pacific Regional Fisheries Management Council in collaboration with Department of Fisheries Malaysia. Cooperation with SEASTAR2000 was finalized for the satellite tracking of sea turtles.
2005-2009: Stock Enhancement of Sea Turtles in the Southeast Asia	
Tagging and Satellite Telemetry Tracking To enhance sea turtle migration studies in the region, specifically in countries where turtle rookeries are concentrated.	Tagging of sea turtles (green turtles, hawksbill and olive ridley) using Inconel tag, Passive Integrated Transponder tag (PIT)/microchip and Platform Terminal Transmitter (PTT)/satellite telemetry tracking was conducted in participating ASEAN countries. Posters highlighting the SEAFDEC tagging program were distributed for public awareness. Results indicated that sea turtles are sharing resources and their foraging has been confirmed in certain areas in the Southeast Asian region.
Head Starting Technique To collect information and conduct analysis on head-starting, a technique for raising sea turtles in captivity for release later to improve survival during their early years, which is still relatively new in the region.	Information collection on head starting programs in the region and other countries outside Southeast Asia was initiated.
Sea Turtles- Fisheries Interaction To mitigate the interaction between sea turtles and fisheries and minimize mortalities of sea turtles from fishing operations.	Assessment/evaluation of lessons learned from the introduction and promotion of TEDs in shrimp trawls was carried out taking into account the 2004 *"FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations"*. *"Collection of Information on Sea Turtle Interaction with Fishing Operations in Southeast Asia*". Result of the comparative study on the efficiency of the Circle hook and the J-hook in pelagic and bottom long lines indicated that the use of Circle hook (with larger hook width which the sea turtles could not swallow) was the most suitable device for the conservation of sea turtles. *"Mitigation of Fishery- Sea Turtles Interactions: Efficiency of The Circle Hook in Comparison with J-hook in Longline Fishery"* was published containing the outcomes of the studies on mitigation of sea turtles and fisheries interaction. When sea turtles are caught by the Circle hook, hooking position is only around their jaws thus, the hook could be easily removed. Results also showed that sea turtles caught by the Circle hook have no serious injury and could be release safely back to the sea.

Project Activities/Objectives	Accomplishments
DNA Study To identify stock/population of sea turtles from the ASEAN region and detect multiple paternities for estimation of stock size of male sea turtles.	*"The Standard Operating Procedure: Sampling Tissue of Sea Turtles in the Southeast Asian Region"* was published to guide the countries in collecting tissue samples. For green turtles, the genetic study by using mitochondria (mtDNA) analysis had identified 11 genetically distinct breeding stocks (Management Units/ Units stock) throughout Southeast Asia Region. For hawksbill turtle, due to the small number of its population, the samples also small (88 samples/10 locations) and no breeding stock can be concluded. Pilot study on Determination of Multiple Paternity of Green Sea Turtles from Mak Kepit, Redang Island, Terengganu, Malaysia found that multiple paternity occur at that population with 5 clutches are single paternity and 4 clutches are multiple paternity. Symposium on Cloning of Sea Turtle was convened in March 2006 in collaboration with the DoF Malaysia to discuss and compile methodologies and techniques for cloning sea turtles. The *"Conceptual Framework on Cloning of Sea Turtles and Master Plan: Cloning of Sea Turtles"* was published. The Master Plan describes the establishment of advanced reproductive biotechnology and captive breeding for the sustainable management of sea turtles.
Sea Turtle Information Dissemination To enhance awareness, knowledge and understanding of the public on sea turtles and spread awareness on the need to protect and conserve the sea turtles as well as the environment as a whole.	Five volumes of "Sea Turtle Information Kit" were published in 2006: Volume 1 : Sea Turtle Evolution and Biology Volume 2 : Sea Turtle Distribution Volume 3 : Sea Turtle Hatchery Volume 4 : Conservation Genetics of Sea Turtle Volume 5 : Public Awareness on Sea Turtle
2010-2014: Research and Management of Sea Turtles in Foraging Habitats in the Southeast Asian Waters	
Genetic study To study population structures of sea turtles in the region by genetic analysis for conservation of the sea turtle populations in the region.	Colleting on tissue samples of sea turtles in Lawas, Sarawak foraging habitat was conducted. A total of 28 tissue samples of green turtles were collected. The range size of curve carapace length (CCW) of the specimens was between 61 cm to 102 cm and the weight between 25 kg to 105 kg.
Training for scientific survey on foraging habitats	Scientific survey of ecological parameters in a pilot foraging habitat of sea turtles (Brunei Bay) was conducted. Fauna and flora on the sea bottom of the habitat were surveyed by divers. Water quality, such as salinity, temperature, turbidity, and chlorophyll content, was monitored. Technical Officers from Brunei and Malaysia (Sabah) were invited for the training on ecological survey.
Tagging of sea turtles To study population structures of sea turtles in the region by conventional tagging for conservation of the sea turtle populations in the region.	Implementation of inconel tagging was continued at the focused nesting sites of sea turtles in participating Member Countries and tag recovery had been monitored. A total of 40 green turtles were tagged in Peninsular Malaysia, 30 green turtles were tagged in Sarawak, Malaysia and 60 green turtles were tagged in Sabah, Malaysia.
Satellite Telemetry To study population structures of sea turtles in the region by satellite tracking for conservation of the sea turtle populations in the region.	One juvenile green turtle was released in Lawas foraging habitat of Sarawak waters on 12 February 2011. From 12 February until 30 April 2011 the turtle with ID No.67589 is still swimming in Lawas waters of Brunei Bay with the distance between 5 and 34 km from the shore. This indicates that Lawas waters with seagrass bed are foraging habitats of this turtle.
Sea Turtles- Fisheries Interaction	Continuation of the study was made for modification of responsible fishing gears to reduce the sea turtles by-catch. Promotion and awareness raising on the use of C-hook in hook-and-line fishing in SEAFDEC Member Countries was also conducted.

APPENDIX 2. AQUATIC SPECIES FARMED IN SOUTHEAST ASIAN COUNTRIES AND SOURCES OF SEEDSTOCKS

Country	Species	Sources of Seedstock
Brunei Darussalam	Tilapia (Nile, red), giant freshwater prawn, sea bass, grouper, snapper, shrimps (*P. monodon*, *L. stylirostris*), trevally	• Hatchery-bred for most species except for trevally, but if insufficient, certified seedstocks are imported from Malaysia, Indonesia, Thailand and Philippines (Metali, 2011)
Cambodia	Thai silver barb (*Puntius gonionotus*), common carp, Chinese carps, catfish (*Clarias* sp.), Nile and Mozambique tilapia Snakehead* (*Channa striata*) and pangasid catfishes*	• Hatchery-bred especially for most of the indigenous freshwater species * wild seedstock since none are as yet available from hatcheries (Da, 2011)
Indonesia	Catfish (*C. batrachus*, *Pangasius* sp.), tilapia, carp, gourami, giant freshwater prawn, shrimps (*P. monodon*, *P. vannamei*), milkfish, grouper (*Epinephelus* sp., *Cromileptis altivelis*, *Plectropomus* sp.), sea bass/barramundi (*Lates calcarifer*), crabs (*Scylla* sp., *Portunus* sp.), shellfish (abalone, pearl oyster), seaweeds (*Eucheuma cottonii* and *Gracilaria* sp.)	• Hatchery bred but supply 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 carp, silver carp, grass carp), Indian major carps (rohu, mrigal), common carp, catfish (*Clarias macrocephalus*), barb (*Puntius gonionotus*) and indigenous species, *e.g. Cirrhinus microlepis*, *Morulius chryzophecadion*	• Fingerlings produced in 30 government stations and 33 small-scale private hatcheries (Roger, 2011)
Malaysia	16 marine fish species, 4 marine shrimp species, mollusks (blood cockles, green mussels, oysters)*, seaweeds, giant freshwater prawn*, mudcrabs*, 15 freshwater fish species, Nile and red tilapia,	• Hatchery bred * Wild sourced (Hassan *et al*., 2011)
Myanmar	Tilapia (*O. mossambicus*), rohu, striped catfish (*Pangasius sutchi*), sea bass (*Lates calcarifer*)**, red snapper**, grouper** and seaweeds (*Eucheuma cottonii*), mud crab	• Hatchery bred ** wild sourced prior to 2004 (Win, 2011)
Philippines	Nile tilapia, red tilapia, Chinese carps, catfish, milkfish, shrimp, mud crab, grouper, sea bass, red snapper, pompano, rabbitfish, abalone, sea cucumber, seaweeds	• Hatchery-bred; some wild-sourced (Adora, 2011); hatcheries usually dominated by the private sector
Singapore	Marine species include: Asian sea bass, grouper (*Epinephelus* and *Plectropomus* spp.), snapper (*Lutjanus* spp.), pompano, trevally, mullet, milkfish, marine tilapia, Pacific oyster, lobster and green-lipped mussel Freshwater species include: giant snakehead, tilapia, marble goby and catfish	• Hatchery bred for some species • Seedstocks are also imported from Indonesia, Malaysia, Philippines and Taiwan
Thailand	Tilapia, common carp, silver barb, snakeskin gourami, striped snakehead, striped catfish, giant freshwater prawn, marine shrimps (*P. vannamei*, *P. monodon*, *P. merguensis*), green mussel, arc shell, oyster, sea bass, groupers (*Epinephelus* spp.), snappers (*Lutjanus* spp.)	• Private hatcheries especially for freshwater aquaculture seedstocks • Sea bass seeds from government and private hatcheries • Grouper, snapper mostly from wild seeds (Yashiro *et al*., 2011)
Vietnam	Black tiger shrimp, Mekong Pangasius, tilapia, Chinese and Indian carps, giant freshwater prawn	• Seeds produced by breeders from five national broodstock centers (under research institutes : RIA 1,2,3) and provincial hatcheries (Luu, 2011) • Sometimes imported seeds used but imported stocks undergo strict quarantine and quality control (Hishamunda *et al*., 2009)

APPENDIX 3. GENETIC METHODS EMPLOYED IN VARIOUS SOUTHEAST ASIAN COUNTRIES FOR PRODUCTION OF QUALITY SEEDS FOR AQUACULTURE

Genetic Program/Method	Technology/ Product Generated	Southeast Asian Countries where developed*/available
NILE TILAPIA		
Genetically improved farmed tilapia (GIFT) program • Combined family and within family selection for improved growth	GIFT technology and strain	Philippines*, Malaysia
Genomar Project • Combined selection for improved growth	Genomar Supreme tilapia (GIFT- derived stock)	• Philippines*, China
GET-Excel Program • Out-crossing two fast-growing strains (FAST and GIFT) for improved growth	GET Excel stocks	• Philippines*
Genetically Male Tilapia (GMT) Program • Selective breeding, sex reversal methods	GMT or YY supermale technology and strain	Philippines*, Thailand
Brackishwater Enhanced Selected Tilapia (BEST) Program • Hybridization and outcrossing	Salt-tolerant BEST tilapia strain	Philippines*
RED TILAPIA		
• Originally through interspecific hybridization; conventional breeding for strain propagation	Red tilapia strains (Philippine, Thai, Taiwan)	• Philippines*, Malaysia • Indonesia, Taiwan* • Thailand*
CATFISHES (*Clarias* spp)		
• Interspecific hybridization (between *C. macrocephalus*, and *C. gariepinus*)	Clariid catfish hybrids	• Philippines, Thailand
OTHER FRESHWATER SPECIES: *Probarbus jullieni*		
• Molecular biology and genetic engineering techniques	Cryopreserved sperm for planned breeding	• Malaysia*
GIANT FRESHWATER PRAWN		
• Broodstock management • Strain evaluation	Best or improved strain with good growth and reproductive ability (in progress/ already developed)	• Philippines*, Malaysia • Thailand*
• Selective breeding	GI-MACRO (genetically improved Macrobrachium)	• Indonesia*
MARINE SHRIMPS		
• Selective breeding (marker assisted)	High health shrimp stock (SPF/SPR) (on-going for *P. monodon*, *L. stylirostris*) Markers related to disease resistance	• Brunei Darussalam* • Indonesia
	High *health P. monodon* and *P. merguensis* (development in progress)	• Malaysia*, Philippines*
MARINE FISHES (*Lates calcarifer*)		
• Selective breeding for disease resistance	High health *Lates calcarifer* stock to be developed	• Malaysia*
• Sperm cryopreservation	Cryopreserved sperm for planned breeding	• Malaysia*
ABALONE		
• Interspecific hybridization	Better (hybrid) stocks that are fast growing and have good carcass quality (in progress or developed)	• Philippines*, Thailand*
OYSTER		
• Triploidy induction	Triploid oysters produced	• Malaysia*
SEAWEEDS		
• Genetic manipulation • Conventional selection for disease resistance • Tissue culture • Marker-assisted selection	Disease resistant seaweeds Seaweeds with improved carrageenan quality	• Malaysia*, Philippines*
MUDCRABS		
• Selective breeding	Fast growing mud crabs with improved reproductive ability (in progress)	• Philippines*

APPENDIX 4. TECHNICAL AND NON-TECHNICAL ISSUES IN THE PRODUCTION OF QUALITY SEEDSTOCKS FOR AQUACULTURE IN THE SOUTHEAST ASIAN REGION

Problems	Species		
	Tilapia, carp, catfish, milkfish	FW 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)	☑ especially for Clariid catfishes	☑ especially for mud crabs	☑ true for most species as domestication and hatchery protocols are currently being verified
2) Poor quality of hatchery-bred seeds	☑ true for milkfish especially those produced from ageing broodstock	☑ (slow growth of hatchery produced seeds)	No indications as yet
3) Inadequate or no domesticated broodstock	☑ slightly inadequate domesticated milkfish	☑ (inadequate)	☑ (inadequate for grouper; none or very few for emerging species)
4) Poor broodstock quality	☑ especially for ageing stocks of domesticated milkfish	☑ matures at small size for mud crab and FW prawn; low PL survival for FW prawn and low fecundity for mud crabs	No indications as yet; early stages of broodstock domesticated
5) inadequate or no supply of genetically improved seeds	☑ especially for catfish and milkfish	☑ selection programs on-going	☑ none to date; no selective breeding program as yet
6) Poor/difficult/expensive access to genetically improved stocks	☑ poor access particularly for carps	☑ expensive especially for specific pathogen-free (SPF) shrimp stocks	NA
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	☑	
5) Feeding management (especially for broodstock and larval stages)	☑ continue research to address gaps	☑ continue research to address gaps especially in abalone	☑ intensify research on feed management
6) Environment management (need to adopt better management practices, biosecurity in farms)	☑	☑	☑
7) Socio-economic and legal issues (especially marketing of unselected and/or better seeds, formulate seed certification guidelines)	☑	☑	☑

APPENDIX 5. IMPACTS OF CLIMATE CHANGE ON FISHERIES AND AQUACULTURE

Changes	Biophysical Effects	Implication for fisheries and aquaculture
Increased CO_2 and ocean acidification	Effects on calciferous animals *e.g.* molluscs, crustaceans, corals, echinoderms and some phytoplankton	Potentially reduced production for calciferous marine resources and ecologically related species and declines in yields
Changes in sea surface temperature	Warm-water species replacing cold-water species	Shifts in distribution of plankton, invertebrates, fishes and birds towards the North or South poles, reduced species diversity in tropical waters; Impacts on availability on seed for aquaculture
	Plankton species moving to higher latitudes	
	More frequent harmful algal blooms; Less dissolved oxygen; Increased incidence of disease and parasites; Altered local ecosystem with changes in competitors, predators and invasive species	For aquaculture, changes in infrastructure and operating costs from worsened infections of fouling organisms, pests, nuisance species and/or predators. For capture fisheries, impacts on the abundance and species composition of fish stocks
	Timing of phytoplankton blooms changing	Potential mismatch between prey (plankton) and predator (fish populations) and reduced production and biodiversity and increased variability in yield
	Changing zooplankton composition	
	Damage to coral reefs that serve as breeding habitats and also help protects the shore from wave action	Reduced recruitment of fishery species. Worsened wave damage to infrastructure or flooding from storm surges
	Changes in sex ratios Altered time of spawning Altered time of migrations Altered time of peak abundance	Altered timing and reduced productivity across marine and fresh water systems
Higher inland water temperature	Increased stratification and reduced mixing of water in lakes, reducing primary productivity and ultimately food supplies for fish species.	Reductions in fish stocks
	Raised metabolic rates increase feeding rates and growth if water quality, dissolved oxygen levels, and food supply are adequate, otherwise possibly reducing feeding and growth. Potential for enhanced primary productivity	Possibly enhanced fish stocks for capture fisheries or else reduced growth where the food supply does not increase sufficiently in line with temperature. Possible benefits for aquaculture, especially intensive and semi-intensive pond systems
	Shift in the location and size of the potential range for a given species	Aquaculture opportunities both lost and gained. Potential loss of species and alteration of species composition for capture fisheries
	Reduced water quality, especially in terms of dissolved oxygen; Changes in the range and abundance of pathogens, predators and competitors; Invasive species introduced	Altered stocks and species composition in capture fisheries; For aquaculture, altered culture species and possibly worsened losses to disease (and so higher operating costs) and possibly higher capital costs for aeration equipment or deeper ponds
	Changes in timing and success of migrations, spawning and peak abundance	Potential loss of species or shift in composition for capture fisheries; Impacts on seed availability for aquaculture
Changes in ocean currents	Increased invasive species, diseases and algal blooms	Reduced productivity of target species in marine and fresh water systems
	Changes in fish recruitment success	Abundance of juvenile fish affected leading to reduced productivity in marine and fresh water
Changes frequency of El-Nino-Southern Oscillation (ENSO) events	Changes in timing and location of upwelling and ocean currents alters nutrient supply in surface waters and consequently primary production	Changes in the distribution and productivity of pelagic fisheries
	Changed ocean temperature; bleached and die-off coral	Reduced productivity of coral reef fisheries
Sea level rise	Coastal profile changes, loss of harbours, homes	Increased vulnerability of coastal communities and infrastructure to storm surges and sea level
	Increased exposure of coastal areas to storm damage	Costs of adaptation lead to reduced profitability, risk of storm damage increases costs of insurance and/or rebuilding
	Loss of land	Reduced area available for aquaculture; Loss of freshwater fisheries
	Changes to estuary systems	Shifts in species abundance, distribution and composition of fish stocks and aquaculture seed
	Salt water infusion into groundwater	Damage to freshwater capture fisheries; Reduced freshwater availability for aquaculture and a shift to brackish water species
	Loss of coastal fish breeding and nursery habitats *e.g.* mangroves, coral reefs	Reduced recruitment and production and yield of coastal and related fisheries for capture fisheries and seed for aquaculture; Worsened exposure to waves and storm surges and risk that inland aquaculture and fisheries become inundated

Changes	Biophysical Effects	Implication for fisheries and aquaculture
Increased frequency and / or intensity of storms	More days at sea lost to bad weather, risks of accidents increased	Increased risks associated with fishing, making it less viable livelihood options for the poor
	Aquaculture installations (coastal ponds, sea cages) more likely to be damaged or destroyed	Reduced profitability of larger-scale enterprises, insurance premiums rise
	Large waves and storm surges. Inland flooding from intense precipitation. Salinity changes. Introduction of disease or predators into aquaculture facilities during flooding episodes.	Loss of aquaculture stock and damage to or loss of aquaculture facilities and fishing gear. Impacts on wild fish recruitment and stocks. Higher direct risk to fishers; capital costs needed to design cage moorings, pond walls, jetties, etc. that can withstand storms; and insurance costs.
Changing levels of precipitation and water availability	Where rainfall decreases, reduced opportunities for farming, fishing and aquaculture as part of rural livelihood systems	Reduced diversity of rural livelihoods; greater risks in agriculture; greater reliance on non-farm income. Displacement of populations into coastal areas leading to influx of new fishers
	Changes in fish migration and recruitment patterns and so in recruitment success	Altered abundance and composition of wild stock. Impacts on seed availability for aquaculture
	Lower water availability for aquaculture. Lower water quality causing more disease. Increased competition with other water users. Altered and reduced freshwater supplies with greater risk of drought	Higher costs of maintaining pond water levels and from stock loss. Reduced production capacity. Conflict with other water users. Change of culture species
	Changes in lake and river levels and the overall extent and movement patterns of surface water	Altered distribution, composition and abundance of fish stocks. Fishers forced to migrate more and expend more effort
Less predictable rain/dry seasons	Decreased ability to plan livelihood activities – *e.g.* farming and fishing seasonality	Increasing vulnerability of riparian and floodplain households and communities
More droughts or floods	Damage to productive assets (fish ponds, weirs, rice fields, etc.) and homes	
	Lower water quality and availability for aquaculture. Salinity changes	Loss of wild and cultured stock. Increased production costs. Loss of opportunity as production is limited
	Changes in lake water levels and river flows	Reduced wild fish stocks, intensified competition for fishing areas and more migration by fisher folk

***Source:** Adapted from Allison* et al. *(2008) and WFC (2007)*

PART V
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PART VI
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• Minimizing Impacts of Aquaculture on the Environment	Dr. Ma. Junemie Hazel Ramos (AQD)
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• Human Resources in Fisheries	Dr. Chumnarn Pongsri and Ms. Nualanong Tongdee (Secretariat) Mr. Renato F. Agbayani (AQD)
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