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Executive summary

This report describes the overview of aquaculture and seafood industry in Thailand and also covers the gap analysis and needs assessment for long-term sustainability of the sector. Despite the efforts of various organizations, seafood industry has suffered tremendously. Recent occurrence of tilapia Lake Virus is threatening the culture tilapia, which is dominant species in Thailand and in many other countries. Thailand ranked no. 1 for shrimp export last two decades but it has ups and downs. Culture of *Penaeus monodon* collapsed in mid-nineties. Introduction of Pacific White Shrimp (*Litopenaeus vannamei*) rescued the industry replacing the *P. monodon*. However, it has again suffering due to the disease problems mainly early mortality syndrome (EMS). There are a number of mass fish kills and environmental problems in various occasions in various locations, which are threatening the very important part of food production system which supplies highest quality protein to the local people as well as abroad where demand is so high. The industry is in need of more qualified human resources to overcome such challenges and also to fulfill the increasing demand for seafood consumption. However, there are less number of graduate students enrolled or interested in the fisheries and aquaculture sector. Graduates with higher education degrees are supposed to be the key persons responsible for taking care of the seafood industry and its security. It has been realized that new technologies and practices are required to improve the quantity and quality of seafood products during production process, at the same time during the period of handling, processing, storage, transportation and retailing. With a view to contributing to achieving sustainable seafood and nutrition security, this study attempted to identify gaps or needs, and opportunities and challenges of the sector especially for higher education, short-term training required for human resource development fro the sustainability of seafood highlighting the need for "Sustainable Seafood Security" academic programme and recommending attractive courses.

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Chapter 1: Introduction

1.1 Global status of seafood

Fish or seafood is the staple food of over billion people. It is the main source of protein in most of the countries in Asia. Aquatic animals have been caught from rivers, rice field, swamps, lakes, reservoirs and ocean to consume at home and also for export since long. Aquatic animals include a number of finfishes, crustaceans, shellfishes, and seaweeds. Seafood is defined as "food from the sea" (Kim and Venkantesan, 2015) or "edibles harvested from the sea" (Lee, 2017). However, for seafood industry and seafood processing, freshwater is included in seafood, and it is considered as a seafood material. For seafood industry, seafood is defined as "all products located in the deep ocean as well as in freshwater rivers, streams, lakes, and estuaries are considered seafood" (Surak and Wilson, 2007). For seafood processing, Code of Federal Regulations of the United States of America (Part 400 TO 424 revised as of July 1, 1994) described seafood materials as the freshwater and saltwater fish and shellfish to be process (Federal Government of the United States, 1994). Therefore, freshwater aquatic animals are a part of seafood.

Nutritive value of aquatic animals has been realized recently. More and more people are consuming aquatic animals. Globally, seafood consumption is only about 20 kg per capita per year. Most Asian countries, where fish is a part of traditional diet, consume above this average. However, in developed countries red meat consumption is a lot higher than seafood. For example, Australia and USA, annual beef consumption is over 80 kg per capita. Similarly, pork consumption is Europe is about 46 kg per capita whereas fish consumption is half of that (Bhujel, 2014). Most people in developed countries know seafood is the best source of highest quality animal protein; however, its price and availability is limiting its consumption. Due to awareness among people about health benefits, and relatively cheaper prices, demand is growing. However, fish catch from the ocean is declining. Therefore, farming of fish is becoming more and more important. Therefore, aquaculture is the world's fastest growing food production technology, and in 2014 it surpassed wild fish as a source of seafood for human consumption (FAO, 2015). However, aquaculture is also a controversial food production technology that constitutes a new way of using the environment, which creates new negative externalities (Naylor et al., 2000). The consumption of seafood profoundly affects the health of marine social-ecological systems (Smith et al., 2010). This has led to a negative perception of aquaculture in many markets and several studies indicate a consumer preference for wild fish (Salladarré et al., 2010; Roheim et al., 2012; Uchida et al., 2014a). Recently, the Aquaculture Stewardship Council (ASC) introduced an eco-label certifying that the production process for the labeled fish is environmentally sustainable while a number of certification bodies have standards specifically developed for organic shrimp culture e.g. Naturland (2012) and Soil Association (2011) (Jonell and Henriksson, 2015).

1.2 Thailand

Fish consumption per capita reached over 30 kg in Thailand, which was relatively high compared to the consumption of the other three main animal protein commodities,

namely pork, beef, and chicken. Because of a robust in-bound tourism industry and cosmopolitan consumption preferences by Thai medium-to-high income consumers, Thailand is a promising market for imported high-value seafood products such as halibut, cod, salmon, lobster, scallops, crab, and mussels. These U.S. seafood products have been well received in Thailand, and enjoy a large market share of all imports. On the other hand, Thailand's billion-dollar seafood export industry remains infested with human rights abuses despite government pledges to stamp out slavery in its fishing industry, according to research by Human Rights Watch. In addition, there has been an increase in food safety incidents involving farmed shrimp, such as chemical and antibiotic residues and contamination resulting from infrastructure and hygiene deficiencies at processing factories (Cato and Subasinge, 2003).

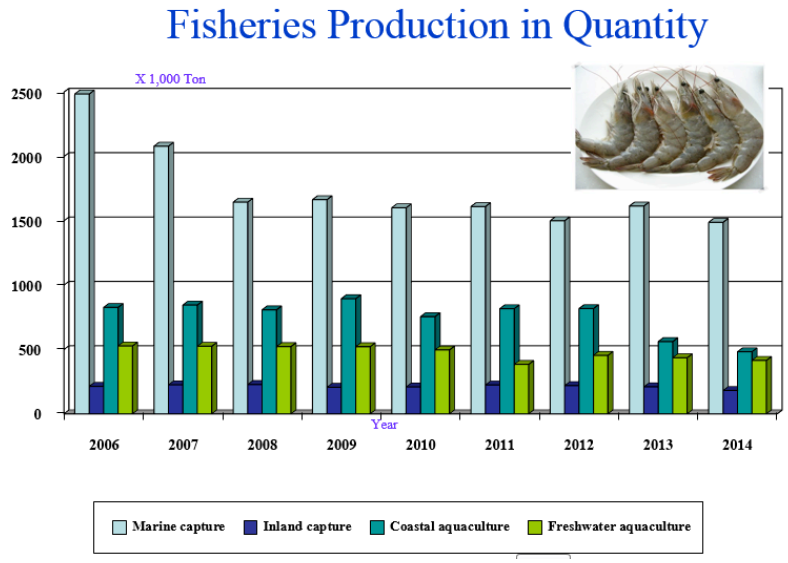

Figure 1. Thai fish production from capture fisheries and aquaculture year 2006 – 2014 (Department of Fisheries, 2016)

Thailand covers an area of 514,000 square kilometers locating in the middle of mainland Southeast Asia with a coastline of 2,614 km. Marine fisheries in Thailand is very important to coastal communities and country's economy. They support the livelihoods, incomes and employment for nearly million people; 172,430 fishermen and 515,000 people employed in supporting industries e.g. fish processing industry, ship building industry, canned and frozen fishery product industry, fish meal factories. Also important to national food security and be affordable source of protein for more than 2,500 coastal villages along the long coastline of Thailand. Capture fisheries in Thailand produce more than a half of the total seafood production. In the capture fisheries sector, marine capture accounts for over 90%. More than one million ton of marine production is produced each year (Fig. 1). According to Department of Fisheries (2017), about 1.32 million tones of marine animals were caught in 2015, comprised with multi species including pelagic fish, demersal fish, crustacean, mollusk, other food fish, other invertebrates and trash fish. The total production includes marine fish of Thai waters and outside of Thai waters. Marine capture production was accounted as 63.3% of total fishery production in last two decades. They contribute one third of total value gained from overall fisheries production. Marine catches have shown downtrends since 1996. It has been continuously decreasing from 2.79 million tones in 1996 to 1.32

million tones in 2015, average 3.6% annually. However, inland capture production was unaltered (Fig. 2).

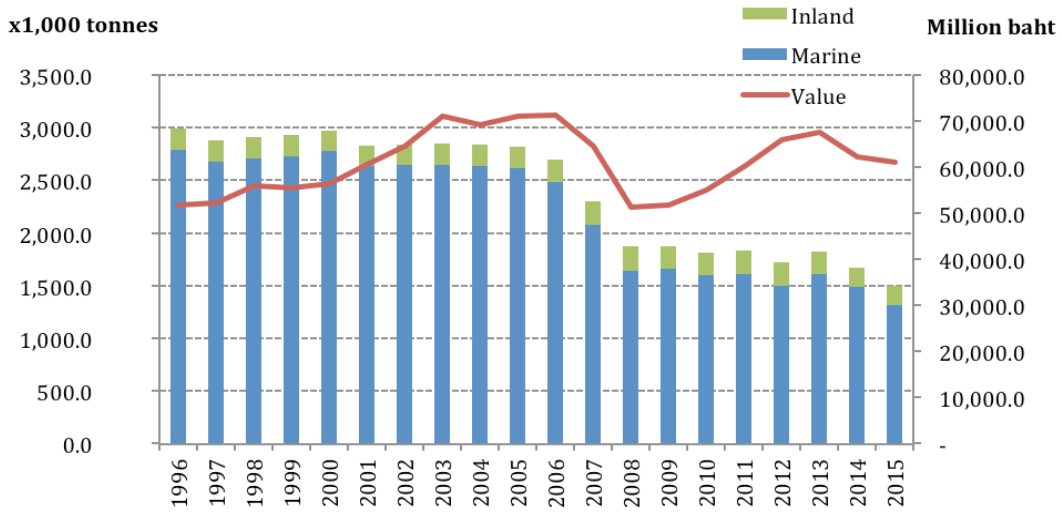

Figure 2 Marine fish catch in Thailand

Over one million hectares of coastal areas have a great potential for coastal aquaculture. Aquaculture production in Thailand was estimated 0.897 million tones and valued approximately US$2.30 billion (Information and Communication Technology Center, 2016). Aquaculture activities in Thailand have been promoted to replace the decreasing capture fish production. Thai aquaculture can be separated into two main categories: freshwater aquaculture and brackish water aquaculture. The five most important freshwater species, in term of annual production, are Nile tilapia, catfish, silver barb, giant prawn, and snakeskin gourami. The most important brackish species cultivated are fish such as barramundi and grouper, shrimps, shellfish, and other crustaceans such as mud crab. As a result, Thailand became one of the world largest seafood exporters, especially for shrimp products. Thai seafood production relied mainly on marine fishing and shrimp aquaculture. However, Thailand also imports fish and seafood products both to meet domestic demand as well as for processing and re-export. Unfortunately, the shrimp production in 2016 was lessened due to lower international prices and diseases.

FAO stated that there are many different kinds of fish markets in Thailand and a very large number of traders of different types. Fish is sold fresh as well as in processed form. Cultured fish is sold both alive and dead. Normally, fish intended to be sold alive are transported by trucks (pick-up, six-wheel trucks and ten-wheel trucks) and kept in water-filled metal boxes. However, poor transport practices may cause fish death, which will cause the price to be reduced by as much as 40-50 percent. To transfer fish to consumers several categories of traders are involved; they work either in primary markets, intermediate markets or terminal markets. The primary market is the point where fish marketing starts. It occurs either at the landing places or at the farm gate. The intermediate market is the point where fish is redirected to the terminal market. The terminal market is the market where fish is sold to consumers through retail outlets including supermarkets, restaurants and hotels.

Surprisingly, there is increased demand for seafood consumption but few people are interested to get degrees (low student enrollments). This project aims to improve the existing curricula of higher education in Aquaculture and Fisheries Thailand leading to

produce quality personnel that industry needed. With capture fishery production relatively static since the late 1980s, aquaculture has been responsible for the notable growth in the supply of fish for consumption (Fig. 4).

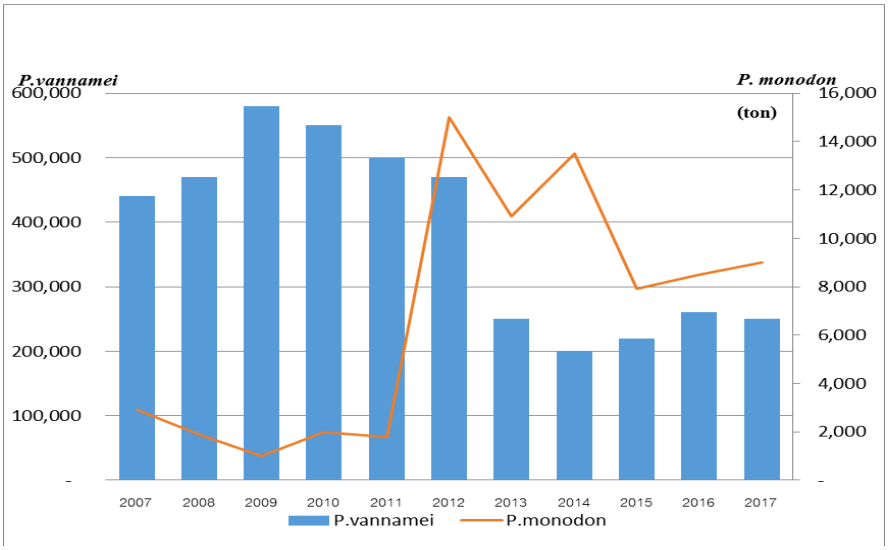

Figure 3. Thai cultured marine shrimp production traded through a movement document

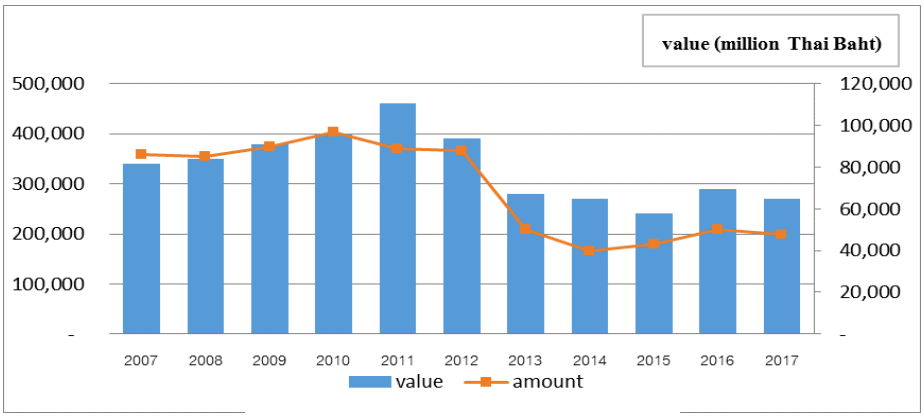

Figure 4. The Thai shrimp export

Table 1 Balance of import and export of fish and fish product 2011 – 2014

		Year			
		2011	2012	2013	2014
Export	Quantity (Ton)	1,974,962	1,908,099	1,741,845	1,793,306
	Value (mil. Bt)	259,863.2	264,449.2	227,722.0	228,284.3
Import	Quantity (Ton)	1,670,068	1,665,698	1,670,400	1,627,136
	Value (mil. Bt)	84,975.9	100,037.4	99,567.5	92,668.2
Balance Value	Million Baht	+174,887	+164,412	+128,155	+135,616

Exchange Rate: 1 USD = 31.38 Thai Baht (April 19, 2018)

Chapter 2: Seafood industry: Prospects and Problems

2.1 Seafood industry

The averaged data showed that 74% of seawater resources were used processing and the rest 26% were used for fresh consumption (Fig 4) (Fisheries Statistics Analysis and Research Group, 2018). The processing of seawater food was categorized into human food and non-human food. Processing of human foods included chill & frozen, canning, salted-dry, fermentation, and steam & smoke. Non-human food included fishmeal, which is produced from trash fish and used for animal feed production. Chilling & frozen, canning, fishmeal, fish sauce fermentation are considered big industries with the investment values of >200. Million Baths. Salted-dry and steam & smoke are small and medium scale industry with the investment of <50 and 50-200 million Baths for the small and medium scale, respectively.

Processing of freshwater food is completely different from the seawater. Data from Fisheries Statistics Analysis and Research Group (2018) showed that 74% of freshwater resources were used for fresh consumption. Only 26% were used for processing including fermentation, salted-dry, steam and smoke, fishmeal, and other preserved products (Fig 5). Most of the freshwater food processors are small and medium scale enterprises.

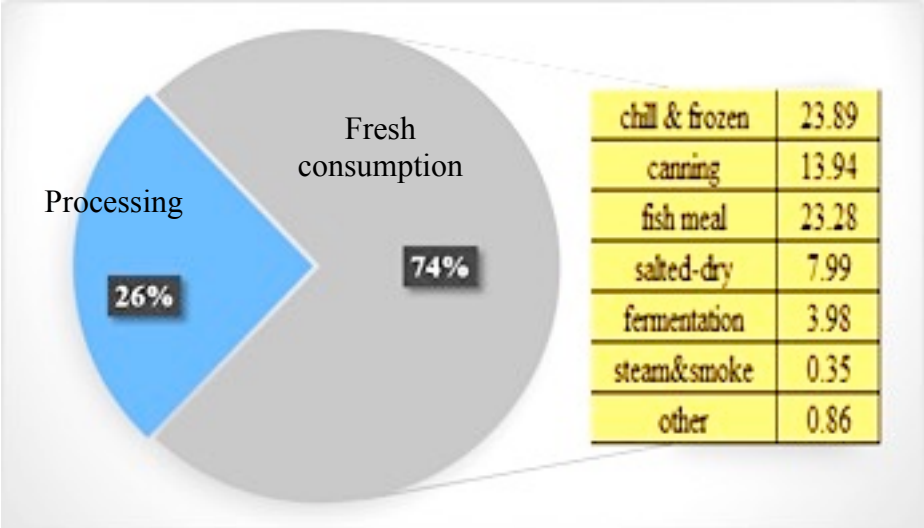

Figure 4 Utilization of seawater resources in Thailand

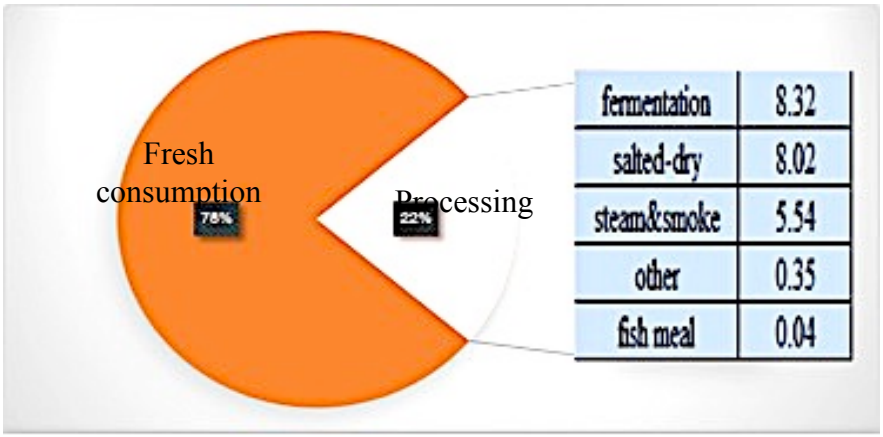

Figure 5 Utilization of freshwater resources in Thailand

Chilled & frozen shrimp and canned seafood were the first two processing industries contributing to Thai's economic. The Center for International Trade Center (2011) reported that 36.1 and 37.8 % of Chilled & frozen shrimp and canned seafood were exported, respectively. However, number of seafood processing factories in Thailand had decreased continuously during 2004-2013 (Fig 6). Reduction of captured seawater food and labor shortage were the most important problems causing the shrinkage of the industry (The Center for International Trade Center, 2011). Sustainability of seafood supply will ensure nutrient supply for people and material supply for processing industries. Education may play a crucial role in sustainability of the seafood supply. Proper educational methods can enhance the protection natural seawater and freshwater resources, as well as increase the production of aquaculture.

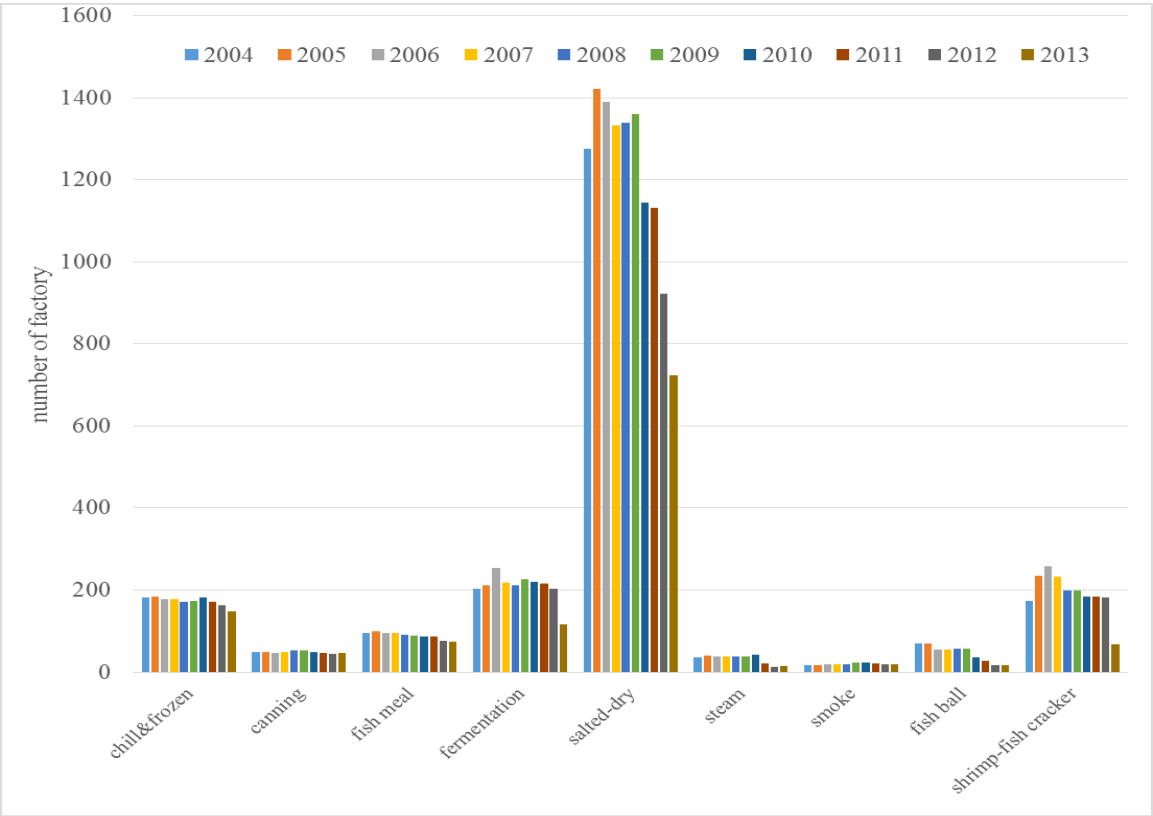

Figure 6 Number of seafood processing factories in Thailand during 2004-2013

2.2 Seafood industry and problems

Seafood in Thailand originates from two main sources, seawater/ocean and freshwater. Production of seawater food has been documented by the Fisheries Statistics Analysis and Research Group, Department of Fisheries, Ministry of Agriculture and Cooperatives, for more than 15 years. The data showed that seawater food contributes mostly to the national seafood production (Fig. 7).

Seafood is produced from two main sources; capture from natural water bodies and culture in controlled environment (aquaculture). Amounts of captured and aquaculture seawater food are shown in Fig. 7. Most of production of seawater food is obtained from the capture. High production from capturing process was recorded during 1994-2006. After that, the production had declined. The decline was caused by reduction of natural resources due to over fishing (Marine knowledge management subcommittee, 2018). To sustain the natural supply of seawater food, Thai Government announced the restricted fishing grounds, prohibited fishing during spawning season, and banned certain types fishing gears, used for harvesting fish fry and lava. The declining production was then minimized during 2008-2012 as shown in Fig 7. Aquaculture plays an important role in Thai economic and partially fills up the demand for seawater food. The production of aquacultured seawater food has been continuously increased since 1997. Shrimp (Pacific *white shrimp*; *Litopenaeus* v*annamei*), fish (sea bass), and clam (green mussel) are the most three important aquacultured species in Thailand. Freshwater food production of Thailand is showed in Fig 9. Aquaculture contributes mostly to the production. Most of the production comes from tilapia culture, followed by catfish, and Thai silver barb, respectively. The production of aquacultured freshwater fish increased during 1994-2004 and maintained at the levels of 400-425 (x1000 Ton) during 2004-2010 (Fig. 8). Rapid reduction of aquacultured fish production was reported in 2012. It was caused by the major flood of 2011. The production was slowly recovered 2013.

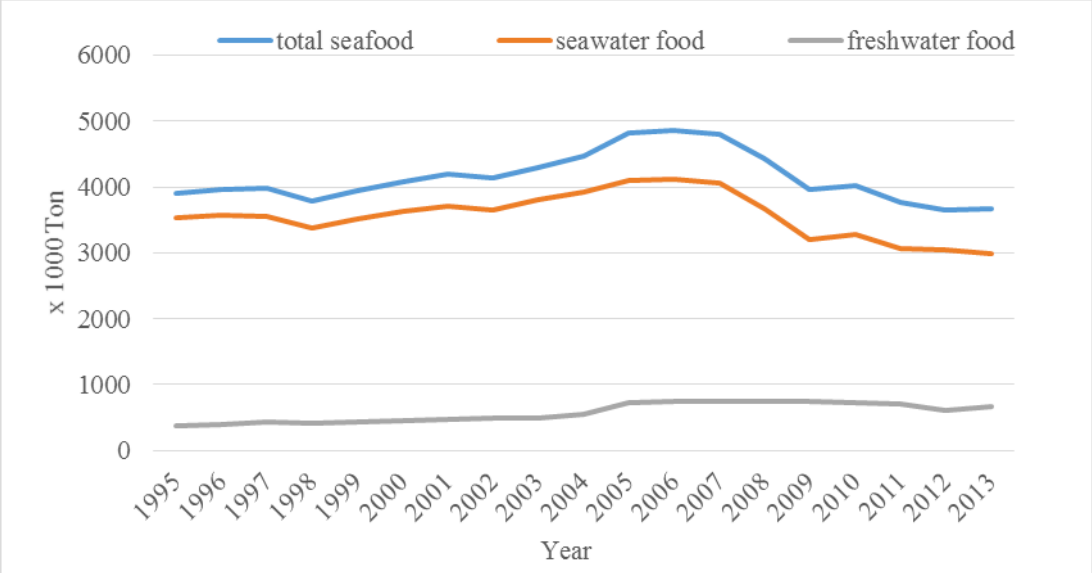

Figure 7 Total production of seafood, seawater food, and freshwater food of Thailand

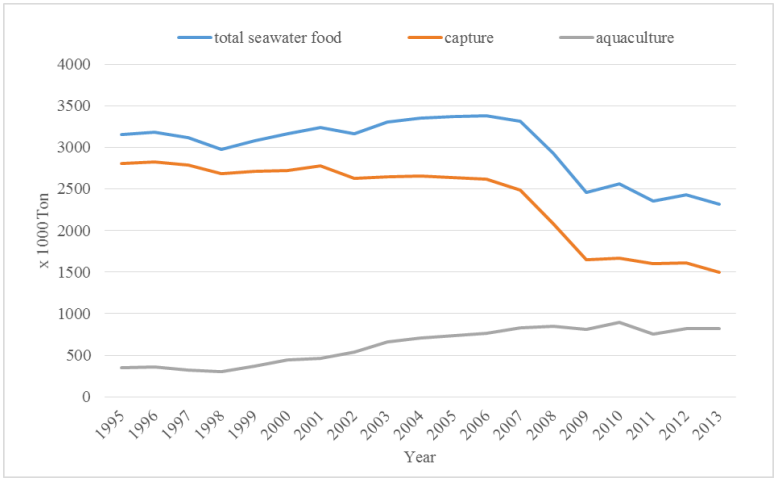

Figure 8 Total production, captured, and aquacultured seawater food of Thailand

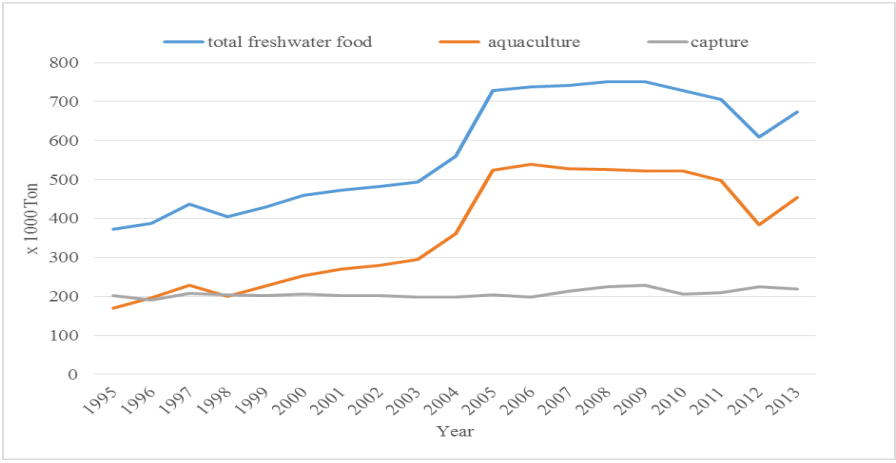

Figure 9 Total production of freshwater food, captured freshwater food, and cultured freshwater food of Thailand

Marine shrimp is the predominant species and makes a major contribution to export earnings. Over 90 percent of the cultured marine shrimp is exported. In 2007when Thai shrimp was at its peak in production it was over 500,000 tons, valued at about USD 1.75 billion. Of the total production in coastal aquaculture, marine shrimps accounted for more than 50 percent in quantity and over 90 percent in value (FAO, 2009). Marine shrimp farming in Thailand has been part of the culture for the last 80 years; however, the technology of intensive shrimp farming has expanded significantly along the coastal province in the last two decades (Tookwinas et al., 2005). The farming species are *Penaeus monodon* and then are replaced by a white shrimp, *P. vannamei* due to virus infection in *P. mondon* in the mid-90s (Fig. 10). Because of a new breeding program to promote fast growth of white shrimp and a new super-intensive farming technology have been developed from 2005 to 2008, stocking densities increased to 40 PL/m^2 to 200 PL/m^2 and yields increased to about 8,000 to 30,000 kg/ha/yr, allowing Thailand to produce nearly 600,000 tons in 2009-2010 (Miao and Lal, 2016). Then in 2011, an outbreak of early mortality syndrome or acute hepatopancreatic necrosis disease (EMS/AHPND), caused by a toxin producing strain of *Vibrio parahaemolyticus* was reported in Thailand. This EMS outbreak led to a serious decline in shrimp production to about 217,437 tons a year by the end of 2014 (Miao and Lal, 2016).

Not only viral disease infection in marine shrimp, but also the fear of disease in Tilapia has been wide spread. During 2015–2016, several outbreaks of tilapia lake virus (TiLV) infection occurred among tilapia in Thailand (Fig. 11). Phylogenetic analysis showed that the virus from Thailand grouped with a tilapia virus (family Orthomyxoviridae) from Israel (Surachetpong et al., 2017). This emerging virus is a threat to tilapia aquaculture in Asia and worldwide. In the outbreak reported by Ferguson et al. (2014) and Dong et al. (2017) fingerlings were mainly affected. Dong et al. (2017) reported approximately 90% mortality in red tilapia fingerlings within one months of stocking into cages. Mortality just over 9% in medium to large sized Nile perch was notes by Fathi et al. (2017). Due to viral infection in tilapia, it is recommended that countries that have imported tilapia for aquaculture carry out surveillance studies for its presence and also add TiLV to their import quarantine inspection list.

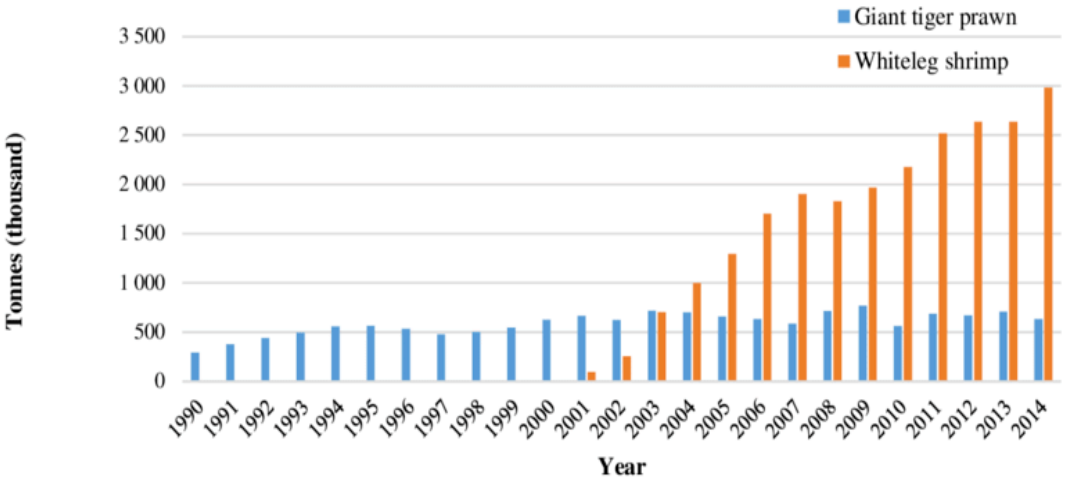

Fig. 10 Trend in *P.monodon* and *P. vannamei* production

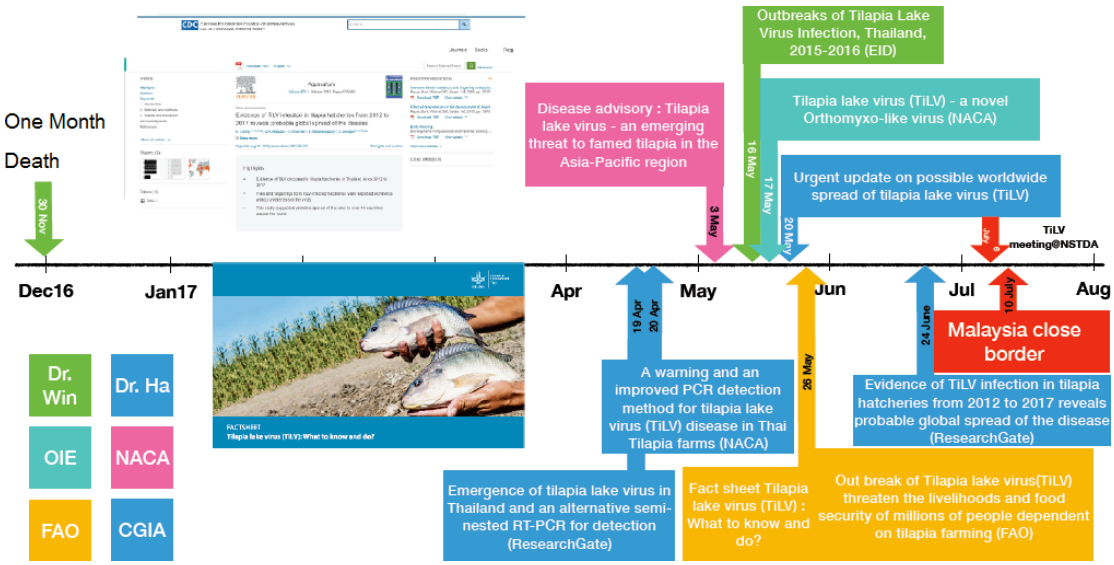

Fig. 11 The outbreaks of tilapia lake virus (TiLV) infection in Thailand

Chapter 3: Existing similar programs and curricula

3.1 Existing academic programs

As the fishing industry is a major sector of the national economy, education in fisheries science has been provided for nearly a century. Currently, there are 32 institutions offering the fisheries and aquaculture programs. Ten universities offer a higher (MSc and PhD) education in fisheries and related fields. The biggest Fisheries school is the Faculty of Fisheries, Kasetsart University with five departments: Fishery Biology, Fishery Management, Fishery Products, Aquaculture and Marine Science. Other universities offer fisheries science related programs such as Marine Science, Aquatic Science, and Fishery Technology. In some universities, fisheries science is a department in the Faculty of Agriculture, or the University offers some fishery subjects as part of science curricula. However, with the exception of the Department of Marine Science of Chulalongkorn University, most of the curricula that are offered by other universities are modeled on the curricula followed in Kasetsart University.

Aquaculture and Aquatic Resources Management at AIT provides a specialized aquaculture program. Others arrange two main options; one is the research only which focus group are part-time students, while the other is the course work and on-campus base. Most of the courses are offering too basic science based courses, sometime too specific and narrow based. Students often get into trap of too technical jargons and systems and lack how the sector could be more sustainable in relation to resource utilization and integration with other food production sectors. Teachers and students often forget about the ultimate goal is to provide seafood and nutrition security to the people for their benefits in the long run. There is no single program offering degree in that direction with special focus on seafood and nutrition security. The examples of courses offered at AIT, MJU, and KKU are shown in Table 2-4. Seminar and Statistics courses are required for Master degrees. Core and elective courses are various depending on the availability of faculty members. It is 2-year program for a master's study but it usually takes 3 years or more for students to graduate.

The main universities offering aquaculture and fisheries courses (BSc, MSc, PhD, and also short-term training courses) in Thailand are presented in Tables 2-4.

Table 2. Major universities and degree programs

Name of Universities	**Founded**	**Location (Main Campus)**	**Degrees offered**
Asian Institute of Technology (AIT)	1959 (1981)	Pathum Thani	MSc & PhD (Aquaculture and Aquatic Resources Management)
Maejo University (MJU)	1996	Chiang Mai	BSc, MSc & PhD (Fisheries)
Mahasarakham University (MSU)	1994	Maha Sarakham	BSc (Fisheries)
Nakhon Phanom University (NPU)	2005	Nakhon Phanom	BSc (Fisheries)
Naresuan University (NU)	1990	Phitsanulok	BSc (Fisheries)
Prince of Songkla University (PSU)	1967	Songkhla	BSc, MSc & PhD (Aquatic Sciences)
Silpakorn University (SU)	1943	Bangkok	BSc (Aquatic Animal Technology)
Ubon Ratchathani University (UBU)	1990	Ubon Ratchathani	BSc, MSc & PhD (Fisheries)

Burapha University (BU)	1955	Chonburi	BSc, MSc & PhD (Aquatic Sciences) BSc (Marine Technology)
Chiang Mai University (CMU)	1964	Chiang Mai	BSc (Agriculture)
Kasetsart University (KU)	1943	Bangkok	BSc, MSc & PhD (Fisheries Management, Fisheries Biology, Fisheries Product, Marine Science, Aquaculture)
Khon Kaen University (KKU)	1964	Khon Kaen	BSc, MSc & PhD
King Mongkut's Institute of Technology Ladkrabang (KMITL)	1960	Bangkok	BSc, MSc & PhD
University of Phayao (UP)	2010	Phayao	BSc
Thaksin University (TSU)	1968	Songkhla	BSc
Walailak University (WU)	1992	Nakhon Si Thammarat	BSc, MSc & PhD

Table 3 Rajabhat Universities

	Acronym	**Founded**	**Location (Main Campus)**	**Degree Offering**
Buri Ram Rajabhat University	BRU	1971	Buriram	BSc (Fisheries)
Lampang Rajabhat University	LPRU	1971	Lampang	BSc (Fisheries)
Maha Sarakham Rajabhat University	RMU	1925	Maha Sarakham	BSC (Agriculture)
Nakhon Si Thammarat Rajabhat University	NSTRU	1957	Nakhon Si Thammarat	BSC (Agriculture)
Phetchaburi Rajabhat University	PBRU	1926	Phetchaburi	BSC (Aquaculture)
Phuket Rajabhat University	PKRU	1971	Phuket	BSC (Aquaculture)
Rambhai Barni Rajabhat University	RBRU	1972	Chantaburi	BSC (Aquaculture Technology)
Sakon Nakhon Rajabhat University	SNRU	1964	Sakon Nakhon	BSc (Fisheries)
Songkhla Rajabhat University	SKRU	1919	Songkhla	BSC (Aquaculture)
Suratthani Rajabhat University	SRU		Surat Thani	BSC (Aquaculture)
Ubon Ratchathani Rajabhat University	UBRU	1947	Ubon Ratchathani	BSc (Fisheries)

Table 4. Rajamangala Universities of Technology system

	Acronym	Founded	Location (Main Campus)	Degree Offering
Rajamangala University of Technology Isan	RMUTI	1975	Surin	BSc (Fisheries)
Rajamangala University of Technology Lanna	RMUTL	1975	Lampang Phitsanulok Nanhttps://en.wikipedia.org/wiki/Chiang_Mai	BSc (Fisheries)
Rajamangala University of Technology Srivijaya	RMUTRV	1975	Tranghttps://en.wikipedia.org/wiki/Songkhla	BSc (Fisheries)
Rajamangala University of Technology Suvarnabhumi	RMUTSB	1975	Phra Nakhon Si Ayutthaya	BSc (Fisheries)
Rajamangala University of Technology Tawan-ok	RMUTTO	1975	Chonburi	BSc (Fisheries)

The Office of the Higher Education Commission (OHEC), Thailand has a significant mission to encourage full-fledge quality assurance systems within all public and private higher education institutions by providing policy guidelines, supporting for knowledge sharing activities, and implementing related international projects. The quality systems are the external quality assurance (EQA) has been conducted by the Office for the National Education Standards and Quality Assessment (ONESQA) while the internal assurance (IQA) has been prepared in the form of self-study report by higher education institutions. OHEC has launched the second phase of the quality assurance system in academic year 2014, encouraging higher education institutions to conduct quality assurance at the level of program of study, faculty and institution. Every program has to update at least every 5 years. For graduate programs, research skills and self-study must be highlighted. Thailand has established a standard credit system which is presented in Table 5.

Table 5 The minimal credit hours to fulfil the degrees (Thailand Qualifications Framework B.E. 2548)

Education Level	Credits
BS • General Education • Core courses • Elective courses	At least 120 • 30 • 84 • 6
MS • Research-based • Research + course work	At least 36 • Thesis + Seminar + Research Methodology • Thesis + Seminar + Research Methodology + courses
PhD • Research-based • Research + course work	At least 48 • Thesis + Seminar + Research Methodology • Thesis + Seminar + Research Methodology + courses

3.2 Existing curricula

Courses at the Asian Institute of Technology (AIT): Aquaculture and Aquatic Resources Management (AARM)

Asian Institute of Technology (AIT) has produced over 500 graduates (MSc & PhD) in the field of aquaculture / fisheries, and trained over 1,000 government officials and private company managers/ entrepreneurs from Bangladesh, Cambodia, Malaysia, Nepal, Thailand, India, Laos, Vietnam and several others from African, American, Australian and European countries. Courses offered are presented in Table 6. The short-term training courses offered by AIT help update knowledge on recent developments in the field and provide opportunities to acquire specialized skills. A wide range of training courses are taught by the experts in the field of Aquaculture, and also external resource persons who have experience of over 20 years or so. The following courses are offered occasionally which are listed below:

Table 6 Course offered at AIT as regular MS/PhD degrees

Course code	**Course name**	**Semester**	**Credits**
ED71.04	Aquatic Seed Production	August	3(30-45)

ED71.09	Coastal and Inland Fisheries Management	January	2(30-0)
ED71.25	Aquaculture and Aquatic Resource Systems	August	2(30-0)
ED71.26	Coastal and Inland Aquaculture	August	2(30-0)
ED71.28	Aquaculture Planning and Management	January	2(30-0)
ED71.29	Genetics and Biotechnology in Aquaculture	January	2(15-45)
ED71.36	Aquaculture Nutrition and Feed Technology	August	3(30-45)
ED71.37	Wetlands Ecosystem Management	August	2(30-0)
ED71.44	Coastal and Marine Social Ecological Systems	InterSem	2(30-0)
ED71.45	Guiding Principles of Integrated Coastal Management	InterSem	1(15-0)
ED71.47	Coastal Project Design	InterSem	3(15-90)
ED71.48	Sustainable Intensification of Aquaculture	August	2(30-0)
ED71.49	Aquaculture Business Management	August	2(30-0)
ED71.50	Health Management in Aquaculture	January	2(15-45)
ED71.51	Water Quality Analysis in Aquaculture	January	2(15-45)
ED71.52	Research Workshop	January	2(15-45)
ED71.53	Tools and Strategies for Integrated Coastal Mangt	August	3(45-0)
ED71.54	Aquatic Biodiversity and Ecosystem Management	January	2(30-0)
ED71.55	Statistics for Aquaculture and Fisheries Management	January	3(30-45)

AIT also developed 1-year Professional Masters Degree Program in Aquaculture Business Management with a view to offer business oriented program that combines the technical skills as well as gives business management ideas (Table 7).

Table 7. List of courses with their credits for professional Aqua-business

List of Courses/Semester	**Credits****
Semester 1: January-May (14 Credits)	
Required courses:	
Aqua Business Management: Principles and Practices	2
Global Aquaculture Business - Managerial Perspective	2
Business Communication	2
Elective courses:	
Strategic Marketing of Aquatic Products & Services	2
Aquaculture Certification and Quality Control	2
Aquaculture Economics and Managerial Accounting	2
Aquaculture Project Management	2
Aquaculture Systems Analysis	2
Aquaculture Seed Business	2
Inter-Semester: June-July: Aquaculture Business Research or Case Study: (Individual Project)	5
Semester 2: **August-December at AIT (14 credits)**	
Required courses:	
Managing Technology	2
Aquaculture Supply Chain Management	2
Entrepreneurship and Aquaculture Business Plan Development	2
Elective courses:	
Corporate Social Responsibility and Ethics	2
Post harvest Management and Food Safety in Aquaculture	2
Decision Making and Negotiations in Aquaculture Business	2
Seafood Trade and Business Law	2

Statistics for Managers	2
Environmental Management & Sustainable Aquaculture	2
Aquaculture seed/Feed Business	2

**Notes: *Minimum credits required for each semester is 14.*
Total credits required for the degree is 33.

Table 8. MS Fisheries Technology, Maejo University

First Year 1

Semester 1	Credits	**Semester 2**	Credits
FB 571 Biological Techniques in Fisheries	3	FM 511 Fisheries Resources and Aquatic Environmental Management	3
FA 511 Aquaculture Technology	3	FB 581 Fishery Biotechnology	3
FT 511 Research Methodology in Fisheries	3	FT 699 Thesis	2
		(Elective course)	3
FT 597 Seminar 1	1	FT 598 Seminar 2	1
(Elective course or English for graduate study)	3		
FT 698 Special Problems for Graduate Study	1		
Total	14	Total	12

Second Year 2

Semester 1	Credits	**Semester 2**	Credits
FT 699 Thesis	8	FT 699 Thesis	8
Total	8	Total	8

Table 9. Masters in Sustainable Agriculture from Khon Kaen University

Core course	Expertise based course	Module/credit	Course name/credit
Statistics methodology Seminar in Agri I Seminar in Agri 2	Sustainable live-stock production	7 modules (15 credit)	
	Sustainable land resource and management	5 modules (15 credit)	
	Sustainable crop production and safety	5 modules (15 credit)	
	Suitable fruit and vegetable production	5 modules (15 credit)	
	Sustainable aquaculture and processing	8 modules (15 credit)	Module 1: Fish Breeding and Production Planning/2
			Module 2: Sustainable Aquaculture /2
			Module 3: Fish Diseases and Diagnosis/2
			Module 4: Fish Disease Control and Health Management/2
			Module 5: Fish Nutrition/2
			Module 6: Fish Feed and Alternative/1
			Module 7: Post-harvest

			Technology for Aquatic Animal/1
			Module 8: Preservation and Value-addition Technology for Aquatic Animal/3

Table 10. Kasetsart University, MS (Fishery Science and Technology), Min. 36 credits

First Year 1

Semester 1	Credits	**Semester 2**	credits
Fishery Resources and Food Security	3	Seminar 2	1
Research Methods in Fishery Science and Technology	3	Elective courses	9
Seminar 1	1		
Elective course	3		
Total	10	Total	10

Second Year 2

Semester 1	credits	**Semester 2**	credits
Thesis	6	Thesis	6
Elective course	3	Elective course	2
Total	9	Total	8

Table 11. Prince of Songkla University: Faculty of Natural Resources**,** M.S. (Aquatic Sciences)

	Total: 36 credits
Core courses	
Biological Statistics and Research Methodology	4
Advanced Aquatic Resources Management	3
Seminar 1	1
Seminar 2	1
Special problem	3
Thesis	18
Elective courses (at least 6 credits)	
Aquatic Science	
Aquatic Ecology	
Lotic Ecology	
Coastal Benthic Fauna and Applications	
Fishery Science	
Fish Population Dynamics	
Chemical Oceanography	
Estuarine Oceanography	
Coastal Process and Morphology	
Air-Sea Interaction	
Advanced Technology in Aquaculture	
Advanced Aquatic Animal Diseases	

Shrimp Pathology Advanced Aquatic Animal Nutrition Quantitative Genetics for Fish Improvement Freshwater Resources Management Coastal Resources Management

3.3 Existing Vocational Education Training (VET) course:

Vocational training courses offered by AIT

Course 1: Recent Advances in Tropical Aquaculture
This training course provides basic principles of aquaculture, its role in rural development, food security and income generation. In addition, gives a lot of ideas about where and how a person can set-up a fish farms as a business. This course is suitable for beginners who have simple biology or agriculture background and want to start farm immediately.

Course 2: Commercial Tilapia Hatchery & Grow-out Techniques
This course includes a 2-3 hr lecture each day followed by 3-4 hrs hands-on practice on producing millions of high quality tilapia fry and table fish. In addition, it gives a lot of ideas about where and how tilapia farming can be applied. This course is suitable for those who want to start tilapia business / farm immediately or who want to provide consultancy to others. Using the technology, some of the farmers in Thailand have produced over 30 million fry per month i.e. 1 million a day (which is over 10,000 USD/day revenue). Many people say its hard to believe but this is happening in Thailand. Only those who join the training will know it and feel its value. Practical: Brood preparation, harvest, cleaning, weighing, incubation, MT feed preparation, feeding, nursing, grading, conditioning, packing & selling

Course 3: Shrimp / Prawn Farming
Thailand is no. 1 in shrimp export in the world. Every year Thailand earns US$ 2-3 billion. Production ranges from 6-10 tons per hectare. When price was good, last year a farmer in Surat Thani showed the calculation of US$45,000 net profit from a hectare pond. So managing a few ponds would sufficiently give good income. But training is necessary to make that happen.

Course 4: Catfish / Pangasius Culture
The hatchery where our trainees are taken for practice produces and sells over 5 million catfish fry in a single day. The Manager says, demand reaches up to 10 million a day but that is too much work to do. Its again hard to believe but this is happening in Thailand. Our trainees inject the fish, and assist in stripping several kilos of eggs; and will have no question on how manage such a large-scale hatchery. Practice: Hormone injection, stripping, incubation etc.

Course 5: Farm Design and Planning
Course 6: Asian Sea bass / Baramundi Breeding, Nursing & Grow-out
Practice & field visit in Private farms
Course 8: Feed Formulation and Feed Manufacture
Course 9: Aqua-ponics

Course 10: Research Design and Data Analysis In this course: It includes a hands-on practical session (3 hrs) after each theory session (1:30 hrs) starting from simple statistical functions in MS Excel then use of SPSS, MiniTab etc.
Course 11: Aquaculture Business Planning & Management:
This course has been designed, upon request, for the Executive / Senior Managers, CEOs and Consultants with or without technical background but are planning to start aqua business or provide supports to others.

VE Training organized by the Network of Aquaculture Centres in the Asia Pacific (NACA):

1. Marine finfish seed production and grow-out training course, July 2018, Thailand
2. Regional Training Course on Culture-based Fisheries in Inland Waters
3. Broodstock management in aquaculture: Long term effort required for regional capacity building
4. Workshop on sustainability of small-scale freshwater aquaculture: Group 1
5. Good aquaculture practices (GAP)
6. Study tour on aquaculture and wet land management
7. Hatchery and Nursery management of grouper: A best-practice manual
8. Training Workshop for Cluster Certification Trainers
9. Better Management Practices for Striped (Tra) Catfish Farming
10. Training of Trainers: Strengthening capacity of small holder ASEAN aquaculture farmers
11. SPC Marine Finfish Hatchery Training Course
12. Strengthening Aquatic Animal Health Capacity and Biosecurity

3.4 Best practices

Internship: AARM uses facilities of Thai government and non-government organizations, and private aquaculture farms in Thailand and other countries e.g. Bangladesh, Nepal and Vietnam. Internship in these organizations is arranged for students who would like to spend few months in Asia and at the same time gain real work experience in these organizations as course credits.

Research: Research is an integral part of the academic degree. Therefore, it should be selected based on the need of the communities. Students are also encouraged to select research topics relevant to their own careers and conduct research in their own countries. They are taught to identify real world problems related to aquatic resources and to use participatory problem solving approaches to develop practical solutions that can be implemented at local level. Students also undertake their thesis research on campus using field facilities, well-equipped laboratories and hatcheries. The followings were the topics of research for last three decades:

- Small-scale aquaculture
- Seed production and genetics
- Aquaculture nutrition and feed technology/ management
- Participatory approaches to aquatic resources management
- Integrated coastal management
- Regional education development

Outreach: Since early 90s, aquaculture program was been actively working on capacity development of institutions mainly through training of their officials and upgrading their education system especially in Laos, Thailand, Vietnam, Cambodia and Bangladesh. More recently, AARM has introduced innovative approaches to post-graduate education in aquaculture and aquatic resources management in Bangladesh, Cambodia, Nepal and Vietnam. There was a program called, 'Wetland Alliance" composed of AIT, WWF, WorldFish Center and Coastal Resources Institute (CORIN) worked with 30 partner organizations in Cambodia, Laos, Thailand and Vietnam for poverty alleviation, wetlands management, and sustainable local development. Continuing the efforts of AARM's Outreach Programme, the Alliance offered faculty and students with opportunities and encourages them to engage in research and educational activities that are of critical relevance for local Alliance partners.

Chapter 4: Gap analysis

Demand for seafood is increasing and a wide variety of problems are arising. More experts and professionals are in need for the support of industry. However, the institutions which prepare professionals and researcher to serve this expanding industry, higher education institutions are themself facing challenges such as: Aquaculture or Fisheries degrees are less attractive, declining trend in student enrollment, poor employability, employers have low satisfaction rate with graduates. These indicate that there is something wrong with curriculum, teachers, or institutional system. It is quite critical especially in Thailand.

A number of institutions exist in Thailand to play role in making seafood industry sustainable. For example, Department of Fisheries (DoF) under the Royal Thai Government, Food and Agriculture Organization of the United Nations (FAO-UN), Network of Aquaculture Centers in the Asia Pacific (NACA), South-East Asian Fisheries Development Centre (SEAFDEC) and so on. Most of these organizations focus on high level planning and policy-making, which involve organizing regional, national level workshops, consultation meetings and conferences. Despite their efforts, seafood industry in Thailand is still suffering by several setbacks time and again. It is our claim that field level research to generate accurate knowledge and real time information then use for education and extension are needed to make the industry more sustainable.

A high quality education is required for human resource development, innovative technology generation, research conduct, and also policy making. However, the existing aquaculture and fisheries curricula seems not adequate since the improvement of program will be conducted every 5 years leading to not up-to-date programs. As it takes time for curriculum development and improvement, the short course training might be an alternative way to cope with this problem. Internship or research training abroad is needed for Thai students; however, they might face the difficulty in English communication.

In recently year, Thai seafood products have been in the European Union Commission's illegal, unreported and unregulated (IUU) fishing watchlist, traceability system including fishing gears used. There is a pressure to improve the fishery resource and habitat management, vessel lists, law and regulation enforcement and so on. Considering

the fisheries management is important many universities are offering Fisheries Management program. Despite the large number of Fisheries management programs, and large number of people graduated, fisheries management has been tough, and fish catch is still declining. Traditional fisheries courses are not effective enough. There is a great need to have new way of thinking in fisheries management.

Some of the courses could be very useful such as Fisheries Governance and policies, Fishery Sector Management, Coastal resources Management, Gender and fisheries Sea grasses and seaweed conservation, Coral Reefs and their Restoration, and Sea plastics and pollution control. The SSNS partners in Thailand have been critically analyzing their curricula, comparing with other universities, and identifying missing gaps with a view to develop an attractive curricula to develop "Sustainable Seafood" MSc program.

4.1 Asian Institute of Technology (Lead Partner, P1)

AIT is the one first realizing the need of a new curriculum for "**Sustainable Seafood and Nutrition Security (SSNS)**" program proposing the idea for this project. Aquaculture program at AIT has been passing through a series of changes since its establishment in 1981 following regular curriculum development programs (every 4 yours), consultations with stakeholders, feedback survey from its alumni global network and so on. Therefore, a brief description on its historical background of how AIT felt the need of SSNS i.e. current proposal would serve the purpose in this context.

AIT was established in 1959; however, Aquaculture as a separate program started only in 1981. Since the beginning systems approach or a holistic approach was used in education, instead of traditional systems of rote learning that still exists in much of Asia. AIT established Aqua-Outreach program having field-based offices in Cambodia, Lao PDR, Thailand and Vietnam to collect baseline data, and also conduct participatory research with farmers. Farmers were considered the ultimate beneficiaries and their improvement in their livelihood was the main target. Therefore, working with them for research and development, they learned the lessons and experiences and incorporate into their curriculum. More importantly, AIT Aquaculture program assisted many universities and vocational colleges in these SE nations to develop or revise their existing curricula based on the changing needs. Most of the universities and colleges had fisheries, fishing technology or in other forms within Zoology, natural sciences or Agriculture faculties. Globally fish catch was dwindling. AIT had realized the value of aquaculture, and it is the only way to compensate decline in fisheries. AIT's specialized Aquaculture programme was to promote sustainable aquaculture in Asia or beyond. Initial courses were as follows (Table 12, AIT, 1994):

Table 12. Courses offered at the beginning of aquaculture at AIT

Aquaculture courses	**Supporting courses**
1. Aquaculture systems	Systems approach to Agriculture Development
2. Fish Breeding	Livestock production systems
3. Fish Nutrition and Feed Technology	Crop production systems
4. Integrated farming and Waste water recycling	Farm economics
5. Experimental design & Analysis in Aquaculture	Agricultural Devt. and planning
6. Water Quality Analysis and Management	Project planning & implementation

7. Fish bio-energetics	Agricultural sector analysis
8. Fish diseases	Soil fertility management
9. Aquaculture and the Environment	Remote sensing and GIS
10. Coastal aquaculture	

AIT's aquaculture has gone a number of changes. Once it was combined with agriculture systems program, and offered as some sort of hybrid program combining with agriculture sector so that graduates could do better in terms of farming systems as farming in reality is a combination of several things e.g. rice paddies, livestock, poultry, vegetables, fruits and so on. There was a time of inter-disciplinary approaches. AIT had Integrated Tropical Coastal Zone Management program which means planning for aquaculture development involves all aspects of water, land, forest, and coastal resources. A program was developed and offered for about 5 or more years. AIT offered degrees focusing on three key issues:

Aquaculture Technology (AT)

AT Aquaculture production accounts for almost half of world fish supply. Asia contributes over 90% of global aquaculture production and plays a key role in the development of appropriate culture systems and technologies. Aquaculture production increases by 6-7% and it is expected to surpass capture fisheries production in the next 10 years. Further development of aquaculture is also expected to help us move away from dependency on overexploited capture fisheries resources and to enhance and conserve aquatic habitats and biodiversity, but this expansion should not exceed the carrying capacity of water resources.

Courses

- Aquaculture and Aquatic Resource Systems
- Aquatic Seed Production
- Coastal and Inland Aquaculture
- Aquaculture Nutrition and Feed Technology
- Aquatic Animal Health Management
- Genetics and Biotechnology in Aquaculture
- Analytical Techniques in Aquaculture
- Aquaculture Engineering and Water Quality Management
- Aquaculture Planning and Management
- Seminar on Recent Developments in Aquaculture and Aquatic Resources Management
- Statistical Applications in Aquaculture and Aquatic Resources Management
- Thesis Research Workshop
- Internship in Aquaculture

Aquatic Resources Management (ARM)

Wild aquatic resources are essential sources of nutrition for rural populations. Any degradation of these resources due to over-fishing, use of illegal fishing gears, introduction of exotic fish, misuse of chemicals, and agro-industrial waste discharge, deforestation and breeding ground destruction and dam constructions that can lead to blocking of migratory pathways will have dramatic impacts on the nutritional and health status of rural people.

Courses

- Aquaculture and Aquatic Resource Systems

- Aquatic Ecosystem Assessment and Management
- Aquatic Biodiversity and Conservation
- Tools for Aquatic Resource and Environmental Assessment
- Wetland Ecosystem Management
- Coastal and Inland Fisheries Management
- Geo-informatics for Resources Planning and Management
- Seminar on Recent Developments in Aquaculture and Aquatic Resources Management
- Statistical Applications in Aquaculture and Aquatic Resources Management
- Thesis Research Workshop
- Internship in Aquatic Resources Management

Integrated Tropical Coastal Zone Management (ITCZM)

Population growth, poverty, resource use conflicts, illegal activities, pollution, biodiversity conservation, policy and institutional gaps and conflicts are the major issues and problems in coastal management. A management approach that integrates sectors (government agencies, non-government organizations, community, etc.), disciplines (science, engineering and management), land- and sea-based activities (agriculture, livestock, aquaculture, fisheries, tourism and so on) is important to address the various issues and problems in the coastal area.

Courses:

- Marine and Coastal Ecosystems
- Principles of Integrated Coastal Management
- Tools for Integrated Coastal Management
- Workshop on Integrated Coastal Management
- Seminar on Recent Developments Integrated Coastal Management
- Thesis Research Workshop
- Internship in Integrated Coastal Management
- Elective courses from other fields of study such as:
    - Rural and Regional Development Planning
    - Natural Resources Management
    - Gender and Development Studies
    - Urban and Environmental Management
    - Environmental Engineering and Management
    - Geotechnical and Geo-environmental Technology
    - Water Engineering and Management
    - Remote Sensing and GIS and related courses from the School of Management

Certificate and Degree Programs

- Certificate program (9-12 credits, 1 semester)
- Diploma program (26 credits, 2 semesters)
- Professional masters program (32 credits, 2 semesters & 1 intersem)
- Regular masters program (48 credits, 4 semesters for full time, 6 semesters for part-time)
- Doctoral program (84 credits, 6 semesters)

Aquaculture started from rural and subsistence based. Over the period it has developed highly commercial and corporate level. Realizing the need of human resources,

especially managerial staff, and to attract private funding, a Professional Aquaculture Business Management program (AqBM) was developed. It was felt that aquaculture program was providing only technical skills, but for business, they also need managerial knowledge and skill. Therefore, the courses were developed combining some MBA courses of AIT (School of Management) and existing aquaculture technical courses. The program was initially launched in Vietnam after having a survey of stakeholders was conducted with the help of VASEP (Vietnamese Seafood Exporters and Producers) and other partners. It was well received to offer. However, due to managerial problem, it could not be continued. Same program and courses were also offered at AIT, Thailand. It seems students in this sector still look for donor supports for higher degrees. Hardly few have been seen to be willing to pay fees. Therefore, availability of education fund is very important for any sector to survival or flourish.

These experience show there is no easy and magic solution to attract more students with a view to developing human resource and make the sector sustainable. Recently during a faculty meeting at AARM, the following courses, categorized into two streams of specialization; aquaculture technology and fisheries management are being offered as listed in Table 13.

Table 13. Recent courses rearranged in 2017.

<table>
<tr><td colspan="2">AARM Course</td></tr>
<tr><td colspan="2">Required courses:
1. ED1.25 Aquaculture and Aquatic Resource Systems
2. ED1.26 Coastal and Inland Aquaculture
3. ED1.51 Water quality analysis for aquaculture
4. ED1.55 Statistics for Aquaculture and Fisheries Management</td></tr>
<tr><td colspan="2">Specialization</td></tr>
<tr><td>A: Aquaculture Technology</td><td>B: Fisheries Management</td></tr>
<tr><td>1. Genetics and Biotechnology in Aquaculture
2. Aquaculture Nutrition and Feed Technology</td><td>1. Coastal and Inland Fisheries Management
2. Aquaculture Planning and Management
3. Wetlands Ecosystem Management
4. Coastal and Marine Social Ecological Systems</td></tr>
</table>

The first two semesters in the regular masters and doctoral programs are devoted for coursework. Thesis and dissertation research are conducted after the first year.

AIT is building on to curriculum development program in the field of aquaculture and aquatic resources management. AIT improved the curricula of Aquaculture in Cambodia, Nepal and Vietnam with the support of EU under Asia Link Programme during 2005-2008. Five major themes were agreed and established as essential topic to develop as courses from existing courses. Aquaculture systems, Aquaculture Nutrition, Aquatic Seed production, Water quality management, and Fish Diseases and Health Management. The teachers who were teaching the same subjects in all the partner institutions gather together to develop a common courses outline. Later adapted to local condition. The developed new course outlines were implemented in their respective institutions and again improved based on the feedback form students and other stakeholders.

During the implementation of this project, the Project Team realized the need of internship program that was later developed as a proposal and submitted to EU. It was also awarded for implementation. With the project support, Aqua-Internship programs were developed in each partner institution linking with private and public organizations. Students were sent to the field to get hands on experience as well as identify the problems faced by the farmers and real field practitioners. SSNS curriculum development another step build up from the previous efforts.

Around the time of development of this proposal, AIT formed a working group involving its faculty members immediately after 17 Sustainable Development Goals (SDGs) were established and promoted by the United Nations (UN). One of the Vice Presidents was playing the key roles for the initiative, when he was at UN. AIT had a plan to develop some proposal for overall food security and Zero Hunger goal along with others. Taking this opportunity, aquaculture group came up with the idea of SSNS, which means Fish or seafood as the vehicle for Zero Hunger goal. Attempts have been made to align the curricula with the Sustainable Development Goal 2 i.e. Zero Hunger, of the United Nations. There is an opportunity if SSNS program could be made valuable to these SDG goals, supports

4.2 Maejo University (Partner 2)

The Faculty of Fisheries Technology and Aquatic Resources of Maejo University had conducted a focus group discussion on April 27, 2018. This meeting consisted of 3 representatives from stakeholders who hire our graduates, 4 students, and 8 teaching staffs. As the MSc curriculum of Fisheries Technology had been recently adjusted, we are not able to develop the new M.Sc. program. The number of students who are interested in joining program is quite low. However, from the meeting we got the idea to improve the program when it is possible (maybe in next three years). According to the specialized of faculty and the area of the study, they suggest the improved MSc courses should contain subjects in aquaculture, aquatic resource management, and aquaculture business including value-added product development. Moreover, this program must support the government policies in fisheries and aquatic resource management. New graduates might have a potential to start their own business. The new improved program should be unique. Two new courses might be generated including an innovation in fisheries sciences and aquaculture business management.

The Faculty of Fisheries Technology and Aquatic Resources of Maejo University had conducted a focus group discussion (Fig 12) on April 27, 2018. This meeting consisted of 3 representatives from stakeholders who hire our graduates, 4 students, and 8 teaching staffs. As the MSc curriculum of Fisheries Technology had been recently adjusted, we are not able to develop the new M.Sc. program. The number of students who are interested in joining program is quite low. However, from the meeting we got the idea to improve the program when it is possible (maybe in next three years). According to the specialized of faculty and the area of the study, they suggest the improved MSc courses should contain subjects in aquaculture, aquatic resource management, and aquaculture business including value-added product development. Moreover, this program must support the government policies in fisheries and aquatic resource management. New graduates might have a potential to start their own business. The new improved program should be unique. Two new courses might be generated including an innovation in

fisheries sciences and aquaculture business management. Students should conduct their theses based on the requirement of private and government sectors as well as communities. Moreover, students should have gained their experiences in working or conducting a research with private company or communities. In addition, committees must regulate them to finish their degrees on time.

Figure 12. Meeting at Maejo University

4.3 Khon Kaen University (Partner 3)

Division of Fisheries is one among the nine divisions in the faculty of Agriculture, Khon Kaen University. It was established in 1990 and offered a B.Sc. program for the first batch of 15 students in 1991. After offering the B.Sc. course for 19 years and having well-qualified teaching staffs, the division had launched a M.Sc. and Ph.D. program in 2010. Recently, the division has 10 teaching staffs in the fields of aquaculture (3), fish nutrition (2), fish pathology and immunity (2), fish biology and ecological science (2), and fish processing (1). Students compose of 130 undergraduate students, and 9 graduate students (4 M.Sc. and 5 Ph.D.).

The graduate programs are mainly focused on advanced courses in Fisheries. Along with the courses, core courses (statistics and research methodology, and seminars), used for strengthening academic capability, are compulsory. After graduating, most of graduate students work as researchers or teaching staffs in academic institutes such as universities, and government agencies.

Recently, Thailand is stepping in an aging society due to the low birth rates, thus composing high percentages of elderly population with the age > 60 years old. The reduction of birth rate has lowered the number of student entering into education systems, including university. Number graduate students in division of Fisheries tends to decline (Figure 1). Several reasons can be accounted for the decline.

Firstly, B.Sc. graduates tend to join private companies. Most of undergraduate students

in the division of Fisheries come from the northeastern region of Thailand, considered the poorest area of the country. They mostly rely on government loan for their study. The loan needs to be paid back when they work. Overwhelmed by the debt, the B.Sc. graduates tend to join private companies, offering high salary, in state of pursuing a higher degree.

Secondly, number of teaching staff in Thai universities has been reduced. Number of teaching staff in Thai universities relies mainly on number of student, which is referred as staff-to-student ratio (SSR). Declining number of student consequently decreases the number of teaching staff. Undergraduate students, aiming to work as a teaching staff in universities, are reluctant to pursue a higher degree due to the limitation of future position.

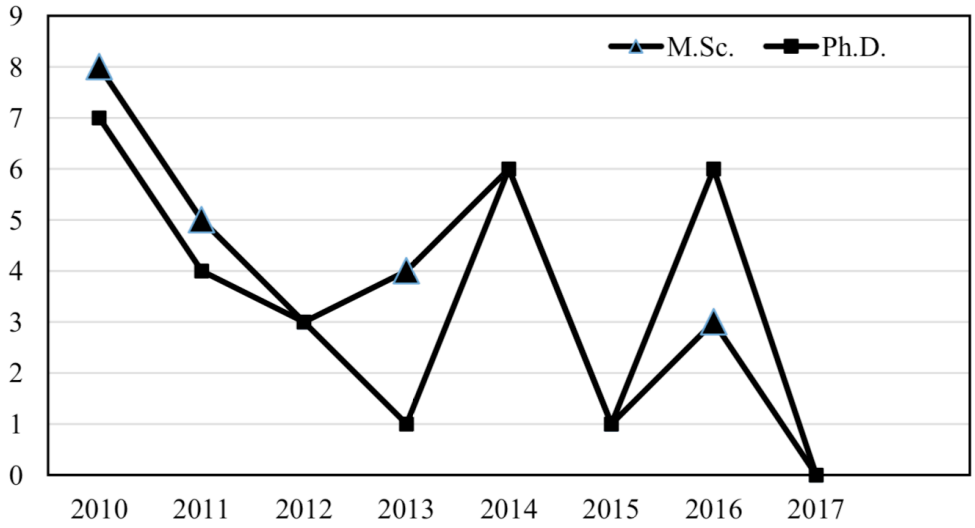

Figure 14. Number of graduate students at Fisheries Division, Khon Kaen University

Competition between Thai universities, offering the same Fisheries program, reduces the number of graduate student. In the past, Thai universities had launched countless number of graduate programs, especially the M.Sc. In the northeastern region of Thailand, there are at least 5 universities offering M.Sc. programs in Fisheries, including 3 major universities, Khon Kaen University, Mahasarakan University, and Ubol Ratchatani University. The others are Rajabhat and Rajamangala Universities. Therefore, number of students joining each institute is low. The oversupply programs, unable to recruit graduate students, have to be closed. The samples were found in the faculty of Agriculture, Khon Kaen University, the international programs in Agronomy and Animal Sciences were demanded to close by the university council in May 2018.

In 2015, the division of Fisheries had as many as 15 students (7 MSc and 8 Ph.D.). However, it was obvious that no student enrolled in 2017. During the period of student reduction, the division had a new group of student, those aiming to work for their own SME fish processing company and farm. These students will run their SME fish processing companies and fish farms, handed down from their parents. In addition to that, the recent trend of self-employed and business startup is well accepted among young generations. The job of graduate students is no longer limit to researchers or teaching staffs in government agencies. The graduates may join SME companies or run their own companies. The SSNS curriculum should be adapted to suit this circumstance.

Focus group

Focus group was arranged (Fig 13) on 12 June 2018 at the division of Fisheries to find study courses and vocational training programs, suitable for the SMEs fish processing and fish farm. The focus group consisted of 6 teaching staffs from the division of Fisheries, 4 students, 6 representatives from companies. Representatives joining the focus group at the division of Fisheries, Khon Kaen University on 12 June 2018 composed of SMEs, teaching staffs, and students, may provide information about study courses and training programs suitable for SMEs.

Figure 13. Meeting at Khon Kaen University to discuss about the SSNS program

Needs, finding and missing

At the beginning, background of SSNS project and Fisheries courses, offered by KKU, AIT, and Maejo University, were presented. Members of the focus group discussed and proposed possible SSNS courses, training programs, and other required technical knowledge. Information from focus group are shown as follows;

1. Small enterprises in aquaculture and fish processing needed courses related R&D such as research methodology, feed formulation, innovation, fish product development, quality control, and business development. Medium enterprises in aquaculture and fish processing needed courses related to R&D, innovation, and quality control. Large enterprises needed mainly advanced technologies for product analysis. In addition to that, the large enterprise needed human resource development such as professional and internationalized characters.
2. Based on the requirements of small and medium enterprises, courses offered in SSNS program should include;
   2.1 Compulsory course (statistics and research methods, seminars, and thesis) are required to ensure that R&D work is carried on according to scientific methods.
   2.2 Compulsory elective courses, offered in SSNS program, should be updated. And, the courses should contain "production to processing" courses, covering information from upstream-downstream fish industries. Courses, offered in SSNS program, should be a combination of aquaculture, fish processing, and promotion/business management. The possible compulsory elective courses are shown in Table 14.

2.3 M.Sc. internship may full fill the needs of R&D work. The internship may be a part of students' thesis. SMEs can be the sites for on-farm/on-factory research. The research must benefit or partially benefit the SMEs. And, students must be clearly informed about the internship project, and agree to do R&D work that serves the needs of companies.

Table 14 Possible compulsory or elective courses for SSNS program

Field	**Course name***	**Contents***
Aquaculture /fish production	Fish production and broodstrock management	- Genetic and broodstock management - Fish breeding - Production plan - Operation of machine and cellphone/remote control/electronic devises in fish farms - Law related to animal welfare - Farm certification and certification bodies
	Feed formulation and alternative feed material	- Computer program for fish feed formulation - Alternative low-cost feed materials - Advanced techniques in feed analysis
	Fish disease and water quality control	- Water quality control - Remote sensing for water quality control - Rapid method for water quality assessment - Farm management for disease control - Rapid disease diagnosis
Fish processing	Fish quality assessment and quality control	- Quality characteristics of fish and fish products - Assessment of microbiological, physical, chemical, and sensory parameters - Quality control in fish and certification of quality control standards (primary GMP, GMPs, HACCP, BRC)
	Fish processing and fish by-product utilization	- Practical fish processing technologies and equipment for SMEs - Suitable processing plant layout for SMEs - Fish product development and related food law - Thai FDA registration for fish product and food processing facility - Advance technologies in fish processing - Utilization of fish processing by-product
Promotion/business management	Entrepreneurship and business management for SMEs fisheries	- Creative entrepreneur - Consumer research and marketing for fish farm and fish processing - Supply chain of fish and fish product - Business management and ethics in business - Developing business plan

Focus group of SMEs, students, and teaching staffs also yielded possible vocational training programs as follows;

1. Fish product development and fish processing
2. Rapid diagnosis and practical disease control for fish disease
3. Developing business plan for SMEs fish farm and fish processing

4. Water circulating system for fish farm
5. Remote/digital/cellphone control for fish farm
6. Sustainable aquaculture
7. Basic experimental design, data collection, and data analysis for aquaculture and fish processing
8. Laboratories design, fish quality assessment, and techniques for fish quality assessment
9. Quality assessment, quality control and quality standards certification
10. Value addition of fish by-product

Other project activities

Progress SSNS activities in the division of Fisheries are as follows;

1. SSNS activities were continuously informed to the division head (Dr. Siripawee Charoenwattanasak) and members of the division of Fisheries as shown in Table 15.
2. The faculty of Agriculture, Khon Kaen University has appointed the SSNS working committee as shown in Appendix 3.
3. The faculty of Agriculture has approved to the division Fisheries to display a sign of SSNS coordinating center (Fig 15).

Table 15 SSNS activities informed to members of the division of Fisheries, Khon Kaen University

Date	Issues	Type of meeting and results
23 March 2018	SSNS inception workshop arranged from 18-20 April 2018 at AIT was informed to the division head.	- Informal meeting. - Two KKU representatives were requested to attend the workshop. Dr. Somsamorn Gawborisut was assigned to attend the meeting.
18-20 April 2018	Dr. Somsamorn Gawborisut attended the inception workshop at AIT.	- Formal inception workshop. - Dr. Somsamorn Gawborisut understands SSNS assignments. The assignments were reported to the division head. And, the division head agrees to assist the SSNS activities.
26 April 2018	Dr. Somsamorn Gawborisut reported SSNS assignments in the division meeting.	- Formal meeting. - Meeting report is shown in Appendix 4.
26 June 2018	Focus group results and SSNS progress were reported in the division meeting by Dr. Somsamorn Gawborisut.	- Formal meeting. - Meeting report will be endorsed thereafter (data not shown).

1. The faculty of Agriculture, Khon Kaen University has appointed the SSNS working committee.
2. The faculty of Agriculture has approved to the division Fisheries to display a sign of SSNS coordinating center.

The SSNS grant was transferred from AIT to Khon Kaen University on 25 May 2018. Khon Kaen University has issued the receipt and asked the division to obtain a formal SSNS account. The grant is in the process of being transferred from the university's account to SSNS account. Financial report will be concluded in the next progress report

because the grant has not been allocated to any member of the division.

Figure 14. SSNS Program office in Khon Kaen University

Conclusions and suggestions

Possible 6 SSNS compulsory elective courses and 10 vocational training programs were listed. Course names and contents will be further revised by teaching staffs in charge. Three possible vocational training programs will be selected. The courses are based on needs, finding, and missing of SMEs in the northeastern region of Thailand, which may be different from other regions of the country. Focus groups, conducted in the central and northern Thailand, by AIT and Maejo University, will provide more information about suitable SSNS programs for other regions of Thailand.

4.4 Other universities

As fishery stock is declining, farming of seafood or aquaculture has been considered the only way to compensate the reduction in seafood catch. With increasing population, and change in habits of the people from red meat to white meat then to seafood, its demand is increasing faster then ever. As a result, seafood export from developing countries is doubling every decade. Realizing the need, AIT started Aquaculture program to emphasize the need of focus on farming in 1981. Similarly, few others have Master degree program in Fishery or Aquaculture; namely; Kasetsart University, Burapha University, Prince of Songkla University, King Mongkut's Institute of Technology (Latkrabang) and Walailak University. Whereas other universities such as Rajabhat Universities located in some campuses such as Phetchburi, Phuket, Prince of Songkhla, and Surat Thani have aquaculture programs, mostly established by the AIT alumni, but only at the undergraduate level. Eventually, they would want to upgrade to offer MSc programs which means more competition will be there in the near future. Therefore, there is a need to develop new and attractive programs, which should be instrumental in solving the current problems encountered by the fishery sector.

The proposed program of "Sustainable Seafood" would be very much needed in Thailand. If the courses are designed based on the need, and delivered effectively, this

program should be very attractive and useful. For the new program, some of the courses, can be taken from existing courses such as fish diseases and health management, aquatic animals breeding, nutrition and feeding management. However, courses such as "Sustainable aquaculture, aquaculture and the environment, value addition, Aquaculture business can be among the courses which can be developed.

Fish veterinary courses are missing and we can see the possibility of considering the frequent occurrence of diseases in aquaculture industry. Although there are fish diseases and fish health management usually offered in undergraduate level, some advance in fish diseases and related courses are offered in MSc program. However, sometimes the up-to-date information is needed to deliver so training in biosecurity, emerging fish diseases, fish production inspection and standards are required.

In addition, value-added products, organic fish, smart fish farming, precision aquaculture, online business, digital fisheries management, etc. might be taken into a consideration for curriculum development. In addition to that, internship course, enable the MSc students to strengthen their work and research experiences, should be added to the program. Entrepreneurship in Seafood Business, Seafood safety and certification are becoming more and more important, as there are so much regulations in import and export businesses.

To strengthen this area, the scientific equipment and funding might draw an attention of students to enroll more leading to human resource development to ensure the long-term sustainability of seafood industry. However, in order to come up with the right program, more detailed work and consideration of other country report is necessary.

Chapter 5: Conclusions and recommendations

Specialized seafood security program should be developed and launched as soon as possible, as there is no such program exists. We assume that basic fisheries aquaculture courses are taught at BSc level as shown in Table 16, whereas for MS and PhD level courses should be either advanced (Table 17).

Table 16. Recommended courses for BSc level in Thailand

SN	**Basic Fisheries Management**	SN	**Applied Aquaculture**
1	Fisheries ecology	1	Principles of aquaculture
2	Fish physiology	2	Aquaculture systems
3	Fish biology	3	Fish nutrition and feeding management
4	Fish population dynamics	4	Fish genetics and breeding
5	Aquatic ecosystems	5	Water quality analysis and management
6	Fishing technologies	6	Fish health management
7		7	Re-circulatory Aquaculture Systems (RAS)
8	Internship	8	Internship

Table 17. Recommended courses for BSc level in Thailand for "**Sustainable Seafood" MSc program**, the following courses are recommended:

SN	**Sustainable Catch Management**	SN	**Sustainable Culture Management**
1	Seafood and food security	1	Seafood and SDGs
2	Fisheries governance & policies	2	Entrepreneurship in Seafood business
3	Sustainable fishing technologies	3	Green/Organic aquaculture
4	Fisheries ecology & tourism	4	Precision aquaculture
5	Stock assessment & monitoring	5	Aqua feed business
6	Culture based fisheries	6	Aqua seed business
7	Sea grasses and seaweed conservation	7	Integrated multi-trophic Aquaculture
8	Coral reef conservation and restoration	8	Mariculture (sea bass, grouper, eels..)
9	Plastics & wastes and water pollution	9	Deep sea/offshore aquaculture
10	Livelihood diversification for fishers	10	Aquaculture and the Environment
11	Gender and fisheries	11	Biosecurity & Fish Diseases
12	Rare Animals Breeding & stocking	12	Aquaculture and the environment
13	Integrated coastal zone management	13	Aquaculture and global warming
14	Post-catch handling and management	14	Value-added seafood products
15	Climate change and Fisheries	15	Seafood safety and certification
16	Seminar	16	Seminar
17	Special case studies	17	Special case studies
18	Internship	18	Internship
19	Thesis research & publication	19	Thesis research & publication

Vocational Education Training / short term courses:

Following courses are recommended:

1. Fish/shellfish diseases diagnosis and treatment
2. Seafood business start-ups
3. Hatchery and grow-out of tilapia
4. Hatchery and grow-out of shrimp/prawn
5. Biofloc / Aqua-mimicry
6. Hatchery and grow-out of sea bass
7. Water Recirculation Aquaculture System (RAS)
8. Aquaponics
9. Seafood processing and product marketing
10. Good Aquaculture Management practices
11. Seafood safety and certification

Best practices in teaching methods or course delivery are:

1. Planned Field Visits (e.g. AIT)
2. Feed factory visit (e.g. AIT)
3. Internship (e.g. AIT)
4. Special case studies (at least one very relevant to respective course)
5. Research with industry partnership
6. Seminar courses (e.g. Kasetsart University)

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