Upgrading the Purse Seine Fishing Vessels to Promote Responsible Fishing Operations:
a pilot study in Pattani Province, Thailand

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Located in Southeast Asia, Thailand is bordered by two productive sea areas, the Andaman Sea in the west and Gulf of Thailand in the east, giving a long continental coastline of 2,624 km and shelf area of about 394,000 km^2. Fish is the country's primary source of animal protein, especially for people in the coastal provinces, with an average fish consumption of 33.73 kg/capita/year as of 2016. The country's fish production comes from three sub-sectors, namely: marine capture fisheries, inland capture fisheries, and coastal and freshwater aquaculture. Reports have indicated that in 2016, the total fisheries production of Thailand was 2,425.90 thousand metric tons (mt) valued at 4,368.50 billion US$. Of this total, 1,276.00 thousand mt valued at 1,581.50 billion US$ came from marine capture fisheries; 187.30 thousand mt valued at 298.80 billion US$ from inland capture fisheries; and 962.60 thousand mt valued at 2,488.20 billion US$ from coastal and freshwater aquaculture. Thailand has also been one of the world's top exporters of fish and fishery products, and in 2017, the country's total export of fish and fishery products was 1,521.19 thousand mt valued at 6,498.76 thousand US$. Although considered one of the leading countries in the seafood global trade, Thailand had been faced with issues on rising operations costs, especially those related to energy and labor used in fishing operations, impeding the country's efforts to sustain its food fish production. As a consequence, many fishing fleet operations put more efforts into increasing revenues by producing more bycatch while ignoring the welfare of workers onboard the fishing fleet. Such strategy has led to overfishing, IUU fishing, non-compliance with safety at sea requirements, and to some extent human trafficking, prompting the international fish consuming community, *e.g.* EU to slap a yellow card to Thailand. Nevertheless, Thailand was able to address such concerns by implementing reforms and adopting measures based on international standards, in its fisheries sector and after several attempts, the country eventually got a green card from the EU. As part and parcel of such efforts, the SEAFDEC Training Department (SEAFDEC/TD) was approached to assist Thailand in reducing the number of labor onboard fishing vessels and in the proper handling of fish catch onboard. This led to the development by SEAFDEC/TD of an appropriate technology that would optimize not only the energy use onboard but also ensuring safety in fishing operations. Through the efforts of the Department of Fisheries (DOF) of Thailand, the Fisheries Association of Pattani Province agreed to make available their fishing fleet to be used in pilot testing such technology. This article which demonstrates the cooperation between SEAFDEC and the DOF together with the Fisheries Association of Pattani Province in Thailand to pilot test the technology developed by SEAFDEC/TD, is based on the paper presented during the "International Conference on Fisheries Engineering 2019: Realizing a Healthy Ecosystem and Sustainable Use of the Seas and Oceans" organized by the Japanese Society of Fisheries Engineering, 21-24 September 2019, Nagasaki University, Japan (Thanasansakorn and Thimkrap, 2019).

With funding support from the Japanese Trust Fund (JTF), the SEAFDEC Training Department (SEAFDEC/TD) had embarked since 2013, on a six-year project "Optimizing Energy Use and Improving Safety at Sea in Fishing Activities (2013-2019)" with the main objective of transferring appropriate ways of optimizing the use of energy in fishing operations, and improving the safety-at-sea for fishing vessels. Starting in 2017, SEAFDEC/TD carried out "R&D on the implementation of fishing operations with optimizing energy use," specifically on the improvement of fishing vessel design appropriate for local fisheries in the Southeast Asian region. The outputs from this activity would be used as inputs for the compilation of a regional reference for optimizing energy use and ensuring safety at sea of fishing vessels in the Southeast Asian region.

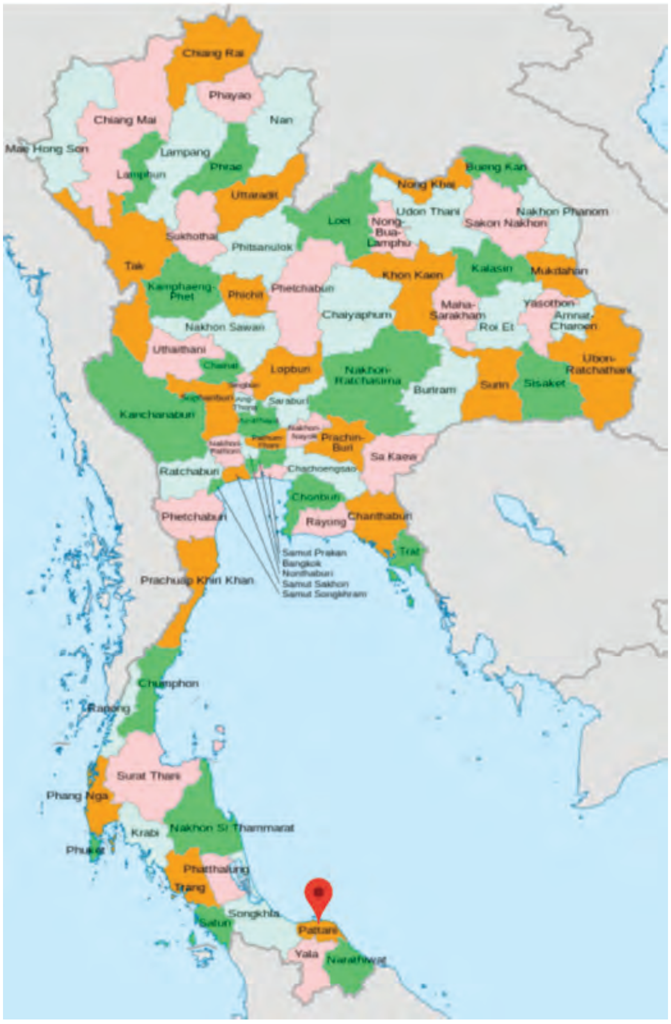

Figure 1. Map of Thailand showing Pattani Province

The funds provided by JTF to defray the costs of the necessary equipment and fish preservation systems in fishing vessels, enabled SEAFDEC/TD to pilot test the technology on the implementation of a hydraulic purse seine hauling device (power-block) in Pattani Province, Thailand (**Figure 1**). In order to facilitate the pilot testing, SEAFDEC entered into a collaborative arrangement with the Department of Fisheries (DOF) of Thailand, the Fisheries Association of Pattani Province, and the operator of the pilot fishing vessel, **Nor Larpprasert 8**, for a period of three years starting in July 2018.

Pilot-testing of the improved technology in purse seines

The improved technology is meant to enhance the safety and reliability of the hauling system, reduce the manpower for hauling and stowing the nets onboard fishing fleet, and improve the fish preservation technique onboard through the use of refrigeration seawater (RSW) cooling system to preserve the quality of the fish catch onboard (**Figure 2**). The RSW cooling system comprises the refrigeration system that removes heat from the catch as fast as possible through a submerged-type evaporator by using seawater as a second cooling medium, and a seawater type condenser that discharges the heat overboard. For the appropriate design and size of the submerged-type evaporator used to maintain fish quality, the following formula (Ben-Yami, 1994) could be adopted:

$A = \frac{Qt}{k\,\Delta T}$, where:

A = Area of the submerged evaporator (m^2)
Qt = Total head load to be taken by the evaporator (Kcal)
Δ*T* = Range of the temperature difference between evaporator and chilling seawater (10°Celsius)
k = Heat transfer coefficient (450 Kcal/h)

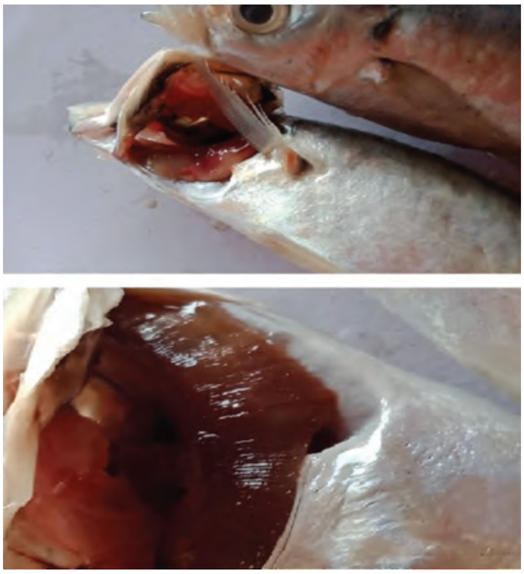

Figure 2. Quality of fish landed, which had been preserved using the RSW cooling system

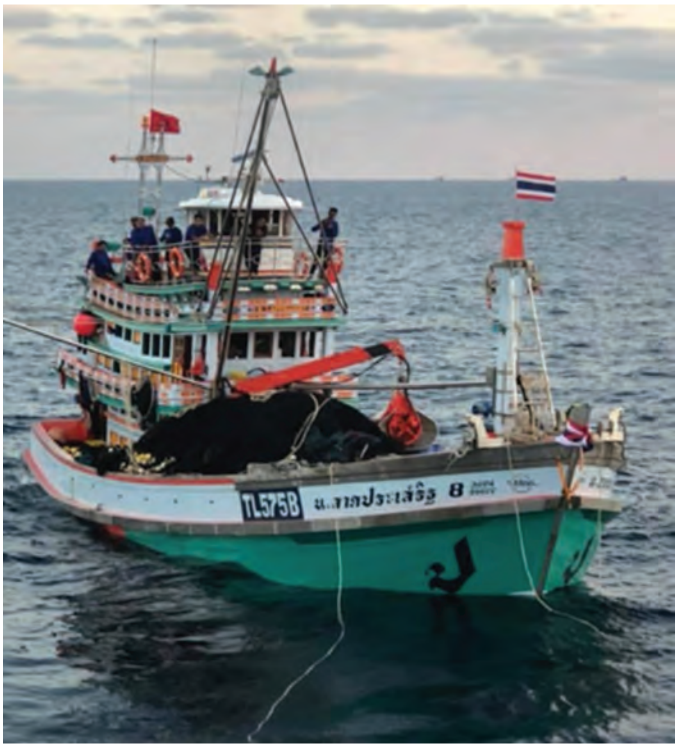

Figure 3. Pilot purse seine fishing vessel installed with appropriate machinery and fish preservation system

The power source of the other essential equipment, *e.g.* crane, power-block, and refrigeration system is the power recovered from using the power take-off technique, *i.e.* the diesel propulsion engine or generator engine is used to produce the power in the form of hydraulic pressure and cooling medium. The cooling medium designed for this vessel could produce 8 tons of seawater at ambient temperature (28°C) down to minus two degrees Celsius (-2ºC), the equivalent of 150 boxes of ice (standard icebox) produced in 12 hours while cruising from the shore to fishing grounds. The pilot purse seine fishing vessel installed with the appropriate machinery and fish preservation system is shown in (**Figure 3**). A training package on the use of this equipment is also being developed for the capacity building of the local fishers, considering that this is still a new system for most fishers. The package also includes proper handling and maintenance of the equipment in order to attain its most effective and efficient utilization in a longer lifespan. Under the system, fuel flow meter, hour-meter and other devices, *e.g.* GPS, satellites are used as tools for monitoring the associated information and data for analyzing the fuel consumption, and other expenses associated with the use of the hydraulic system for net hauling and refrigeration systems. The R&D work to improve energy efficiency at sea, fish preservation on-board, and gathering of technical information for summarizing the cost of energy used and the impact of burning fuel from fishing operations (GHG emission) as well as the lifespan of the hauling device, is being pursued using the support budget from the Government of Thailand through the DOF. This continuing effort of DOF has multi-pronged objectives as shown in **Box 1**.

Box 1. Objectives of the continuing R&D on the improvement of energy use in fishing operations

- Determining the energy consumption (CPUE) of the catch per kilogram unit of the catch, including the cost of vessel operation and the trend of the cost (whether increasing or decreasing) from implementing the energy optimization program
- Studying the quality of the catch using the preservation technique onboard with "premium Grade and loss" as an indicator to measure the quality of fish landed for every fishing trip
- Analyzing the greenhouse gases released from the fishing activities, compared with the amount of fish caught (CO_2/kg of the catch)
- Promoting the use of appropriate technology to improve the working conditions onboard for ensuring sustainable fisheries development and reducing the impact of fishing operations on the environment
- Determining the life span of the auxiliary machines used to support the fishing vessel operations related to the project activities, *e.g.* hydraulic system and the fish handling tools

Trend of fisheries production of Thailand

Thailand is one of the largest economies in Southeast Asia and a leader in the global seafood trade as a result of its increasing production from marine capture fisheries. The total fisheries production of Thailand comes from three major sub-sectors, namely: marine capture fisheries, inland capture fisheries, and aquaculture (coastal and freshwater). During the period from 2012 and 2016 however, the total fisheries production of Thailand had been considerably decreasing as shown in **Table 1**. Such decreasing trend could be observed not only in the total production by volume but also in terms of value (**Table 2**).

FAO (2018) reported that marine capture fisheries contributed almost 50% to the world's total fisheries production during the period from 2012 to 2016, as shown in **Table 3**. In spite of the abovementioned trend, the FAO report also indicated that Thailand has been among the major producing countries in the world, ranking 15th among the major producers from marine capture fisheries and the 4th major producer in Southeast Asia as shown in **Table 4**.

Purse seine fishing is one of the activities that contribute to the total fish production of Thailand from marine capture fisheries. The major fishing gear used in the country's marine capture fisheries could be grouped into purse seine, seine nets, trawl, lift net, falling net, gill net, trap, hook-and-line, push/scoop nets, shellfish and seaweed collecting gears, and others (SEAFDEC, 2018). Purse seine fisheries could also be grouped into anchovy purse seine and fish purse seine. The country's production in 2016 from purse seine fisheries was reported at 443,460 mt representing about 33% of the country's total production from marine capture fisheries (SEAFDEC, 2018). It should be noted however, that purse seine fisheries also require a considerable number of manpower during the fishing operations. As for the export of fish and fishery products of Thailand in 2012-2016, although the trend had also been decreasing in terms of quantity and value (**Table 5**), there is the possibility that this would pick up starting in the next few years.

Table 1. Fisheries production of Thailand (2012-2016) in metric tons (mt)

	2012	2013	2014	2015	2016
Marine capture	1,500,200	1,614,536	1,488,280	1,317,217	1,275,995
Inland capture	219,428	210,293	181,757	184,101	187,300
Aquaculture	1,271,995	997,255	897,763	928,538	962,606
TOTAL	**2,991,623**	**2,822,084**	**2,567,800**	**2,429,856**	**2,425,901**

Source: SEAFDEC, 2018

Table 2. Value of the fisheries production of Thailand (2012-2016) in US$1,000

	2012	2013	2014	2015	2016
Marine capture	1,766,492	1,828,457	1,608,260	1,486,032	1,581,541
Inland capture	359,075	375,993	312,798	301,441	298,804
Aquaculture	3,484,673	2,955,291	2,555,413	2,331,558	2,488,147
TOTAL	**5,610,240**	**5,159,741**	**4,476,471**	**4,119,031**	**4,368,492**

Source: SEAFDEC, 2018

Table 3. World's total production from marine capture fisheries (2012-2016), in million mt

	2012	2013	2014	2015	2016
Marine capture	78.4	79.4	79.9	81.2	79.3
Inland capture	11.2	11.2	11.3	11.4	11.6
Aquaculture	66.4	70.2	73.7	76.1	80.0
TOTAL	**156.0**	**160.7**	**164.9**	**168.7**	**170.9**

Source: FAO, 2018

Table 4. Marine capture fisheries production (2016): Major producing Southeast Asian countries

	Production (mt) Average (2005-2014)	Production (mt) 2015	Production (mt) 2016	Variation 2015-2016
(2) Indonesia	5,074,932	6,216,777	6,109,782	-1.7
(8) Viet Nam	2,081,551	2,607,214	2,678,406	2.7
(10) Philippines	2,155,951	1,048,101	1,865,213	-4.3
(15) Thailand	1,830,315	1,317,217	1,343,283	2.0
(17) Myanmar	1,159,708	1,107,020	1,185,610	7.1
World's TOTAL	**79,778,181**	**81,247,842**	**79,276,848**	**-2.4**

( ) World's ranking
Source: FAO, 2018

Table 5. Total export of fish and fishery products from Thailand (2012-2016)

	2012	2013	2014	2015	2016
Quantity (mt)	1,907,546.30	1,741,373.70	1,793,277.60	1,683,566.80	1,666,248.80
Value (US$1,000)	8,545.34	7,438.88	7,046.04	6,105.10	6,278.59

Source: DOF, 2019

Thailand is therefore exerting efforts to address the issues and concerns that had been encountered in its fisheries sector in order that production of fish and fishery products, as well as trade in fish and fishery products, would be sustained for the economic development of the country and food safety of its people. One of such efforts is towards ensuring that the country's marine capture fisheries is sustainably developed, through improvements in the fishing gear and fishery machinery by adopting appropriate technology for optimizing energy efficiency (saving on fuel) and reducing labor onboard fishing fleet, especially in purse seiners.

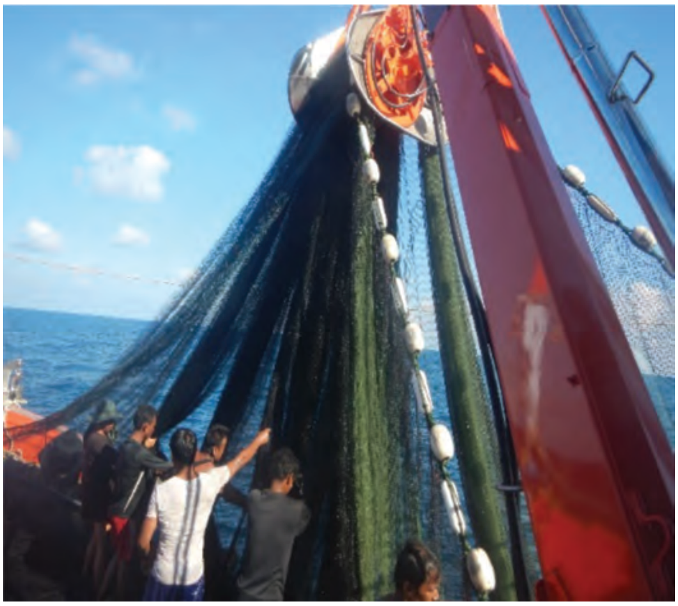

Figure 4. Hydraulic machinery (crane and power-block) to haul and stow nets reduces the number of manpower onboard fishing vessels

Effects of the improved technology on purse seiners

Based on the analysis of the data from the pilot project in Pattani Province, Thailand, it could be gleaned that after providing and installing the auxiliary machinery to support the purse seine fishing and vessel operation, *e.g.* hydraulic crane, net hauler (power block), and the development of hygienic practices onboard for fish handling and storage system (RSW cooling system), the number of labor onboard was reduced by more than 40% (**Figure 4**). The newly equipped power-block system and the newly equipped RSW cooling system worked properly even when operating under severe conditions. The RSW system produced eight (8) tons of seawater from the ambient temperature of 28°C down to -2°C within 12 hours, and maintained the temperature of the chilled water in the fish storage room. When the systems ceased to operate for 24 hours, the water temperature in the storage room increased from -2°C to only 4°C.

The data collected from the sea trial revealed that the total fish catch was approximately 8,800 kg which was kept in the RSW cooling system that maintains the temperature between -2º to 4 ºC until the vessel arrives at the landing site. The combined use of manpower-saving device like the hydraulic net hauling device system (power-block) and the RSW cooling system reduced the number of crew onboard Thai purse seiners which can now use only 16 crew members. Such strategy could be developed and promoted to Thai fishing operators, especially those involved in Thai purse seining in the near future.

Conclusion and Recommendations

From the socio-economic point of view, the technology being promoted to improve purse seine fishing operations could achieve three main aspects: reduced energy utilization, improved working practices, and reduced post-harvest losses. The source of power used in the operations comes from the mechanical power take-off either from the diesel propulsion system or diesel generator engine, *e.g.* to operate the hydraulic fishing equipment, *i.e.* net hauler (power-block), the flexible crane, and the refrigeration system (RSW) for preserving the freshness of the catch. All in all, the use of such power leads to the reduction of energy onboard purse seine fishing vessels. After the hydraulic crane and hydraulic power-block had been installed, the pilot purse seine vessel has reduced the number of crew members by 40%, *i.e.* from 30 to 16 fishing crew. Moreover, the operations do not require hard work, especially in hauling and stowing the nets, as well as in shoveling large amounts of crushed ice, that were handled by the fishing crew before. Therefore, the working practices onboard had improved as fish handling mainly uses cold water instead of crushed ice. The crew members can now have more time to rest, feel comfortable with the system, and more space becomes available for the crew to take rest and sleep.

It is also important that the premium grade of fish catch is landed at landing sites. After the RSW cooling system had been installed onboard the pilot fishing vessel, the quality of the fish landed had improved. In the interview with the pilot fishing vessel operator, *Mr. Surat Rattanasitorn* indicated that all the catch unloaded at the landing site had retained their freshness and graded premium level by the consumers. Moreover, the amount of ice used had been reduced by 50%. It should be noted that prior to the installation of the RSW cooling system, the pilot vessel used to consume 300 boxes of ice but after such installation the amount of ice used was only equivalent to 150 boxes. Therefore, it is necessary to evaluate these factors including the labor costs, *e.g.* fees, transportation, and accommodation of crew from home to the vessel, among others, and the expenditures for food onboard when the number of crew members had been reduced by 40%. The future studies should include these aspects as well as also consider the overall cost of vessel operation and maintenance, including net repairs and so on.

Way Forward

Once the improved technology is refined and verified, this could be promoted to the Southeast Asian region to enhance the sustainable development of fisheries in the region. However, prior to such promotion, further studies should be carried out on the operations and management of purse seiners (**Box 2**). The output of this project should be in a form of standard operating procedures that include the operation tools and systems, the reduction of post-harvest losses, and impact of fishing activities on the environment.

Box 2. Focus of future activities prior to promoting the improved technology to Southeast Asia

- Standardizing the rate of fuel consumption and the average rate of fuel consumption (liters) per kilogram (kg) of the catch (l/kg)
- Comparing the average amount of fish catch in premium grade level with the quality of the post-harvest losses per fishing trip
- Determining the average rate of greenhouse gases (kg CO_2) emitted from the burning of fuel per kilogram (kg) of fish catch
- Identifying the factors that lead to improved working conditions and safety at sea

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