Way Forward

Measures, such as closing the most sensitive areas for certain fishing and modifying fishing gear to be more habitat-friendly, could enhance the sustainability of fisheries as the impacts of fishing activities on the environment could be mitigated. The use of selective fishing gear is also among the measures, as only the desired species and sizes are targeted but this would also entail improvements of the conservation measures. Protection of the larger or older adult and mature fishes is necessary for the sustainability of the species that are currently being utilized for human consumption. Modifications of fishing gear and operations are also necessary to reduce the bycatch of marine mammals.

In SEAFDEC (2020), the areas where SEAFDEC and AMSs could cooperate in exploring the development of new techniques and methods had been summarized, for example in fisheries research, capacity building, and education, especially on the impacts and mitigation of the impacts of fishing on the fishery resources. The topics for research and capacity building could include:

- Technologies and management to reduce bycatch and discards, including selectivity of fishing gears
- Impacts of gears, *e.g.* trawl net, seine net, and dredge, on the sea bottom
- Light and its interaction with fish behavior
- Impacts of fishing operations on ETP species including marine mammals
- Environment-friendly fishing gear materials, *e.g.* natural and biodegradable materials
- Alternative environment-friendly fishing gear other than bottom trawl
- Management concept of fishing gear selectivity has been conducted since the 1950s, thus, the need to reconsider and apply the Balance Harvesting concept
- Mitigating the impacts of fishing on the environment should reconsider the management approach
- Impacts of fishing on the habitats and critical fishing grounds, *e.g.* seagrass beds, coral reefs, nursery grounds, and so on by assessing the habitat complexity and perturbing sea beds (benthic) communities
- Effects of fishing operation on water quality, *e.g.* resuspension of sediments caused by towed bottom fishing gear, *e.g.* trawl, seine, dredge

From the Project "Reduction of Environmental Impact from Tropical Shrimp Trawling through the Introduction of Bycatch Reduction Technologies and Change of Management (REBYC)" which was implemented during 2002–2008 and the Project "Strategies for Trawl Fisheries Bycatch Management (REBYC-II CTI)" during 2011–2016, it was suggested that gear modification could provide the solutions to reduce the negative impacts of fishing on the environment. Therefore, the approaches established through those projects could be applied with appropriate management concepts but should be supported by appropriate legal and incentive frameworks in introducing them to all stakeholders as well as in the decision processes.

4.1.2 Innovations for Responsible Fishing Operations

4.1.2.1 Energy Efficiency and Fuel-saving Options for Fishing Vessels

Improving the propulsion system

All movements of a fishing vessel in the water create resistance force. The vessel is subjected to dynamic force and resistance of its surroundings to maintain its moving speed. In propulsion systems, the thrust force produced must be equal to the resistance force to move forward. To minimize drag, it is necessary to improve the vessel's propulsion system. In general, direct-drive shafting at a zero-degree propeller shaft angle is the most efficient since the propeller thrust is going forward through the water current that goes straight ahead. The efficiency of the shaft angle between 0° and 6° creates small losses, from 6° to 12° gives medium losses, and shaft angles greater than 12° produce variable loading into the propeller blades (**Figure 86**). Minimizing the shaft angle could result in reduced thrust variation on the propeller (cavitation) and significantly increase the life span of the propeller. The reduced propeller shaft angle also minimizes power loss in the transmission system because the upper blade is receding from the onrushing water as it rotates up, while the lower blade is moving forward into the slipstream as it rotates down which results in uneven blade loading that can cause vibration and/or cavitation.

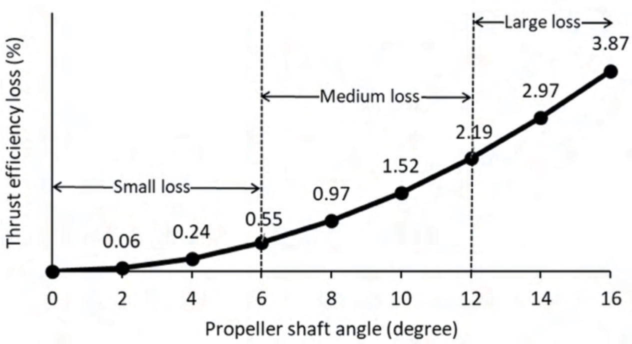

Figure 86. Thrust efficiency loss (%) in relation to propeller shaft angle (degree)

Vessel design, size of the propeller, propeller clearance, and the water flow's path to the propeller blade should be taken into consideration when constructing and/or renovating fishing vessels to improve the performance and energy use of the vessels. If the hull shape of the vessel is obtuse, it will increase the water resistance of the hull to the flow. In case the propeller clearance is small, a propeller with a small diameter should be used, although it might not be able to absorb all the thrust efficiently, resulting in an inappropriate force that facilitates the vessel to move forward in both speed and thrust especially for trawlers and purse seiners. Installing a new propeller shaft aligned to attain improved propulsion efficiency and efficient utilization of fishing vessel fuel, would result in reduced total fuel consumption after vessel renovations. To provide high-efficiency thrust, the flow platform should be improved to ensure that the propeller axis is aligned with the flow pattern of the ship hull for a smooth and efficient flow of water supply to the propeller.

In practice, it is difficult to install such a propeller, but it is most important to have propeller clearance to the hull structure and keel (aperture size) adequate for the propeller size requirements and there must be enough space for the engine and gearbox inside the engine room. The angle of the propeller shaft should be as small as possible compared to the keel (**Figure 87**). Thus, the design of the engine base and the transmission system should be adjusted to match the angle to support the driving force and reduce vibration.

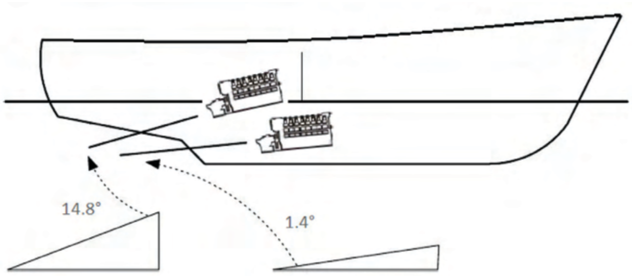

Figure 87. Adjusting the propeller shaft alignment

Most fishing vessel owners and skippers have misunderstood the importance of propeller clearance to avoid the enclosed distance between the propeller and the hull structure. Consequently, many fishing vessels have been set with the angle of the propeller shaft made steeper to avoid such close ranges, missing the hydrodynamics performance and the direction of the force.

To enhance the understanding and awareness of the fishing vessel owners on the aforementioned concepts, SEAFDEC/TD embarked on a six-year Japanese Trust Fund-funded Project "Optimizing Energy Use and Improving Safety at Sea in Fishing Activities" in 2013, which included the "R&D on the implementation of fishing operations with optimizing energy use." Specifically aimed at improving fishing vessel design appropriate for local fisheries in the Southeast Asian region, the R&D activity focused on the SEAFDEC/TD innovation which includes not only in upgrading the purse seine fishing vessels but also the improvement of the propulsion system and of the length of waterline, which has then pilot-tested in Pattani Province in southern Thailand, in collaboration with the Department of

Box 10. Case study on improving the propulsion system of purse seiner in Thailand

Renovation of the engine bed and transmission gears: The engine foundation (engine bed) has been adjusted to a lesser angle so that the propulsion engine and reduction gear are placed at the same angle of the vessel as it moves straight forward and mounted close to the keel of the vessel. As a result, the propeller shaft angle has been changed from 14.8° to 1.4°.

Engine installation in the engine room

Refinement of the stern tube: After the previous propeller shaft exit had been firmly sealed *(left)*, the new propeller shaft angle *(middle)* is installed, and a new exit is drilled at the sternpost for the stern tube installation *(right)*.

Reinstallation of propeller blade: The angle of the propeller blade should be adjusted to higher degrees to optimize the thrust/propulsion efficiency of the fishing vessel during traveling/fishing operations.

Box 10. Case study on improving the propulsion system of purse seiner in Thailand *(Cont'd)*

Evaluation

Engine speed (rpm)	Vessel speed (kt)	
	Pretest	Posttest
1,850	8.0-8.5	11.0-12.0
1,500	5.0-6.0	8.0-9.0
1,200	4.0-5.0	7.0-8.0
1,000	3.0-4.0	6.5-7.0

Cost

Item	Amount (USD)
Materials (engine bed and mounting materials)	2,320
Labor	1,000
Docking and services	1,680
Total	**5,000**

Benefits

- Increased vessel speed
- Efficient fuel consumption and reduced greenhouse gas emission by 36 %
- Reduced vibration and noise at the stern
- Smaller waves or turbulence (vortex) at the stern which means that there is less resistance

Fisheries of Thailand, the Fisheries Association of Pattani Province, and the owner-operator of the pilot purse seine fishing vessel (Thanasansakorn et al., 2019).

Fishing vessel owners in southern Thailand have already applied the innovation on improved fishery machinery for purse seine fishing vessels aimed at enhancing working practices and optimizing the energy utilization of their fishing vessels' operations, e.g in this case where it has become necessary to make the vessel more thrust efficient, as well as improve the length of the waterline to increase the vessel speed capacity and reduce vessel operation cost (**Box 10**). After addressing the issues and concerns with respect to such improved technology based on the results of the pilot study, the results 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.

Improving the length of the waterline

Fishing vessels operate at a certain speed for particular fishing gear. As the vessel speed accelerates, the wave resistance also increases, leading to efficiency loss and high fuel consumption. Reducing fuel consumption allows greater savings for the cost of fishing operations. In general, a vessel cruising at low speed consumes lesser fuel than at high speed, but such a relationship is non-linear. It is therefore important to consider the optimum speed, also called the "operating speed" or "service speed," which is used to set up the speed range of vessels in operation. Such operating speed is an important factor that should be considered in improving and/or renovating the vessel design to increase the vessel speed capacity and reduce vessel operation costs (*e.g.* fuel cost, working days at sea, etc.).

To achieve the optimum speed, the vessel should have an appropriate L/B ratio, where L or LwL is the length of the vessel at waterline from bow to stern when it sits on the water surface, and B is the beam or width of the vessel measured between the most outboard points of the vessel (**Figure 88**). The larger L/B ratio indicates slimmer hull shape and less wave-making resistance, resulting in a more efficient high-speed performance of the vessel, optimized its energy used, and increased its load-carrying capacity. In the pilot project in Pattani Province in southern Thailand, the pelagic purse seiner was improved by increasing the vessel length from 13 m to 18 m (**Box 11**).

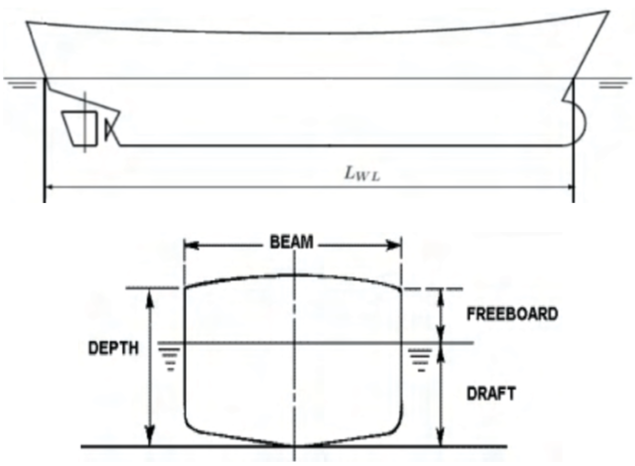

Figure 88. Vessel length at the waterline *(top)* and beam or width of the vessel *(above)*

Way Forward

Pilot testing of the improved technology would be continued to address the issues and concerns encountered during the refinement and verification trials on optimizing energy use in fishing operations and find the best options that could lead to further improvement of the innovations, which also

Box 11. Case study on improving the length of waterline of purse seiner in Thailand

Renovation: Cutting of the hull structure (A); making two sections of hull structure (B); and increasing the hull structure (C) to reach 5 meters in length (m).


A.


B.


C.

Evaluation

	Before renovation	After renovation
Propulsion engine capacity	375 hp	375 hp
Breadth	4.4 m	4.4 m
L_{wl}	13 m	18 m
L/B ratio	2.95	4.09
Maximum speed (nm/h)	8.601	9.944
Fuel consumption (l/h)	27.348 l/h	27.348 l/h
Fuel consumption (l/nm)	3.179 l/nmi	2.750 l/nmi
Greenhouse gas emission per hour	72.198 kg of CO_2	
Fuel consumed/equivalent to produce carbon emission/100 miles	317.963 liters equivalent to 839.422 kg of CO_2 emission	275.020 liters equivalent to 726.052 kg of CO_2 emission
Fuel saved/h or reduced carbon emission/h	4.269 l/h or equivalent to 11.270 kg of CO_2/h emission	

Cost

Item	Amount (USD)
Materials	2,350
Labor	6,300
Docking and services	3,350
Total	**12,000**

Benefits

- Bigger space is available for handling the catch onboard, more comfortable living space is created for fish workers onboard, and better ship stability
- Efficient fuel consumption
- Fresh catch arrives the markets faster and thus, commands good price

include not only improving and/or renovating the operations of the physical structure of the vessels but also on the possible reduction of manpower onboard and on proper handling of catch onboard. Specifically, this would require among others, standardizing the rate of fuel consumption per kilogram of catch, comparing the quality of fish catch and post-harvest losses per fishing trip, determining the average rate of greenhouse gases emitted by the vessels per kilogram of fish caught, and identifying the factors that lead to improved working conditions and safety at sea of fishers on board. After refining and verifying the improved technology at the pilot sites in Thailand and other selected AMSs, this would be promoted to the rest of the Southeast Asian countries to contribute to the enhancement of sustainable fisheries development in the region.

The output of this R&D could form part of the compiled standard operation procedures for optimizing energy use in fishing vessels, especially in terms of the efficient operation of tools and systems, reduction of post-harvest losses, reduction of manpower onboard fishing vessels, and minimizing the impact of fishing activities on the environment, thus, promoting responsible fishing operations in the region. The results could also be used as a basis for the compilation of a regional reference for optimizing energy use and ensuring safety at sea of fishing vessels in the Southeast Asian region.