Moreover, the fuel consumption of propulsion engine is 246.73 liters/day, then correspondingly the gas emitted from fuel consumption is: 246.73 × 2.64 $kgCO_2$ = 651.36 $kgCO_2$/liter.

Catch Per Unit Effort (CPUE): also called the catch rate, is frequently the single most useful index for long-term monitoring of a fishery. Declines in CPUE imply that the fish population cannot support the level of harvesting. Increases in CPUE could mean that a fish stock is recovering, and more fishing effort can be applied. CPUE can therefore be used as an index of stock abundance, where some relationship is assumed between that index and the stock size. The simple calculation of CPUE is the total catch divided by the total amount of effort used to harvest the catch.

$$\text{CPUE} = \frac{\text{Total catch (kg)}}{\text{Total amount of effort used to harvest the catch}}$$

$$\text{CPUE of pilot purse seine fishing vessel} = \frac{260{,}500 \text{ kg}}{219 \text{ days}}$$

CPUE = 1,189.49 kg/day
= 4.82 kg of catch/liter of fuel consumption
Or equivalent to = 1 kg of catch/0.2074 liter of fuel consumption

4.1.2.5 Reducing Labor in Purse Seine Fishing Operations

Due to the kinds of equipment being used for fishing and set up onboard many fishing vessels, *e.g.* purse seiners and trawlers, a large number of workers is required in fishing vessels, especially in the case of Thailand. For example, purse seiners require as many as 30 - 40 fishers onboard while trawlers require up to 22 fishers onboard. In the case of purse seiners in Thailand, heavy demand for labor comes from the enormous weight of the catch, while the nets are largely pulled aboard by hand. In view therefore of such a scenario, the Department of Fisheries (DOF) of Thailand had approached SEAFDEC/TD and with the collaboration of the Pattani Fishery Association in southern Thailand, to design a more labor-efficient purse seiner. In 2018–2019, experts from SEAFDEC/TD worked with the vessel owner on the project that aimed to design and reconfigure a 91-GT purse seiner (Nor Larpprasert 8) based in Pattani Province and used as the pilot fishing vessel for this project.

The design and reconfiguration of the fishing vessel included the installation of a multi-purpose crane, hydraulic system, power block, and central cooling with refrigeration system, on the purse seiner. The crane and power systems facilitate the hauling of nets that was done before by fishers, and the refrigeration system prolongs the preservation of the catch, thereby increasing its value in the market. The costs of the reconfiguration had been shared, with SEAFDEC paying for the equipment and the vessel owner paying for the installation as well as the acquisition of new nets. The installation of the new equipment in 2018 took two months because of the extensive optional renovations, although SEAFDEC estimated that installation of similar equipment installation on other fishing vessels would take less than one month to complete. SEAFDEC also reported that the technology and equipment are promptly available in Thailand and spread the information to all major stakeholders and important fishing ports of Thailand to also undertake the appropriate vessel improvement.

Cost-Benefit Analysis (before and after reconfiguration)

Before the equipment installation, the vessel required around 30 fishers for each seven-to-ten-day fishing trip, yielding a catch that was worth about USD 15,833, based on the vessel owner's price estimates and cross-checked with SEAFDEC experts. Such manning level also meant that the fishers' living space of 72 m^2 (4 levels of 3m x 6m space) was shared among 29 fishers (the skipper sleeps in a different area), and implied that each fisher occupied an average of 2.5 m^2 of space onboard, before the reconfiguration.

Since the installation of the new equipment in early 2019, the purse seiner has seen an approximate reduction of 37 percent in terms of labor required. The power block, crane, and hydraulic systems enable net hauling to be done more efficiently by fewer fishers. In this case, the fishers needed onboard have gone down from 27 to 17, while the average time for hauling the fishing nets is less than an hour and 30 minutes, down from more than two hours before the reconfiguration. With more adjustments, SEAFDEC forecasts that eventually, the manning will come down to 14 or 15 men, about half of the original fishing crew. The total costs of labor per year will be reduced as well, from USD 137,237 per year to USD 108,100 in the second year after reconfiguration, even with an increase of monthly wages for fishers to USD 400 per month, which is at par with past policy proposals made by Thai vessel owners and workers' organizations. The costs of workers' permit will also be reduced along with the overall cost of the workforce by 45 percent (*i.e.* to approximately USD 2,633) in two years. Even accounting for the increases in base pay of the fishers, supervisors, and skippers, the savings from the total labor cost are significant at approximately 21 percent.

The central cooling and refrigeration systems have proven to reduce the quantity of low-quality fish, especially the fish caught on the first few days at sea which loses its value as the quality deteriorates from 34 percent down to around 10 percent. This means that with the current renovations, 90 percent of the catch can be sold at full market price (up from 70–80 percent of the quantity before the installation), increasing revenues by roughly 10 percent from USD 15,833 to USD 17,416 on average per trip.

The work area onboard for fishers has also seen significant change. After the boat reconfiguration, the 72-m^2 living area is now shared by only 17 fishers (excluding the skipper), hence each fisher now has 4.23 m^2 of workspace versus the 2.48 m^2 before. This means that the fishers no longer work in such a crowded space, which has been notoriously dangerous in the fishing industry, this means safer work conditions.

Fuel costs are largely unchanged after the reconfiguration. The vessel owner however noted that any increases in fuel usage due to the installation of the crane are offset by the reduction in the number of fishers onboard. SEAFDEC is planning to change the configuration of the refrigeration system starting in late-2019 as the engineering team believes that such changes could lead to reduced energy costs. With regards to engines used in the fishing industry, certain more efficient fuel-injection engines have been in use elsewhere, but these are not available in Thailand and are three times more costly than the traditional engines. As a result, most vessel owners in Thailand have reportedly shown little interest in the lower-carbon types of engines. Meanwhile, the owner of the pilot fishing vessel and SEAFDEC had estimated that the resale value of the vessel after the reconfiguration is about USD 330,000 an increase of about two-thirds of its USD 200,000–230,000 value before the changes.

Improvements in their working conditions had led to reduced turnover rate of fishers from 30 percent to effectively zero in the months after the reconfiguration. This demonstrates that the installation of basic power-hauling equipment on purse seiners can help alleviate labor shortages and improve the conditions of those working and living onboard the vessels. The total cost of the comprehensive reconfiguration carried out on the pilot fishing vessel (excluding the cost of acquiring new nets) is USD 58,330. This includes the central cooling system, refrigeration system, other installations, and the core reconfiguration: crane, power block, and hydraulic system. The investment cost for the vessel's reconfiguration is relatively high as far as the owners of even the smallest commercial fishing companies that own one or two fishing vessels. However, SEAFDEC is of the view that the investment costs could be reduced if only the core equipment are changed, *i.e.* crane, power block, and hydraulic system. The central cooling system, the refrigeration system, and the purchase of new purse seine nets are not necessary for the core reconfiguration, as vessel owners can make such additional improvements over time. Assuming that a ten percent increase in revenue per trip due to the enhanced cooling and refrigeration systems, from an average of USD 15,833 per trip to USD 17,416 per trip, at 30 trips per year, the increase in annual revenue during the second year after the reconfiguration is estimated at USD 47,500. Adding the savings from the labor cost of USD 29,138 per year, the total amount could easily cover the investment cost for the reconfiguration and installations in less than one year. The summary of the cost of the vessel reconfiguration and benefits gained is shown in **Table 67**.

Table 67. Summary of reconfiguration cost and benefits

Comprehensive Reconfiguration Cost (excluding new nets)	USD 58,333
Estimated increase in revenue per year after reconfiguration	USD 47,500
Savings from labor cost per year after reconfiguration	USD 29,000
Return on investment (estimated period)	Less than 1 year

Way Forward

Currently, SEAFDEC/TD is undertaking this activity under the Japanese Trust Fund Project "Responsible Fishing Technologies and Practices" that includes 1) marine engineering technologies (*i.e.* fuel efficiency, greenhouse gas reduction, and safety of fishing operation at sea) at the national and regional level; and 2) the development of fish handling techniques onboard fishing vessels. The R&D on the development of appropriate technologies to reduce carbon emissions to the environment at a low level in response to the issues of global crisis by climate change and reduce labor onboard by applying appropriate hauling devices to contribute to improving the national economies and fishers' well-being onboard fishing vessels, would be enhanced and continued. The results of such activities would be shared by SEAFDEC/TD with the AMSs through the production of information and training materials/models that would be introduced through the training courses of SEAFDEC/TD on the improvement of appropriate fishing vessel technology in terms of marine engineering, and also through the SEAFDEC website. Capacity-building programs through online workshops and demonstrations, as well as hands-on practical sessions, could also be organized.

4.1.3 Abandoned, Lost or Otherwise Discarded Fishing Gear

Abandoned, lost or otherwise discarded fishing gear (ALDFG) is a collective term for the various causes of loss of fishing gear as identified by Macfadyen, *et al.* (2009). The term "abandoned fishing gear" means fishing gear over which the operator or owner, although has the control, is unable to retrieve and deliberately leave the gear at sea due to force majeure or other unforeseen reasons. Meanwhile, "lost fishing gear" refers to fishing gear over which the owner or operator has accidentally lost control and can no longer be located and/or retrieved by the owner or operator. The term "discarded fishing gear" refers to fishing gear that is released at sea without any attempt by the owner or operator for further retrieval or recovery. Unless un-retrievable, fishing gear is deliberately abandoned by fishers at sea and becomes ALDFG because of bad weather, or injury of fishers, or mechanical failure of the fishing vessel, and finally the gear could no longer be retrieved. Fishers engaged in IUU fishing may also abandon their gears when at risk of being inspected or arrested, and in order to escape quickly, have to dispose of any evidence.