Report

Online Training Course on Energy Audits for Fishing Vessels

Organized duration
21-23 June 2022

Marine Engineering Section
Training and Research Supporting Division

Southeast Asian Fisheries Development Center Training Department

TD/RP/230

Abstract
This report is a part of an online regional training course on Energy Audits for Fishing Vessels organized from June 21to23, 2022, online via the Zoom platform under the situation of the Corona Virus-2019 (COVID-19) pandemic in the Southeast Asian region and all over the world.

This online training course was envisaged for updating technical information on technologies of energy saving or optimizing fuel use for fishing vessels. This includes measuring the energy consumption of each fishing vessel to help assess optimal performance and operating conditions for the most cost-effective use of energy. Hence, It could be ways forward for improving and raising awareness of the optimal utilization of fuel in fishing activities. Expected participants of the online training course, who came from those relevant working experiences and related fishing vessels, can gain, and transfer the knowledge and experiences from the training program to fishers or related people in their Countries. Success from this course is indispensable without kindly contribution from the Japanese Trust fund, which has several main targets to improve the livelihood of fishers in the Southeast Asian Region. There were two sessions at the online training: (1) Literature reviews and (2) Discussion/evaluation. All details in this report summarize the main points made during the presentations and discussions. For other reference information such as lists of participants, presentation files, photos of activities, etc. are presented in the appendix behind.

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Contents

Course Information

I. Background:

The fishing vessel energy audit is a process of determining how to reduce the associated energy used in each fishing trip including the propulsion system, generator, hydraulic, and refrigeration system. An energy audit involves the skilled application of sensitive instrumentation that records fuel flows, shaft speeds, torque, current flows, radiated heat, hydraulic fluid flows, and other parameters. Once data are collected, an analysis is required to identify high-energy-use areas and suggest energy conservation measures (ECMs). The substantial cost of the fishing vessel energy audit normally puts its outreach to small fishing vessel owners. The process of energy audits for the fishing vessel is using the tool that allows the fishing vessel owners/skippers to monitor the consumption of vessel performance at each vessel's operating model. If they know or use stored data on a similar vessel collected during the onboard energy audits conducted, that data as a tool for calculating baseline energy use is expressed as a liter or consumption cost and presents summary data in tables and pie charts for each system and operating model.

The skippers/fishing vessel owners in the fisheries sector are already experiencing issues such as high fuel costs, and fishery resource depletion, particularly for bottom trawling which requires much fuel. However, bottom trawling also causes pollution that directly impacts marine resources, fisher's income, and livelihoods. Some of the fishers had to stop fishing due to the depletion of marine resources and the high cost of fishing. The inefficient use of fuel also affects the profitability of fishing apart from climate change.

Therefore, capacity building is needed to reduce the burning of fossil fuels used in capture fisheries and increase fuel efficiency (energy saving) including monitoring the fuel consumption. In this connection, SEAFDEC/TD will organize the "Online Regional Training Course on Energy Audits for Fishing Vessels" via the Zoom platform on 21–23 June 2022 with support from the Japanese Trust Fund.

II. Objectives:

The training course has objectives as follows:

1. Enhance the technical knowledge of the participants of the existing methods and techniques to improve fuel efficiency and fuel consumption monitoring in fishing activities.
2. Raise the awareness of responsible fishing as well as reduction of fishing vessel carbon dioxide gas emission through improved energy efficiency (energy saving) in capture fisheries.
3. Establish a network to promote the sharing of technical information on energy optimization and energy monitoring of fishing vessels to mitigate the impacts of climate change to achieve a low-carbon society.

III. Target Participants

The target participants in the Online Regional Training are fisheries officers, extension officers, and engineers from the ASEAN Member States including Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand, and Viet Nam. It is recommended that the participants should have relevant work experience in engineering and be capable to transfer the knowledge gained from the training to apply the energy audit techniques in their respective countries.

The participants will be requested to make a presentation (5–10 min) on the energy consumption in fishing operations and ways to promote energy efficiency (energy saving) on fishing vessels in their respective countries.

IV. Expected Outcomes:

1. The participants from member countries gain knowledge and experience from presentations and discussions on fishing vessel energy audits to support the elimination of climate change and methods to reduce greenhouse gas in the capture fisheries at low carbon levels.
2. The participants from member countries can be enhanced their capacity to develop a plan of action to disseminate the knowledge of energy audit and fuel efficiency in fishing vessels in their respective countries
3. The participants from member countries can increase the ability to improve energy efficiency and energy-saving technical knowledge that will be useful and effective for skipper/vessel owners to reduce the current cost of energy used in fishing vessels

V. Course Structure:

Date	Time	Subject	Present by
21 June 2022	09:00–09:15	○ Welcome Remarks	*Deputy Chief of the SEAFDEC Training Department*
	09:15–09:30	○ Introduction of the Online Regional Training Course	*SEAFDEC/TD*
	09:30–10:30	○ Country Report	*ASEAN Member States*
	10:30–12:00	○ Energy-audit process to suit certain types of fishing vessels and methods to undertake a trial, data collection, and energy audit on fishing vessels for future work at the international level	*Dr. Stephen Eayrs*
22 June 2022	09:00–10:30	○ Optimizing energy use in fisheries in Southeast Asian region: fishing vessels energy audits and way forward	*Mr.Bundit Chokesanguan*
	10:30–12:00	○ Energy efficiency and energy-saving technologies in fisheries – options for LIFE-fishing	*Dr. Petri Suuronen* (LUKE)
23 June 2022	09:00–10:30	○ SEAFDEC and FAO fishing vessels energy audits for a pilot project on Thai trawl vessels	*Mr. Khunthawat Manomayitthikan*
	10:30–12:00	○ Discussion and Evaluation ○ Closing Ceremony	*SEAFDEC/TD and Resource persons*
Remark: The presentations and recorded video will be given to the participants by email after the Online Training			

VI. Online training session

Opening session

Dr.Tomoko Nakazato Deputy Chief of the Training Department welcomed participants from SEAFDEC MCs who represented 6 Country representatives from Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Vietnam, and three resource persons from Australia, Finland, Thai, and SEAFDEC Colleagues to the online Regional Training course and declared the training opened. She highlighted the high price of fishery products, marine fishery resources reduction, and high diesel oil price that are key challenges and heavily impact fishery sectors in several countries in the Southeast Asia Region. To mitigate the impact of rising oil prices, energy crisis, and greenhouse gas emissions impacting marine resources, she pointed out that SEAFDEC/TD under the resolution and the plan of action for food security for the Asian region towards 2030 and having a supporting fund from FAO had implemented by initiating an energy audit project for some demonstrated trawl fishing vessels with both interviewing and onboard fishing vessels auditing carried out during 2015 to 2018. She expected and addressed on this training course will provide technical knowledge and skills on the energy audit process to improve energy efficiency use and reduce carbon gas emissions from a diesel engine for capture fishery. She also once again expressed her gratitude to all and encouraged all SEAFDEC participants to learn and share experiences with them. Finally, she officially declared the online regional training open and wish a successful training. Her opening remark appears in Appendix 1. The Participant's name list appears in Appendix 2

Literature reviews

Country report: The report presents the current situation of the Member States on energy efficiency and energy consumption measurements of fishing boats, where each country has different energy-saving actions due to the impact of different energy issues. But most member countries have been affected by higher oil prices. Reports of each country have alleviated energy problems in various fishing boats, such as the use of biodiesel by fifty percent blending of palm oil or used vegetable oil with diesel fuel, zoning fishing vessel areas, and partial compensation of oil prices to fishermen with conditions of compensation for fish caught for small coastal fishermen, some member countries are encouraging the use of energy-saving technologies or alternative energy sources such as wind and gas or even improving and maintaining fishing boats, engines and fishing gear. It has been observed that most of the solutions or alleviation of energy problems with fishing boats are aimed at using other cheaper sources of energy. But there is still a lack of interest in increasing fisheries efficiency, which includes a variety of methods, including energy auditing to determine the causes of losses and to optimize fishing operations in various ways. Therefore, the organizing team hopes that this training can help to fill in the shortfall knowledge or even build cooperation in the development of energy auditing of the energy consumption of fishing vessels with member countries in the future.

Dr. Stephen Eyars introduced himself that he achieves a PhD. from the United State of America and fully intensive working experiences on board fishing vessels in the US, Saudi Arabia, and Myanmar. The energy audit is one of the projects he has focused on to address the issue of oil costs for fishermen as well as to reduce greenhouse gas emissions from fishing activities that are gradually increasing the impact on the marine environment. The main goal of fishers is to increase their income by catching more fish. This is currently not possible due to the drastically reduced fish stocks. Doing fishing to catch more fish Fishing boats also need more fuel. Therefore, it is not worth the investment, and the more fisheries are done, the greater the environmental impact. These problems can be alleviated by monitoring energy consumption under an energy audit process to determine the efficiency, loss, and payback period that can be applied to fishing vessels. In the measurement of energy consumption on fishing vessels in the past, there were 3 levels of operation: The first stage of the audit covers a brief overview of energy consumption operational inputs, and outputs of fishing operations to assess the value of fishing presented in terms of profit and expense of fishing vessels each month in a year. Fundamentally, the first stage of the audit is asking the question to captains or skippers of trawlers about their excessive fuel consumption. The second stage is what's known as a screening survey by a detailed evaluation which relative sources of consumption and identifying major consumers and recommending options to reduce that fuel consumption. After the second stage, skippers or fishers can find the most impact on fuel consumption. In the last stage, it achieves some detailed investigations and analysis with accurate assessment, which is getting or understanding of exactly where the fuel is being used, how it's being used, and how energy-saving options will save fisher money and make various decisions for further improvements. A simple chart of efficiency of fishing operation shown in a relative of expenses to revenue ratio in 12 months in Queensland, anywhere above one is bad because expenses are greater than revenue where fisher are being lost money. According to the annual statistics, which month earns more than the expenditures for fishing, and in which month the income is less than the expenditures, the fishermen should stop fishing trips. To clarify the fuel consumption picture of fishing boats around the world, Dr.steve presented a snapshot of fuel consumption in the Global, fishing vessels in the Southeast Asian Region have a highly intensive fuel consumption of about 500-1500 liter per square kilometer and addressed an example initiative project of energy audit carried on four bottom trawlers that have a fishing trip for 1 to 2 days fishing in the New England fishing ground. He did the level one and two audits by interviewing and measuring at once within a half day. The measured results were processed to determine the cause of the fuel consumption to suggest ways to increase the efficiency of the fishing vessel in terms of USD. Several methods that he advised to fishers or owners on saving fuel consumption are by applying a paravane stabilizer, installing fairing pieces, mounting a streamlined rudder, reducing underwater fouling, good ventilation in the engine room, and installing a fuel flow meter, etc. These fuel-saving recommendations clarified the estimation of cost, annual fuel saving, and payback period for decision-making by fishing boat owners. To upgrade fishing boat efficiency, fishermen can choose to improve according to several ways so that costs and payback time can be roughly estimated. As aforementioned, the energy audit process has several benefits as it helps to raise awareness of the fuel efficiency monitoring of fishing vessels, saving costs, and reducing the environmental impact of emissions including as information for decision making of the owner before investment to improve fishing boat efficiency It also serves as a guideline for the government to use as information in formulating various policies to help fishermen. He hopes that this energy audit approach will benefit participants and will be put into practitioners in their countries.

Mr. Bundit describes the origins of the energy audit in the Southeast Asian region to address oil costs for fishing vessels, as well as to seek cooperation with member states to take advantage of the knowledge of the energy audit that has already been done. To understand the importance of the use of an energy audit, comparing the number of fishing boats in Southeast Asia over the past 10 years from SEAFDEC's RFVR webpage, the number of fishing vessels can be used to calculate the fuel utilization of fishing vessels in the region. In the current situation, there are problems with oil prices the Global warming, and fishermen in the region still lack the knowledge and understanding of how to reduce energy consumption and greenhouse gas emissions. Fishermen only understand that when the price of oil rises, they must increase their income by catching more fish, which is not possible with today's scarcity of marine resources. The speaker gave a comparison simple based on recorded data from 20-30 years ago, the number of fish caught was 1,000 kg which a fishing boat used 200 liters of fuel, but now a 1,000 kg fishing boat needs 400 liters of fuel. In addition, fishing methods with active fishing gear and passive gear have very different fuel consumption. Passive gear has less fuel consumption because it is stationary and is used to lure fish in. But with active gear, fishing boats must move to catch fish which when there is more resistance from water, the higher the fuel consumption. To reduce fuel consumption for a trawler, an easy way is to use the engine speed in the most economical range or plan in fishing to reduce unnecessary fuel consumption or the use of large propellers. There are several ways to reduce the use of fuel in fishing that are by designing a well-streamlined hull or using the engine rpm during the lowest fuel consumption or maintaining good engine condition or designing fishing gear and doing fishing operations to reduce water resistance as much as possible or optimizing the storage system or increasing mesh size of the trawl nets to reduce fuel consumption and not capture juvenile fishes. In addition, the use of other alternative fuels such as LPG, CNG, wind, solar, wave, etc., and promoting the application of sail for a fishing boat for fuel saving is a project that had been done over the last ten years ago. He also addressed an overview of the energy audit project for some investigated fishing boats and achieve results of the fuel consumption profile of the sample boats for real-time efficient monitoring. At the end of the way forward presentation, the speaker asked for opinions and directions on how to proceed with the energy audit project with member countries.

Dr. Suuronen Petri addressed his work background with FAO in some projects carried in Southeast Asia with SEAFDEC/TD, and back to his own country in 2019 for working at the National Research Institute of Finland until the present. Recently, fishery industries in Europe are under heavy pressure from the energy crisis because of high fuel prices from war. In this training course, he will give information on fuel-efficient technology covering trawl fishing and low impact and fuel-efficient fishing (LIFE). Climate change has many impacts on different migration of fishery resources resulting in scant fishery resources in Europe water. However, importing fishery products into Europe is getting every day harder under intensive official certification. Both negative impacts are forcing fuel oil prices to continue to be increased but the global oil supply is expected to decrease until 2035. Everywhere in the world including Europe, Southeast Asia, and China are affected by high fuel price. In Australia, he guesses that fisheries probably are changed from highly profitable to none. An example of expenses on fishing vessels in Europe in the year is if labor costs increased from 20 to 50 %, fuel costs increased 15%, 40%, and 70%. CO_2 emission is also one key impact parameter of the fishery industry that must be concerned recently. From statistical information, the Global catches have almost been stable but fuel cost per fishing effort increases year by year for 30 years. Heavy fuel consumption depends on the fishing method and target species as a heavy fuel impact of crustaceans uses bottom trawl fishing which is energy intensive fishing practice of about 6-7 liter of fuel per kilogram catch. There is much big national fishing in China, Indonesia, Vietnam, the USA, and Japan, they are the top five burning fuel and almost overfishing and shrinking natural resources so of course that increase the full consumption that kilogram. He suggested that Southeast Asia must consider reducing over-exploitation and modernization lead. Several factors affect fuel consumption for fishing vessels such as fishing gear design selectivity for market species is a key target that the EU expected to drop 20 % fuel consumption from fishing. What are the options to go to other types of fishing than bottom trawler? What is the resource? What is the status of the resource? It is of course the distance to the fishing ground type of fishing ground depth weather is a big player in energy consumption or the regulation and skipper needs, etc. Fishing gear varies widely in fuel efficiency, especially passive fishing gear consumes less fuel than active one. He addressed that the EU target to drop both fuel consumption and carbon footprint by 20 % by using a new technology diesel engine, new fishing boats that use alternative energy or electricity, or high efficient post-harvest technology, or new design of fishing gear under the concept of low impact and fuel-efficient fishing that less drag resistance, or applied high-efficiency navigation systems such as fish tracking by sonar, or improvement or establishment of coastal fishing grounds, or incentives or subsidies achieved from the government. Several designs of low-impact fuel-efficient fishing gear like pot, trap-net, gillnet, coastal-longline, bottom seine, and bottom trawl are recommended. One paper that Dr.Suuronen Petri published in FAO in the year 2012 should be a valuable reference. LIFE will provide for quality rather than quantity, long-run cost reduction, waste elimination from a fishing operation, low environmental impacts, enhanced reputation, create new products and work opportunities, move to proactive mode, and utilize technically solid energy audits to choose suitable saving technologies and practices. And, LIFE leads to utilizing energy-efficient technologies, reducing both operational costs and greenhouse gas emissions of fishing vessels contributing to the most operationally efficient fleet.

Mr. Khunthawat gave a lecture on the energy measurement of fishing boats. He introduced the project initiators and those involved in this project. The implementation of this project exemplifies the measurement methods initiated in Australia. Operations range from collecting various data to measuring the number of fish caught Including processing to find the cause of fuel consumption and finding ways to reduce it. Typically, fishing boats lose power from their engines and propulsion systems, hulls, and fishing gear. A simple way to reduce fuel consumption on a fishing boat is by reducing ship speed or keeping the running speed of the engine during the lowest fuel consumption. As part of the project implementation process, starting from the selection of fishing boat type, in this project, trawlers were chosen because of their higher fuel consumption fishing methods than other fishing methods. Selection and installation of measuring instruments to collect fishery data, location, speed, fuel consumption, the number of fish caught in each fishing operation, and income from the sale of catches. Measurements of the energy consumption of fishing boats are made in the case of streaming and trawling to measure the efficiency of fishing vessels and their gear. The purpose of measuring fuel consumption during a fishery is to find the cost-effectiveness of each fishing operation as well as to find ways to increase its efficiency. When these data were processed, the fuel efficiency curve of each fishing vessel was obtained. This will be documented, and performance data will be sent to the fishing vessel owners and recommendations on how to use the fishing vessel and improve the efficiency of the fishing vessel and fishing gear. This is because each trawl boat has different characteristics of length, width, depth, engine, fishing gear, nets, boat weight, etc. This allows the measurement to obtain a unique fuel consumption curve. In addition to the different fuel wastage lines, the fishing period characteristics are different, the maximum boat speed is different, and the break-even point is different, but the trawl speed is about 1.5-2.1 knot which is a similar speed range. In addition, it was found that small fishing boats had higher fuel consumption than medium and large boats. Moreover, the medium-sized fishing boats with the highest income are from selling live fish at high prices, resulting in the most cost-effective fishing trips. For increasing the efficiency of fuel consumption monitoring and displaying the results immediately to the fishing boat operators, the project provides a real-time fuel consumption monitoring system. This new system allows for the accurate and instantaneous performance of fishing boats. It is also possible to collect data for later processing that will benefit future decisions for fishermen on the repair and improvement of fishing boats and fishing equipment.

Discussions and recommendations

There were questions from a participant from Indonesia about their experience in measuring the oil consumption of fishing vessels but the installation of oil measurement systems on fishing vessels has not yet been accepted by the fishermen. He wondered how the results were measured in kg per liter. It is a measure of total fuel consumption for all fishing trips or per a fishing operation, in this question, Mr. Khunthawat explained that the easiest and least error-prone method is to measure the total amount of fish caught in each trip per approximation of the total fuel for a fishing trip. For kg/L measurement per fishing, the operation is possible. But it was difficult for fishermen to weigh every catch after hauling, and the problem of reading on the scales was difficult. The high tolerances due to the constant rocking of the boat cause the weight to be unstable due to the waves. Therefore, for accurate weighing, fish caught onshore should be weighed and compared with the total amount of oil used. In a question among Myanmar participants about whether reducing engine speed would affect the safety of fishing boats in high wind conditions. In this question, Mr.Thaweesak gave an example of reducing engine speed by using a V-shaped Otto board. Using a V-shaped otter board will use a reduced boat speed to open the trawler's mouth and reduce engine rpm by 50 rpm or reduce fuel consumption by approximately 5% due to the reduced friction of the otto board on the sea floor. As for the cost of constructing a V-shape otto board, the cost is still the same as the flat-shape one. In addition to the V-shape otto board, Mr.Thaweesak has presented a refrigerated seawater system driven by both engine and electric motor, which is driven by the main engine in case of a fishing trip but driven by an electric motor will be used in case of side boats at fishing ports and a prototype fishing boat to reduce labor and increase the refrigerated seawater system by reducing the water temperature from 30 degrees to 0 degrees for 12 hours as the boats sail to the fishing grounds. This reduces ice use by 50%, reducing the weight of fishing boats traveling to fishing grounds, helping to reduce fuel costs and reduce carbon dioxide emissions. As for the promotion of the measurement of fishing boat energy consumption and the use of fuel-saving technology. Mr. Bundit would like participants from member states interested in the technologies developed by SEAFDEC/TD to cooperate or request SEAFDEC to provide training to transfer knowledge through the newly developed training ships. Mr.Suthipong introduced the newly developed training vessels that were installed and improved several systems which are the treatment system for caught fishes with seawater refrigerated system, reduction of manpower by hydraulic crane system, improvement of the cabin crew room, toilets with sewage collection system for good hygienic practice of fishing boats. Before ending this discussion session, Dr.Steve outlined all the key points from this training which provided very useful knowledge and experience. He wants member states to work with SEAFDEC/TD to help fisheries save fuel by keeping the boats clean to reduce hull friction, an easy method. Dr.Steve also emphasized the development of low-impact and fuel-efficient (LIFE) fishing, which Dr. Petri described. Emphasis is placed on catch rate, catch selectivity, and fuel consumption, such as increasing the size of the net to reduce oil consumption and increase catch rate and selectivity, as well as increasing the efficiency of fish storage to increase the value of fish and reduced-destructive fishing practices that do not damage the sea floor surface. In figuring out how or developing further fisheries projects, focusing on fuel consumption measurements, and determining the optimum speed of fishing vessels are essential for optimal fuel efficiency. And Dr.Steve wants a future project to disseminate useful information to fishermen so that they can implement it. The V-shape otto board should encourage fishermen to use them by funding for the construction for fishermen to put into practice and must find fishermen who are willing to cooperate with the proposed fuel-saving technology as well. SEAFDEC and member state officials must provide close assistance to fishermen to help mitigate problems affecting fishery issues. And SEAFDEC/TD should provide a small fuel consumption monitoring system that is easy to install for fishermen is another topic that Mr.Bundit wants fishermen to be able to know the fuel consumption in real-time, which will lead to behavioral adjustments to control fishing boats or to increase fishing efficiency further. Other recommendations from Dr. Petri on promoting low-impact and fuel-efficient fishing in Europe will provide compensation for lost income to fishermen participating in experimental programs.

VII. Evaluation results

The attended participants prefer to improve or update their knowledge or technology by gathering the energy audit for fishing vessels and making a co-working network concerning the topics. Important knowledge or technologies that participants expected are full filled including energy efficient technologies and greenhouse gas emission reduction methods, and advanced auditing techniques for an energy assessment of fishing vessels. They preferred SEAFDEC to organize or coworking on energy-saving technologies by transferring knowledge such as adaptation of real-time energy measuring, refrigeration system, V-shape otter board, etc.

VIII. Closure of the online training

Mr. Suthipong Thanasarnsakorn-Training and Research Supporting Division Head on behalf of SEAFDEC/TD expressed his sincere gratitude to the participants for attending the online training. He hopes that the knowledge and experience from online training can be useful for SEAFDEC member countries. He finally extended his gratitude on behalf of the SEAFDEC Deputy Secretary-General to SEAFDEC member countries participants, resource persons, and organizing staff for their support, valuable time shared for the online training, and active participation. He believed that this online training had been organized successfully and met the objectives.

IX. Acknowledgment

SEAFDEC organizing team is grateful to all the lecturers including Dr.Stephen Eyars who is an Australian Smart Fishing Consultant, Dr.Suuronen Petri from Natural Resources Institute Finland (Luke), and Mr.Bundit Choksanguan who is a former Project Consultant on Energy Audits in Thailand, all participants from SEAFDEC MCs for positive engagement and active participation, and the facilitating staff from the Training and Information Section for their fully and smoothly online technical support both preparation and during training. Special thanks to the Japanese Trust Fund for supporting this SEAFDEC training course and hopefully future continuous encouragement.

I. Appendix 1 Opening remark/Closing remarks

OPENING REMARKS

By Nakazato TOMOKO (Ph.D.)
Deputy Secretary-General of SEAFDEC/TD

Online Training Course on Energy Audits for Fishing Vessels
21-23 June 2022

Distinguished delegates from the Southeast Asian Fisheries Development Center (SEAFDEC) Member Countries.
Resource persons from Australia, Finland, Thailand, SEAFDEC instructors, and staff.
Ladies and Gentlemen. A very Good Morning!

Welcome to the online training course on Energy Audits for fishing vessels that is organized by the Southeast Asian Fisheries Development Center, Training Department, (SEAFDEC/TD), it is my great pleasure to welcome all participants from SEAFDEC member countries to these three days training course which is completely conducted on a digital platform in line with the social distancing norms due to COVID-19 pandemic.

As you all know that the recent high oil price shock since the alleviation of the COVID-19 pandemic and depletion of marine fishery resources for several decades past have been heavily impacting the fishery sector in several countries in Southeast Asian region. Owners of various fishing vessels are spent a lot of fuel costs on propulsion and fish handling system in each fishing operation. Therefore, those fishing vessels implicitly need to risk or halt their fishing because the cost of diesel is too high to risk losing if caught a few fish at a time. SEAFDEC's training department is concerned about this emerging issue and trying to find ways to mitigate the impact of rising oil prices. The initiative project during 2015-2018, namely Energy Audits for trawl fishing vessels funding by FAO implemented by SEAFDEC/TD under Resolution and Plan of Action on Sustainable Fisheries for Food Securities for the ASEAN Region Towards 2030.

Therefore, Energy efficiency is one of the common concerns also been highlighted based on the build-up, awareness, and concepts ideal for improving fuel efficiency to the fishery and extension fishery officers of SEAFDEC member countries, fishing vessel owners, and skippers for a tool or mechanisms to proceeding the fishing vessel energy audits to achieve the goals of fuel-saving and alleviate of the carbon emissions from capture fisheries.

In this regard, I really hope and would like to encourage all of you to take advantage of this training and try to gain as much information and knowledge from this course, with this your active participation would be led to the achievement of the objectives of the training program.

With that note, Honorable Resource persons, and participants, May I formally declare this Online Training Course on Energy Audits for Fishing Vessels for SEAFDEC Member Countries **opened**.

Thank you very much and have a good day!..............................

CLOSING REMARKS
By **Mr. Suthipong Thanasansakorn** (TRSDH)

Online Training Course on Energy Audits for Fishing Vessels
21-23 June 2022

Distinguished delegates from the Southeast Asian Fisheries Development Center (SEAFDEC) Member Countries.
Resource persons from Australia Dr. Stephen Eayers;
Resource persons from Finland Dr.Petri Suurenan;
Resource persons from Thailand Mr.Bundit Choksanguan;
Resource persons from SEAFDEC/TD. and SEAFDEC facilitating staff.

On behalf of the organizers of this online training course, please allow me to inform you that we are very happy with the results. Despite your very hectic schedule, the very objective of this training course was achieved. We can now be assured that our participants have been improved and updated on the current practice of Energy Audits for fishing vessels on the sustainable development of fisheries, as well as on other information that is of relevance to improving energy use and optimization of fuel on fishing vessels. We are also happy that our final goal was reached with your recommendations for the development of further training courses by SEAFDEC/TD, in improving the fuel-saving knowledge of people engaged in the fishing sector in the Southeast Asian Community. For the outputs that you have put together during this discussion session, we are indeed very grateful.

Ladies and Gentlemen, before we end this online training course, we would strongly encourage the SEAFDEC Member Countries to continue to maintain this collaborative environment to foster the understanding of greenhouse gas reduction and fuel-saving applied to onboard fishing boats for sustaining our fisheries sector

At this juncture, I would also wish to thank the SEAFDEC organizing team for their all-out support that made this online training course a success. Finally, we wish all of you the best and every success in whatever approach you would undertake towards addressing the challenges ahead of us, especially to improving fuel-saving onboard fishing vessels and greenhouse gas reduction.

With, Honorable participants, and resource persons, I now declare this Online Training Course on Energy Audits for fishing vessels for SEAFDEC MCs **closed**.

Thank you once again for your cooperation and support. Good day!......................

II. Appendix 2 Lists of participants/resource persons/facilitators/administrative

Brunei Darussalam	
-	-
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List of Resource Persons

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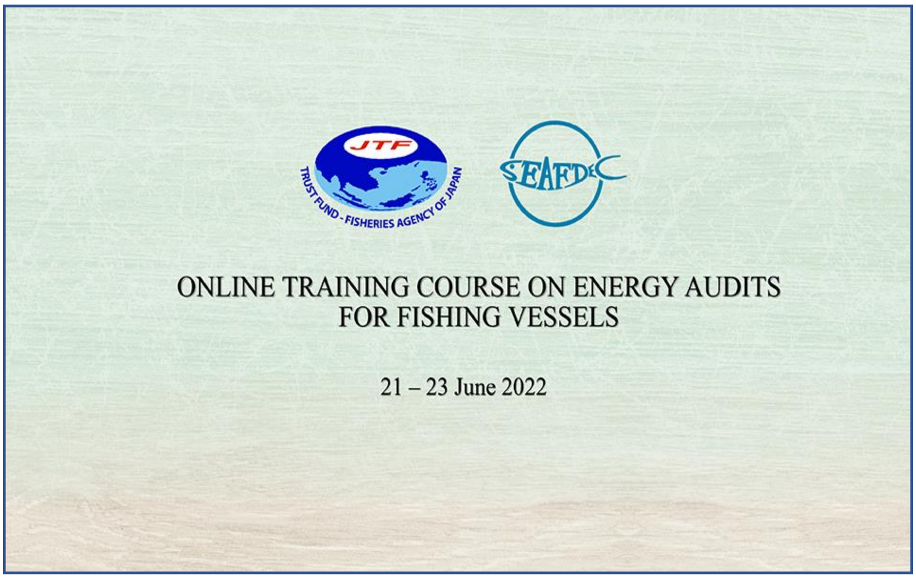
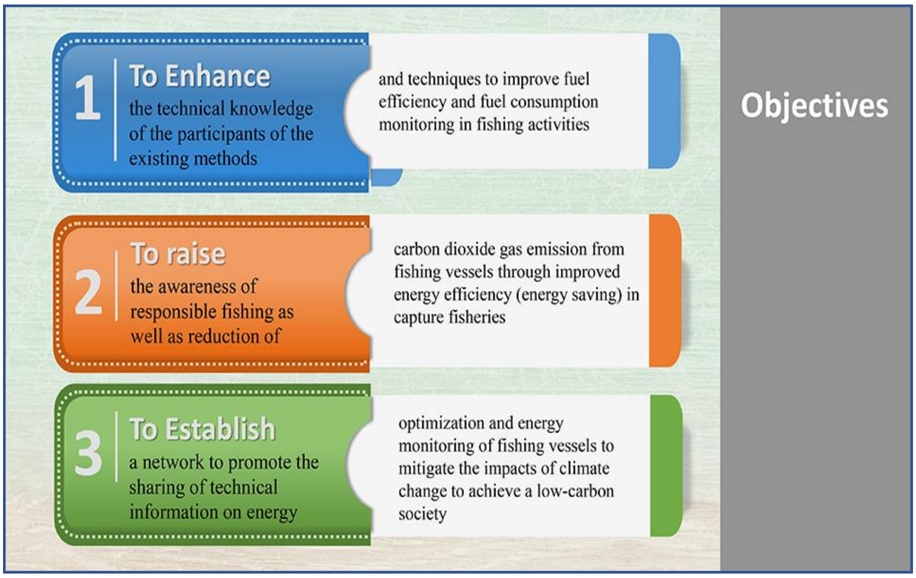
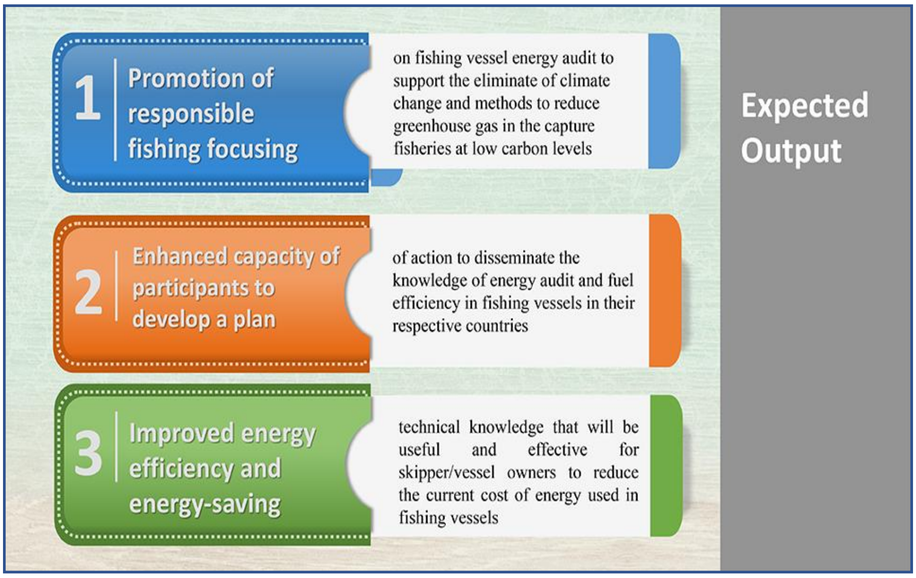
III. Appendix 3 General information of the training course







PROGRAM DESCRIPTION

Module:
- Current situation in the SE and international levels
- Lesson learns of energy audits on Thai trawler
- Discussions and Evaluations

Day	Time	Subject	Resource Persons
21 June 2022	0900 – 0915	◦ Welcome remarks	Deputy Chief of the SEAFDEC Training Department
	0915 – 0930	◦ Introduction of the online regional training course	Mr. Khunthawat M.
	0930 – 1030	◦ Country Report	SEAFDEC member countries
	1030 – 1200	◦ Energy-audit process to suit certain types of fishing vessels and methods to undertake a trial, data collection, and energy audit on fishing vessels for future work at the international level	Dr.Stephen Eayrs
22 June 2022	0900 – 1030	◦ Optimizing energy use in fisheries in Southeast Asian region : fishing vessels energy audits and way forward	Mr.Bandi Chokesanguan
	1030 – 1200	◦ Energy efficiency and energy-saving technologies in fisheries – options for LIFE-fishing	Dr. Petri Suuronen
23 June 2022	0900 – 1030	◦ SEAFDEC and FAO fishing vessels energy audits for a pilot project in Thai trawl vessels	Mr.Khunthawat Manomayidthikarn
	1030 – 1200	◦ Discussion and Evaluation ◦ Closing Ceremony	SEAFDEC/TD and Resource persons

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Finland

DR.PETRI SUURONEN
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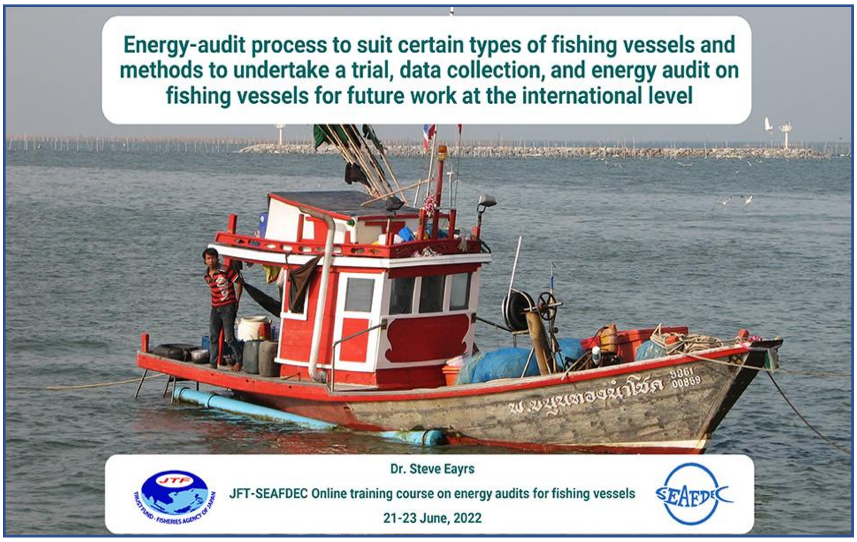
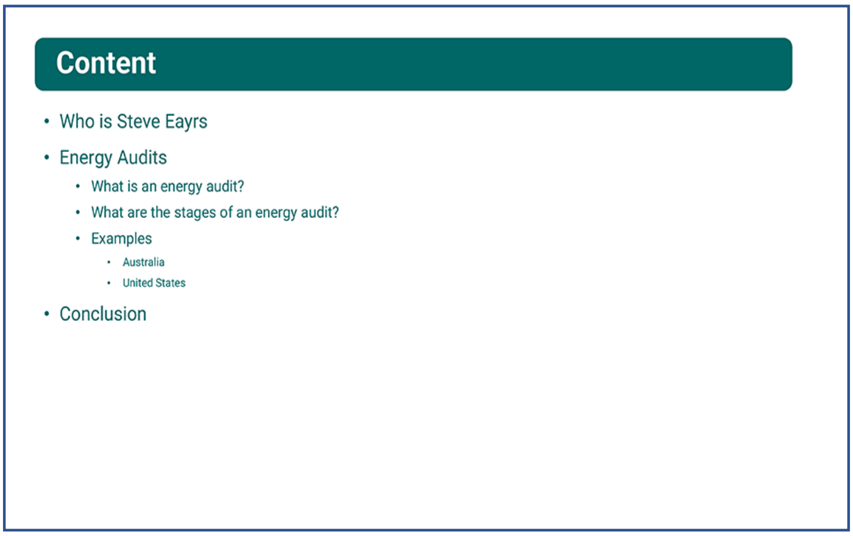
SEAFDEC/TD

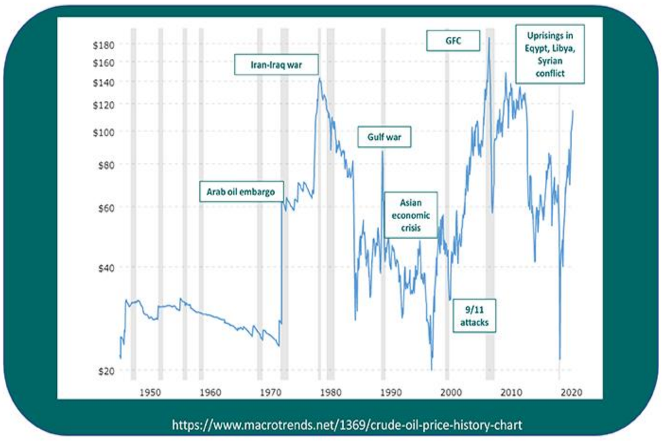
ONLINE REGIONAL TRAINING COURSE OF ENERGY AUDITS FOR FISHING VESSELS

IV. Appendix 4 Presentation of Energy-audit process to suit certain types of fishing vessels and methods to undertake a trial, data collection, and energy audit on fishing vessels for future work at the international level (Dr.Stephen Years)





Here we go again!



What is an energy audit?

An energy audit is an opportunity to reduce energy consumption and greenhouse gas emissions by:

- Identifying and measuring sources of energy consumption when fishing, steaming, and at the wharf
- Identifying relative consumption by each source
- Evaluating causes and conditions of energy consumption including sources of inefficiency and waster
- Identifying costed options to reduce consumption
- Identifying payback periods
- Permitting ranking and prioritization of sources of consumption
- Improving profitability and sustainability

Energy audits are therefore about identifying ways to save money through the conservation of energy & the application of energy efficient practices or technology!

Stages (levels) of an energy audit

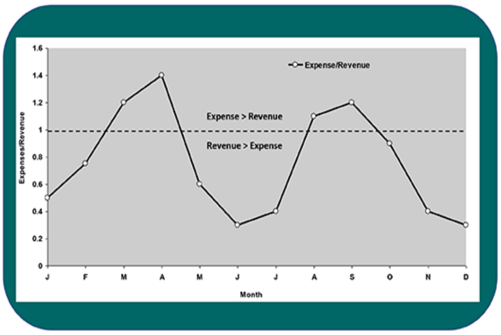
- **Stage 1 – audit of historical fuel consumption data, catch**
  - Broad overview of energy consumption, operational inputs and outputs
  - *Is the consumption excessive?*
- **Stage 2 – screening survey**
  - Detailed evaluation including mapping of relative sources of consumption
  - Identify major consumers and recommend options
  - *Where can I have the most impact?*
- **Stage 3 – detailed investigation and analysis**
  - Detailed focus on major sources of consumption
  - Costed recommendations for potential savings

Accuracy of assessment of costs and savings

Modify or replace

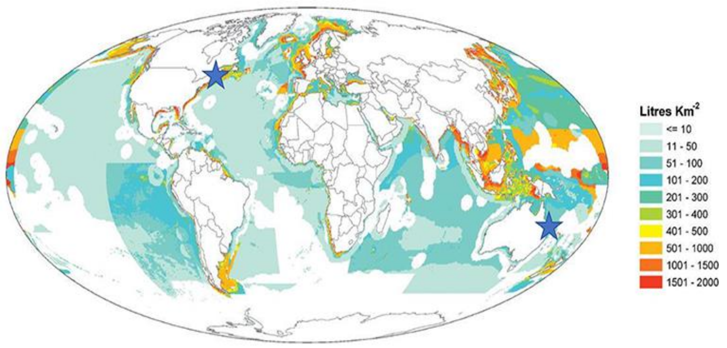
Energy audits

Energy audits stimulate interest and raise questions about the efficiency of a fishing operation, for example:



- *What expense to revenue ratio is acceptable or unacceptable?*
- *How much profit do I want to make each month of the year?*
- *How can I ensure I am profitable every month of the year?*

How much fuel is used in global fisheries?



- Source: Tyedmers, P.H., R. Watson and D. Pauly. 2005. Fueling Global Fishing Fleets. Ambio. 34 (8) : 635-638

New England groundfish fishery

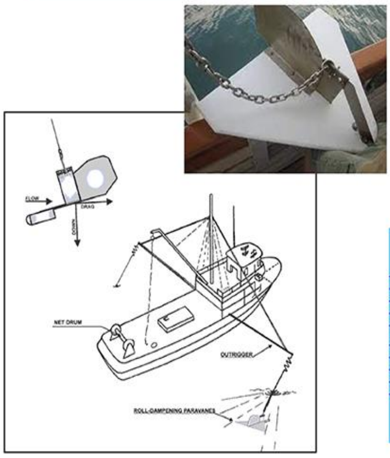
- First ever audit for the fishery
- Focused on 4 trawlers
- TriNAV Fisheries Consultants, CANADA
- Interviews + inspections and measurements of the deck, under the deck, wheel house equipment, and the hull
- ~ ½ day per boat + follow-up questions if necessary (Level 1 and 2 combined)

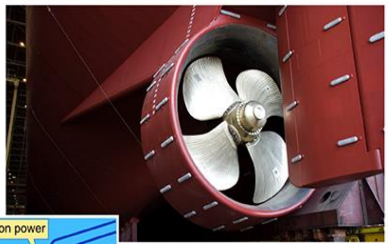
Audit outcomes (Level 1 and 2 only)

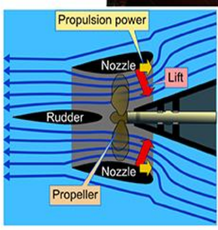
Recommendation	Estimated cost (US$)	Estimated annual fuel saving (%)	Estimated annual fuel saving ($)	Payback period (years)
Reduce use of paravane stabilizer by 25%	0	20	800 - 3 000	0.0
Install fairing pieces	500	5	1 800 - 3 600	0.1 - 0.3
Install streamlined rudder	1 000 - 2 000	5	1 500 - 3 600	0.6 - 1.3
Reduce underwater fouling	2 500	5	3 600	0.7
Modify ventilation to engine room	2 500	5	1 800	1.4
Install fuel flow meter	3 000	15	4 500 - 5 300	0.6 - 0.7
Install more efficient open water propeller	3 700 - 9 000	3 - 8	1 100 - 2 500	1.5 - 5.7
Repair hull surface with gel coat	10 000	5	1 800	5.7
Install autopilot	12 000	5	1 800	6.9
Install knotless netting	15 000	12	2 300 - 4 700	3.2 - 6.7
Install kort nozzle	25 000	23	6 900	3.6
Install acoustic trawl monitoring system	25 000	15	2 800 - 5 800	4.3 - 8.9
Increase waterline length at stern	30 000 - 50 000	15	4 500 - 10 800	3.7 - 11.1

Not all recommendations apply to all boats; Range = min. value – max. value

Paravane stabilizer and kort nozzle







Questions that can be asked of the audit report

What if I want to purchase a fuel saving option, bank the savings to recover the cost, before making another purchase? Total budget - $5500

Recommendation	Cost ($)	An. fuel ($)	Fuel savings (%)	An. savings ($)	An. fuel - An. Savings ($)	Cum. savings (%)	Time to save (mths)
Fuel meter	3 000	30 000	15	4 500	25 500	15.00	8.0
Upgrade rudder	2 000	25 500	5	1 275	24 225	19.25	5.3
Fairing pieces	500	24 225	5	1 211	23 014	23.29	1.0
Total	5 500			6 986		23.29	14.3

Or, what if my initial budget is $3000, and I wanted to used the fuel savings to purchase another fuel saving option? I only want to spend $5500.

Recommendation	Cost ($)	An. fuel ($)	Fuel savings (%)	An. savings ($)	An. fuel - Ann. Savings ($)	Cum. savings (%)	Payback period (mths)
Fuel meter	3 000	30 000	15	4 500	25 500	15.00	8.0
Upgrade rudder	2 000	25 500	5	1 275	24 225	19.25	4.2
Fairing pieces	500	24 225	5	1 211	23 014	23.29	0.9
Total	5 500			6 986		23.29	13.1

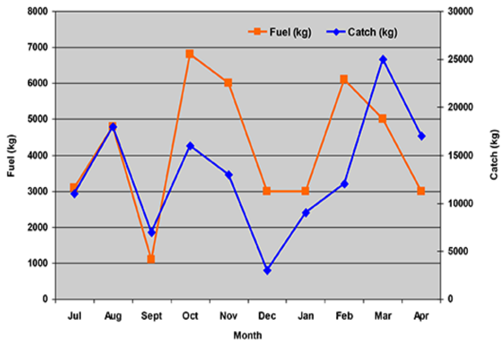
Figures assume fishing every day each month; fuel cost static; zero interest repayments

Queensland east coast prawn trawl fishery

13

Stage 1 – Audit of historical fuel and catch records

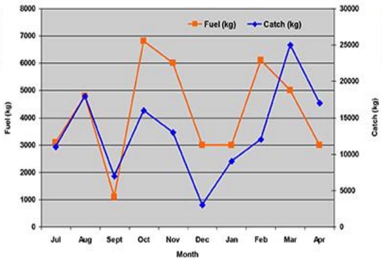
Data from one commercial prawn trawler

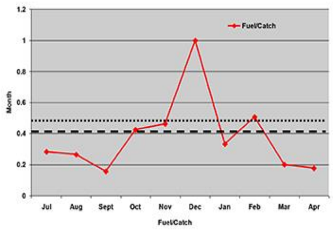


What does this tell us about the fishing operation? Which month is most profitable?

Stage 1

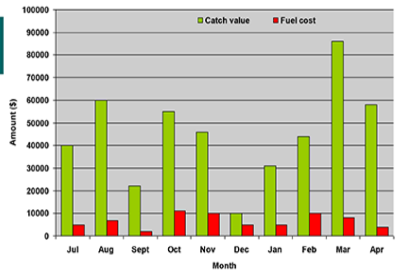
- Fuel to catch ratio provides some insight into best performing months
- Lowest fuel:catch ratio values are desirable
  - Sept. – ratio = 0.2 (2kg fuel:10kg catch)
  - Dec. – ratio = 1
  - Annual average = 0.4
- @$1.53 per kg fuel and $3.50 per kg fish, target ratio is 0.48
- Most months below 0.48, so all is good, yes?
- But, what is going on in December? Why is so much fuel used? Am I profitable in December?

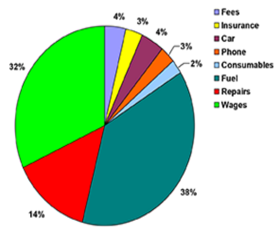




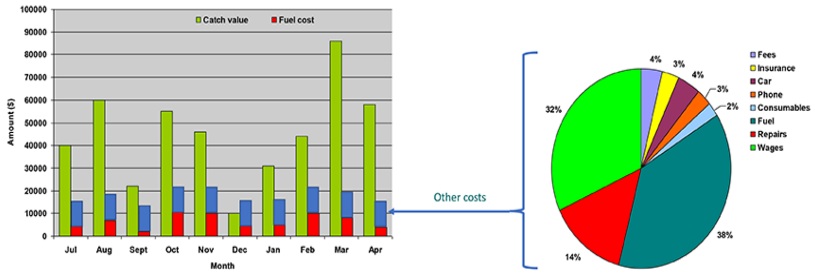
Stage 1

- Lets look at monthly fuel cost, others, costs and revenue
- Each month catch value is greater than fuel costs
- But, what about other costs?
- Given the fuel and low catch value in December, how will other bills be paid?
- Catch value must be 62% (100% - 38% = 62%) greater than fuel cost to break even
- If not, then profits from other months must subsize December





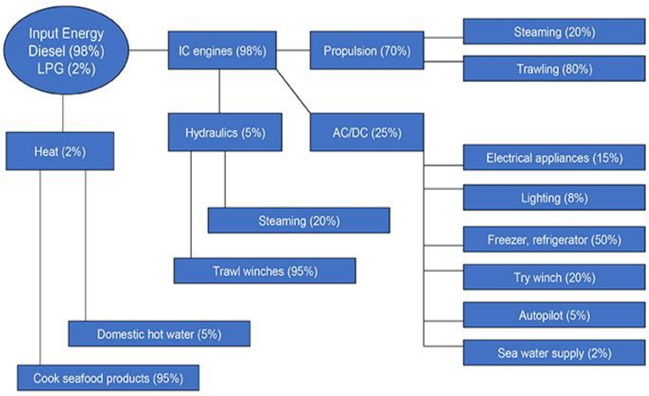
Stage 1



So why would I go fishing in December?

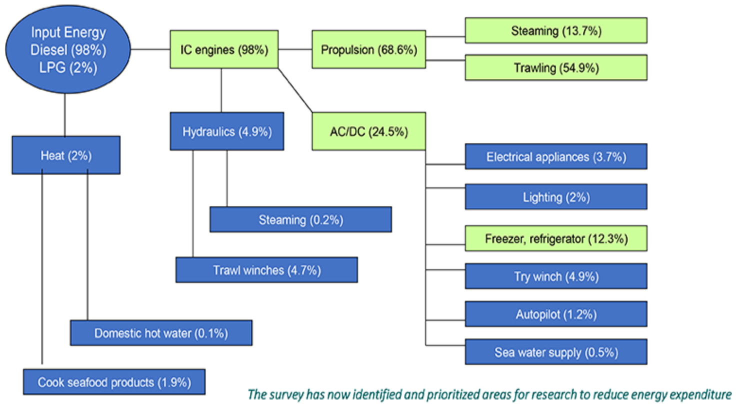
Stage 2/step 1 – Screening survey

- Major sources of energy use identified & proportion of energy use estimated from equipment specifications



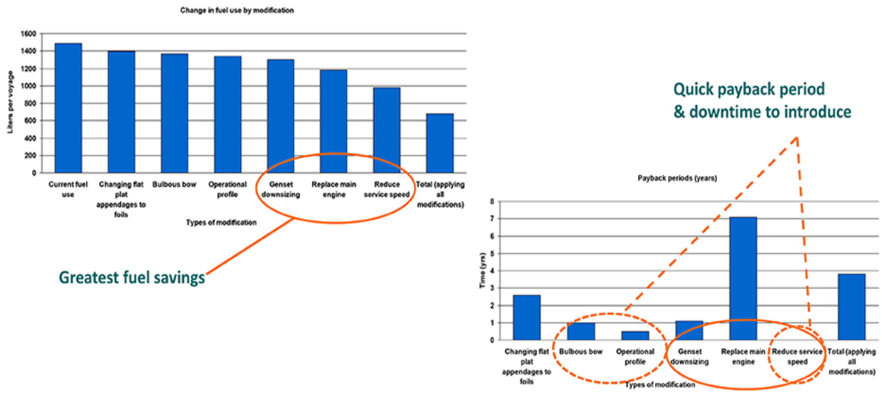
Stage 2/step 2 – Screening survey

- Major sources of energy use identified based on equipment specifications and actual level of usage (frequency of use, extent of use, rate of consumption)



Stage 2/step 3 – Screening survey

- Identify modifications to reduce fuel, their cost, and payback periods



Stage 3– Detailed evaluation of each selected option

- Select preferred options
- Decision time! To purchase or not to purchase? Estimate payback period
- Plan for installation
- Ongoing monitoring of energy consumption after fit-out

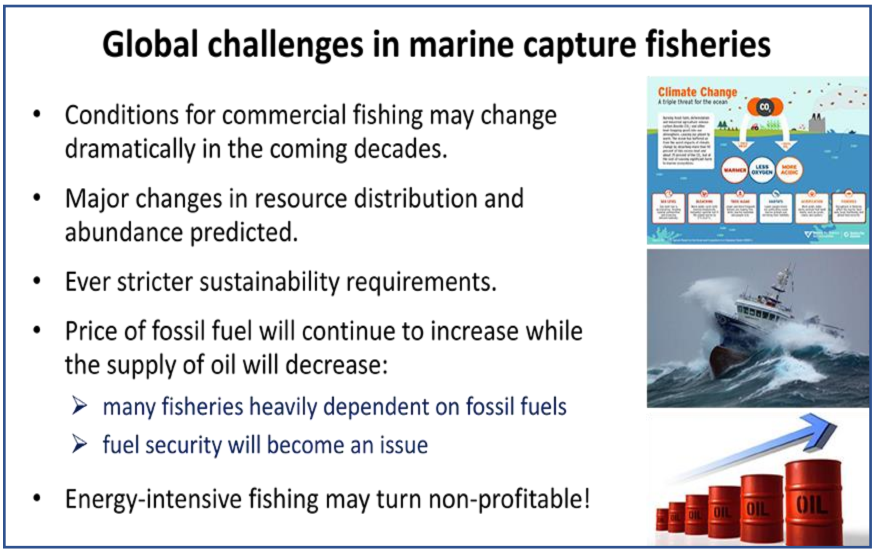
Conclusion

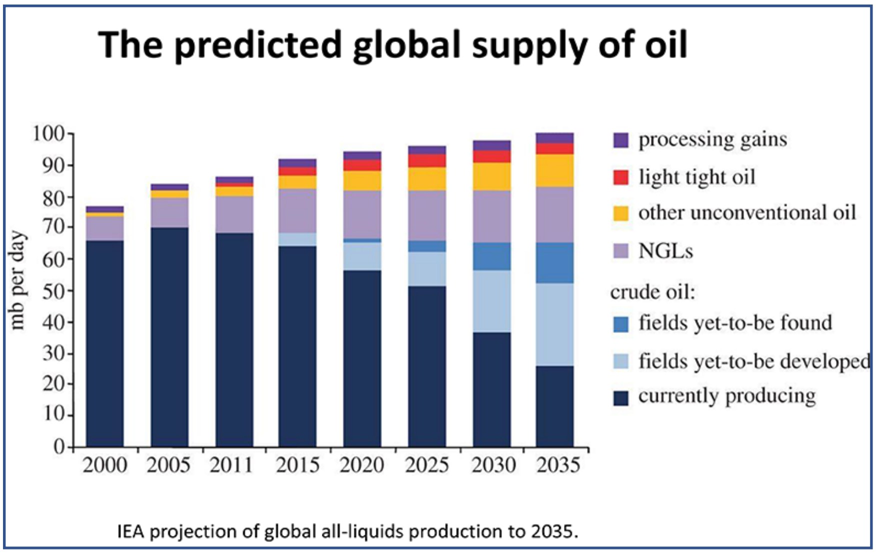
- There are 3 stages of an energy audit process
  1. Audit historical data of energy use
     Collect & analyze records to
     - determine the cost and quantity of energy used
     - annual and seasonal trends in energy use and cost
     - the energy use per unit of output (e.g. gal fuel per lb seafood)
  2. Screening survey
     Conduct screening survey to indicate
     - major energy consuming plant and processes
     - obvious sources of energy waste and inefficiency
     - gaps in metering and reporting of energy use
     - priority areas for further investigation
  3. Detailed investigation and analysis
     Examination of processes identified in screening survey

Conclusion

- Often stage 2 & 3 are combined or abbreviated
- Energy audits raise awareness and prompt consideration of improvements
- A variety of options exist to reduce fuel consumption
- Consider short and long term options and payback periods
- Develop goals, objectives, targets, thresholds, and responses
- Develop appropriate metrics to measure performance
- Each audit is different between boats
- Some suggested improvements are expensive and not easily or quickly applied
- Other improvements can be immediately applied
- Overall, reducing fuel consumption through vessel and gear changes is a long, multi-year process.
- It is likely to require government subsidy to accelerate vessel and gear modification

V. Appendix 5 Presentation of Energy Efficiency and Energy-saving technologies in fisheries – options for LIFE-fishing (Dr.Suuronen Petri)

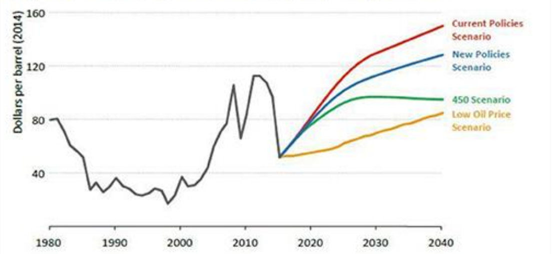




Rising fuel prices a major challenge for many fisheries

- Exposure of fishing sector to rising fuel prices present major challenges for its viability.
- Alternative energy sources (wind, solar, electricity, hydrogen, liquid gas, bio-fuel) not yet practical substitute for many fisheries but the situation may change soon.

Figure 1.5 ▹ Average IEA crude oil import price by scenario



World Energy Outlook

- Labour costs: 20-50%
- Fuel costs: 15% → 40% → 70% !
- Fishing Gear costs: 5-15%
- Repair & maintenance: 5-10%
- Capital costs: 5-25%

Fuel consumption in fisheries on a global level

- The global fishing fleet consumed app. **40 million tonnes** of fuel per year in 2011 (Parker et al. 2018) --- *this may be an underestimation*
    - **that generated a total of 179 million tonnes of CO_2**
- Emissions from the global fishing industry grew by 28% between 1990 and 2011, with little increase in landings.
- Globally, about **0.6 litres** of fuel was used per kg fish landed.
- Fuel consumption is heavily dependent on fishing method and target species:
    - **crustacean trawl fisheries and beam-trawling of sole & plaice may consume up to 6-7 litres of fuel per kg of catch**
- Smaller vessels are not necessarily better in fuel consumption per unit of catch.

Fuel consumption by countries and regions

- Countries with big fishing fleets consume major share of the fuel used in fisheries:
    - China, Indonesia, Vietnam, USA and Japan account for 37% of global landings and 49% of the total emissions
- The high overall fuel consumption in Asia reflects the major role fisheries play there as a source of food and income.
- It also reflects the type of fishing conducted, overcapacity, overexploitation, and the relatively poor utilization of a modern technologies.

European Union promotes low-carbon-footprint fisheries

- Fuel consumed by the European Union (EU) fishing fleet represent on average of 25% of the value of landings.
- Improving fuel efficiency by 20% has been one of the key targets of EU policy:
  - ➢ Documenting environmentally friendly fishing practices is becoming a criterion to grant vessels access to fishing opportunities - **carbon footprint is part of that.**
- Studies done in EU indicate that individual technological or operational adaptations offer energy saving mostly in the range of 5-20%.
  - ➢ In many cases the investments have not been economically feasible but if the price of oil continues to increase, investments will become more feasible.
- Development of "market-incentive" solutions such as **carbon tax** or carbon exchange market are under consideration in EU:
  - ➢ targeting to reduced energy consumption and reduced overall environmental impact

The key theses

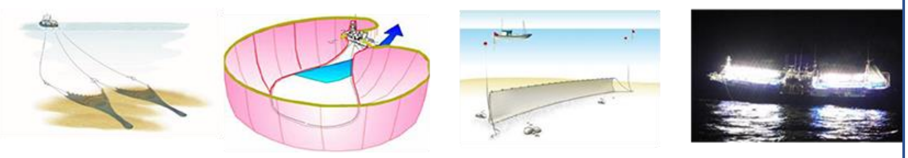
1. **A global challenge for capture fisheries is to promote fishing practices that minimize their environmental impacts while maximizing the societal value generated.**
2. **Fuel consumption acts as an indicator of the environmental impacts of a fishing fleet.**
3. **Saving fuel go hand-to-hand with higher economic returns and economic efficiency.**
4. **We need to look at technology in a new way and minimize the energy value of catching fish.**

Many factors affect fuel consumption

- ➢ vessel design, age, condition and operation
- ➢ type and age of main engines and auxiliary engines
- ➢ propeller and propulsion system
- ➢ other engines/devices than those used for propulsion
- ➢ fouling of hull
- ➢ design of fishing gear and mode of operation
- ➢ target species
- ➢ resource abundance and distribution
- ➢ distance between fishing ground and fishing port
- ➢ type of fishing ground
- ➢ fishing depth
- ➢ weather, sea state, wind
- ➢ catch quotas and other regulations
- ➢ skipper decisions
- ➢ etc

Fishing gears vary widely in fuel efficiency

Fishing Gear	Litres of fuel per kg of catch (average)
Passive fishing gear	0.1 - 0.4
Bottom seine	0.1 - 0.5
Bottom/shrimp trawls	0.5 - 2.5
Midwater trawl	0.1 - 0.3
Purse seine (for small pelagic fish)	0.1 - 0.2



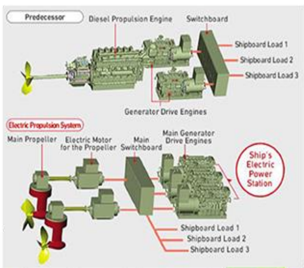
On average, 0.6 litre of fuel is used to catch one kg of fish!

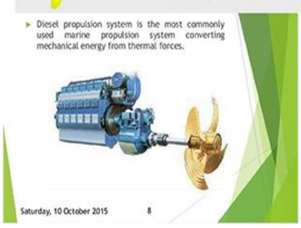
Vessel and engine technology – major progress continues

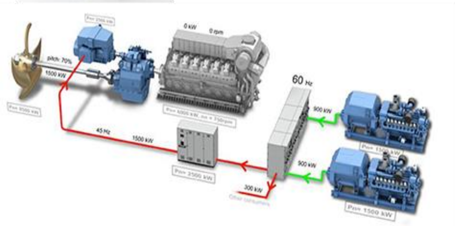
- The correct choice of the engine(s) is critical for fuel consumption (especially when working under high and low load).
- The performance and fuel efficiency of modern diesel engines is much better than just 15 years ago.
- New state-of-the-art trawlers equipped with new-generation diesel engines have a relatively high fuel efficiency.
- High efficiency reduces exhaust emissions and provides extended intervals between service requirements.
- **It makes sense to up-date the engine if there is financial possibility to do that!**

A fuel-efficient Wärtsilä 31 4-stroke engine.

Energy efficient propulsion systems – use of two engines







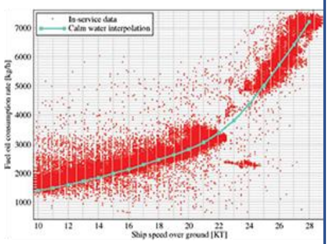
Modernization of fleets

- **Bluewild**'s new trawler built for shrimp and whitefish trawling:
  - these two fisheries require different levels of towing power
- **Ulstein** developed a battery hybrid propulsion solution that provides large reductions in diesel consumption and emissions
  - diesel-electric and diesel-mechanical propulsion
  - improves the efficiency of a wide range of power requirements
- Ca 25% reduction in fuel consumption and emissions compared to a similar trawler performing this type of combination fishing

This new trawler has an efficient hybrid system with two propellers that can combine battery power with both diesel-electric and diesel-mechanical propulsion. This makes the vessel very fuel-efficient compared to a trawler with traditional propulsion.

Economic vessel speed – sail-assisted propulsion

- Vessel speed is on of the key factors affecting fuel consumption
- Fuel consumption increases drastically as a vessel approaches it maximum speed:
  - wave breaking resistance increases exponentially
  - reduction of steaming speed by 10-20 % may reduce fuel consumption by 30-60 %
  - economic vessel speed means fuel saving.
- Vessel weight also plays a role (displacement).
- Multi-hull vessels are more fuel-efficient.
- **Sail-assisted propulsion is coming a realistic option?**
- What about electricity? Complementary energy?



What is the future role of electricity in fisheries?

- There is intensive development.
- How to charge the batteries at sea?

This is a new Finnish ferry using electricity in propulsion.

Post-harvest technologies and energy consumption

- Post-harvest practices are an important element of energy use in fisheries:
  - ➢ fish is easily spoiled
  - ➢ increased shelf life should be a key target
- Preservation and refrgeration technologies are critical and may require a lot of energy:
  - ➢ energy optimization should have a high priority
  - ➢ utilization of solar energy
  - ➢ equipment-efficiency and automation
  - ➢ plant management practices - control of processess
  - ➢ awareness among plant workers
  - ➢ energy auditing

Back to basics - drag of trawl gear components

- Bottom trawling is an energy intensive fishing activity:
  - ➢ it may consume several times more fuel compared to passive fishing methods for every kg of fish captured
- Substantial portion of the time is spent on towing the gear.
- During tow, resistance of the vessel is small compared to resistance of the gear.
  - ➢ trawl resistance has a large effect on the overall fuel economy.
  - ➢ In many cases trawl resistance can be reduced without compromising the catch!

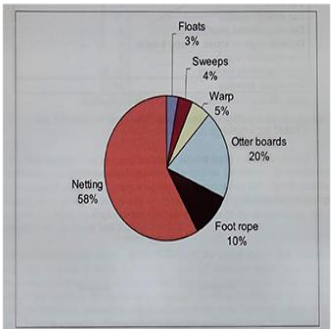
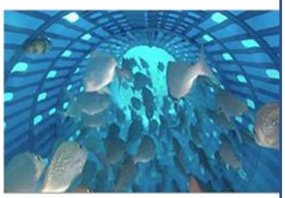


Fig. 1 Drag of trawl gear components (after Wileman, 1984)

Wileman (1984) estimated the drag of the components of a typical Nordic trawl design where the netting contributed 58% of the total drag.

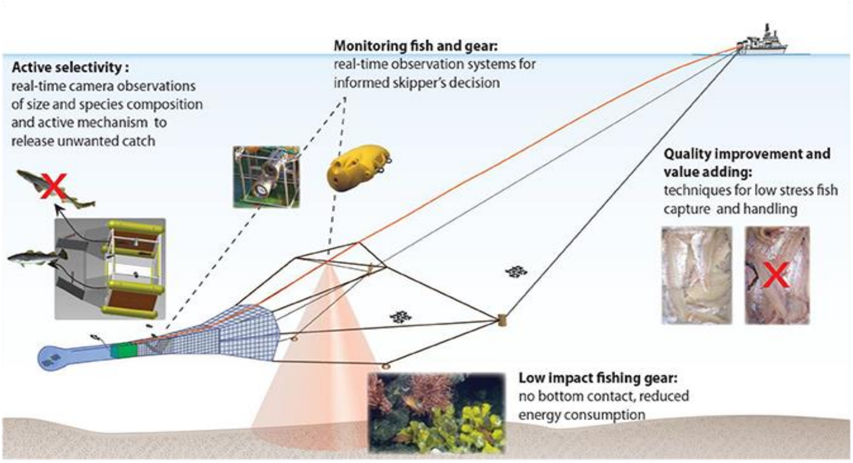
Fuel saving options in trawling

- Larger meshes in the herding parts
- Lower drag netting materials
- Hydrodynamic trawl doors
- Reduced drag surface of floats
- Reduced drag surface of ground gear
- Optimal trawl rigging
- Reduced steaming and towing speed
- Utilization of fish behaviour while trawling
- Increased herding by artificial stimuli while trawling
- Location of dense fish aggregations before trawling starts
- Efficient steering and navigation, etc, etc, etc ....



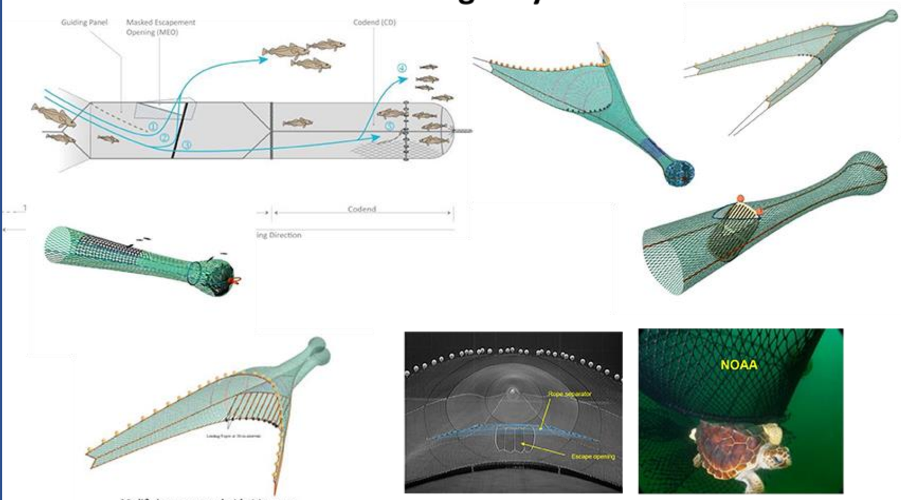
- ➢ Each change has a cost!
- ➢ Payback time of each option varies!
- ➢ Each fishery requires own solutions!

A low-impact and selective trawl (CRIPS-trawl)



Source: **Valdemarsen, J.W., Øvredal, J.T. and Åsen, A., 2011**. *Ny semipelagisk trålkonstruksjon (CRIPS-trålen). Innledende forsøk i august-september 2011 om bord i M/S "Fangst"*. Rapport fra Havforskningen nr. 18. Bergen, Norway, Institute of Marine Research. 17 pp.

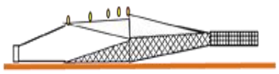
Selective fishing may save fuel



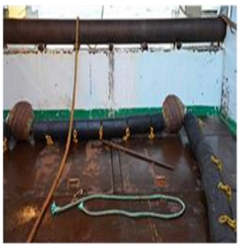
Modified separator trawl with rising ropes

Rope separator trawl, USA. *Rillahan, He and Russo.*

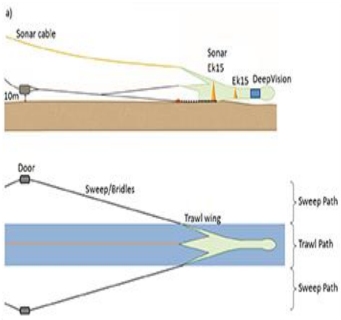
There are many other ways to reduce fuel consumption



- Remove netting in upper wings and panels when catching bottom dwelling organisms like shrimp and nephrops.
- Front part meshes in herding zone can in many cases be larger.
- Use stronger and thinner twine in netting (Dynema etc)



- Reduce pressure of gear components towards bottom



- Lift the trawl doors off-bottom

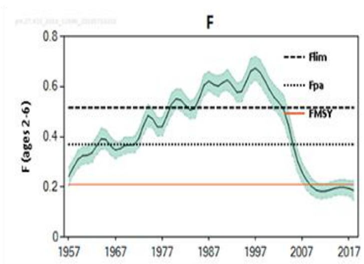
Increasing operational efficiency – many options available

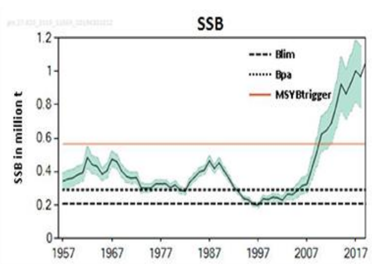
- Improve **knowledge** on resources and fishing grounds
- Improve **navigation** and **fish finding**
  - GPS, electronic charts, etc.
- Improve **control** of gear
- Use modern fuel-efficient engines
- Optimise vessel and propulsion system
- Use **speed** controls
- **Maintain** vessel and engine
- Improve gear **efficiency**
  - reduce netting surface area, increase hydrodynamic components , use lighter groundgear, composite ropes
- Reduce **waste** through improved handling
- Improve fisheries **management** by taking energy issues into account
- Use **alternative** fishing practices (if available)
- etc

Improving the status of exploited stocks improves fuel efficiency

- The overall fuel efficiency often reflect the stock situation.
- When the number of fish available for fishing is low due to overexploitation, fishers have to spend more effort and fuel to catch the same size of catch:
  - ➢ catch per unit of effort (CPUE) is smaller
- Rebuilding stocks makes sense but is not easy!
- During the transitional phase, landings will reduce, and fisheries may need economic support to survive.

An example: North Sea plaice stock is recovering – CPUE is growing





- **When fishing pressure (F) decreases, the spawning stock (SSB) increases:**
- ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/ple.27.420.pdf ...

Incentives and subsidies

- Fuel subsidies largely detrimental to development of sector (see **WTO** recent decision):
  - ➢ subsidies encourage fleet overcapacity
  - ➢ subsidies inhibit the necessary steps in modernization of fleets
- Phasing out fuel subsidies would support more fuel-efficient fishing and trigger the development of alternative systems to operate:
  - ➢ major short-term economic problems for the sector
  - ➢ risk of redirecting current fishing capacity to illegal actions and further impairing the economic viability
- Removing taxation on alternative energy sources may provide an incentive for their use if their price become attractive to the fishing sector.
- Policy outcomes could include market strategies such as certificates for attaining a low footprint seafood products.

Low Impact and Fuel Efficient (LIFE) Fishing

- **Low Impact and Fuel Efficient (LIFE) fishing** refers to fishing gears and practices that ensures fish capture occurs:
  - ➢ **using the minimum possible amount of fuel**
  - ➢ **with minimal impact on the environment**


Fisheries Research

Review

Low impact and fuel efficient fishing—Looking beyond the horizon

Transitioning to another gear

- Transitioning to a new fishing gear or practice may in some cases be a potential solution.
- A change, however, has many uncertainties and an economic risk:
  - ➢ The design of existing fishing vessels often limit the possibilities of changing the fishing method.
  - ➢ Gears and practices are often "tailor-made" to catch specific target species around specific fishing grounds.
  - ➢ There is often a strong resistance to change.
  - ➢ Gears that rank high for one type of direct environmental impact may have a lower rank for another.

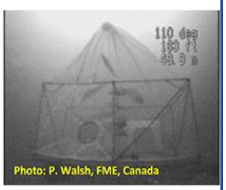
Characteristics of some demersal fishing gears (Suuronen et al. 2012)

	Advantages	Disadvantages	Priority actions
Pot	Low energy use and low habitat impact Selective (species and size) Flexible and transportable High catch quality, live bycatch	Low capture efficiency for many species Ghost fishing of lost pots	**Enhance efficiency** for a wider range of species. Alternative baits. De-ghosting technology.
Trap-net	*More expensive and operation more complex than with pots.*	Capture depth limited Suitability limited to fewer species Capture of non-target species	**Develop practices** to prevent the entangling of non-target species.
Gill-net	Low energy use Flexible and easily portable Size selective Relatively cheap to manufacture	Labor intensive Catch quality a concern Capture of non-target species Ghost-fishing of lost nets	Develop practices and technologies that **reduce bycatch**.
Coastal long-line	Low energy use (*depends*) Minimal habitat impact Flexible and portable Species selective, good catch quality	Labor intensive, time consuming Bycatch of non-target species Snagging on benthic epifauna Availability and price of bait	Capture of bait may be fuel-consuming. **R&D of alternative attractants** & hook design.
Bottom seine	Relatively low energy use Reduced sea bed impacts (light gear) Operation on smaller fishing grounds Good catch quality	Operation limited to cleaner grounds and shallower depths. Not effective for non-herded animals such as shrimp.	Operation on rough grounds, in sea currents and in deeper waters. **Bycatch reduction tech.**
Bottom trawl	Effective Versatile	Seabed impacts, fuel consumption, bycatch, costs, catch quality	A large variety of actions possible to improve this capture method.

Alternative 1: **Bottom seining**

- Bottom seines (e.g. Danish seine):
  - lighter groundrope (than in a bottom trawl)
  - no trawl doors
  - lower hauling speed
  - area swept smaller
  - less pressure (force) on the seabed
  - fuel usage lower
- Fish caught have high quality → live-capture possibility.
- This method is restricted by depth, fishing ground, bad weather and strong tide.
- Unwanted catches may be a problem in some seine fishing.
- Pair trawling / Pair seining → underutilized capture method

Alternative 2: **Pot fishing**



- The advantages of pot fishery include:
  - low energy use
  - low habitat impact
  - high catch quality
  - live delivery option
  - unwanted catch can often be released alive.
  - easy to transport (when collapsible)
- Unwanted catch can be minimized by using appropriate:
  - baits, mesh sizes, materials
  - size, shape, location and design of entrance and escape openings
- Low capture efficiency for many finfish species is a major barrier in pot-fishing!

How to increase fishing efficiency of pot

- Understanding "fish" behaviour in relation to pot is essential.
- A system that prolongs the release of bait odour and in which the odour dispersal is controlled could increase pot efficiency.
- Low catching efficiency of pots is often due to low ingress rate:
  - use of additional stimuli may trigger more fish to enter a pot
  - light, low frequency sound, artificial baits

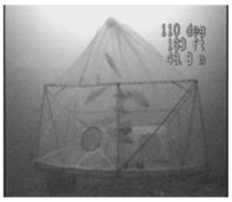


Photo: P. Walsh, FME, Canada

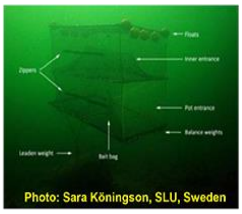


Photo: Sara Köningson, SLU, Sweden

A floating pot - the entrance always faces down current

The reality of fishing sector

- Fishers are reluctant to adopt techniques that may increase costs and workload and reduce earnings or safety.
- Costs, effectiveness and practicability of new designs are important:
  - for capturing certain species, trawling may be the only effective solution
  - **there may not be realistic production alternatives available** (e.g. shrimp)
- Profit margins are small in many fisheries – even relatively minor changes may have unpredictable economic consequences.
- Fishers are often sceptical that an alternative gear would work as well as their traditional – the new gear might even risk their trade opportunities.
- Management limitations: Not always possible to change gears because of rules.
- Fishers generally do not see much reason to change the gear type and they need **time** for a change.
- There should be an understanding what is acceptable and possible.

A change must make sense

- There are reasons why demersal trawls are so popular in many shrimp fisheries!
- No two types of fishing gear do exactly the same thing.
- Passive and active gears are often incompatible in the same areas – passive gears are frequently damaged by towed gear.
- Passive fishing gears cannot easily be automated to the same extent as trawling, and cannot cover so much ground in a given time period and effort.
  - they work better when stock are in good shape
- A switch to passive gear may require some kind of zoning arrangements to avoid gear conflicts.
- A change must make sense!

Main barriers and potential opportunities to gear transition

Barriers:

- Lack of familiarity
- Availability of technologies
- Incompatibility of vessels with new gear
- Risk of losing marketable catch
- Additional work
- Concerns with safety at sea
- High investment costs
- Lack of capital
- Ineffective technology infrastructure support
- inflexible fisheries management systems
- human behaviour

Opportunities:

- Product quality improvement (focus on quality rather than quantity)
- Cost reduction in the long run
- Waste elimination
- Less pressure by environmental advocacy groups
- Enhanced reputation - winning new markets?
- New products and work opportunities
- Improvement in the capacity to deal with the future challenges
- Move from 'reactive mode' to 'proactive mode'

34 19.6.2022

Management systems and research should facilitate LIFE fisheries

- Give fishers more space where to operate LIFE fishing as efficiently as possible.
- Allocate catch quota to LIFE-fishing methods.
- Give preferential access to specific fishing areas (zoning).
- Restore depleted fish stocks (higher CPUE).
- Utilize market forces.
- Develop, promote and commercialize economically viable and practical alternatives.
- Utilize technically-solid **energy audits** to provide operators adequate guidance to choose energy saving technologies and practices.

Conclusions (1)

- Each fishing gear and practice has advantages and disadvantages.
  - ➢ **Optimal solutions vary among fisheries**
- Successful transition to LIFE fishing depends on:
  - ➢ **Developing acceptable technology and creating incentives (win-win situations)**
  - ➢ **Having achievable and realistic objectives**
  - ➢ **Adequate training and technical assistance, and encouragement of innovation**
  - ➢ **Regulatory regimes that facilitate the recovery of fish stocks**
  - ➢ **Making fishers part of the solution**
  - ➢ **Finding balance between short-term costs vs long-term environmental ambitions**
- The management system should reward those who employ best practices.
- Fuel subsidies should be redirected to encourage development and uptake of fuel efficient and low impacts practices.

Conclusions (2)

- The global fishing industry is faced with the dual challenges of increasing operational costs and environmental impacts.
- It makes increasingly more sense to utilize energy efficient technologies.
  - ➢ producing more fish with less energy!
  - ➢ increasing fuel security
  - ➢ reducing operational costs and greenhouse gases emissions
- Energy saving improves industries' competitiveness and free up financial resources that can be reinvested in other important purposes.
- Highly effient solutions are needed.
- The winners are likely to be those with the most operationally efficient fleets!

VI. Appendix 6 Presentation of Optimizing Energy Use_Fishing Vessels Energy Audits (Mr.Bundit Choksanguan)

Optimizing Energy Use in Fisheries in Southeast Asian Region : FISHING VESSELS ENERGY AUDITS AND WAY FORWARD

Bundit Chokesanguan
SEAFDEC

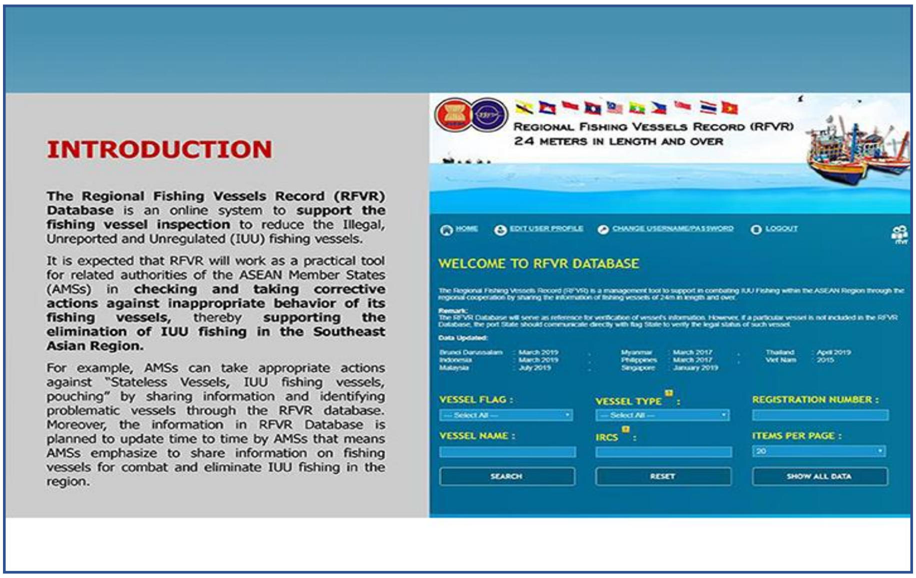
The seas of Southeast Asia

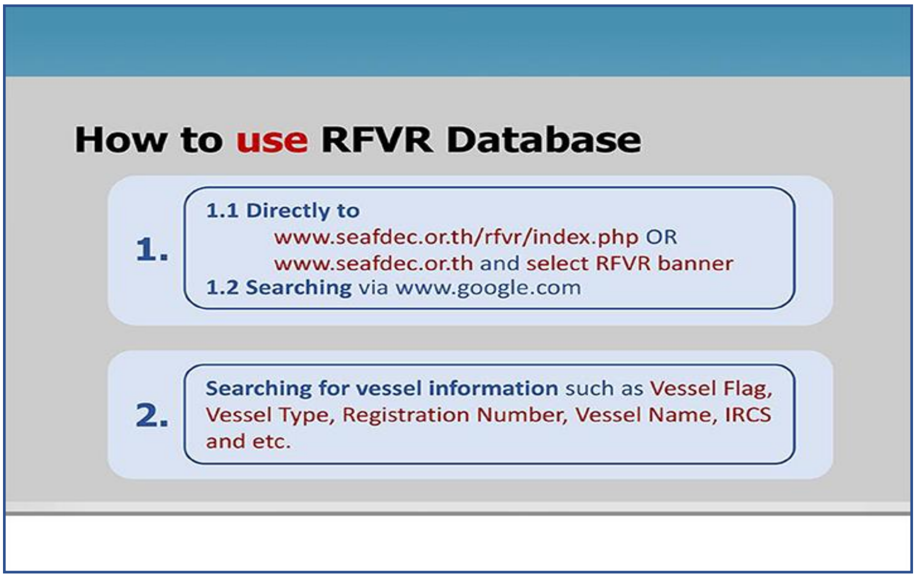
ESTIMATE NUMBER OF FISHING VESSELS IN SOUTHEAST ASIA (2012)

Country	Total	Non-powered boat	Powered boat
Brunei Darussalam	2,627	98	2,529
Cambodia	No Data	No Data	No Data
Indonesia	616,690	172,333	444,357
Malaysia	54,235	2,998	51,237
Myanmar	30,349	15,463	14,886
Philippines	No Data	No Data	No Data
Singapore	4	-	4
Thailand	18,089	-	18,089
Viet Nam	27,988	Unidentified	Unidentified
Grand Total	749,982	190,892	531,102

Reference : Fishery Statistical Bulletin of Southeast Asia 2012


RFVR
Regional Fishing Vessels Record
A primary tool to reduce the IUU fishing in Southeast Asian Region
http://www.seafdec.or.th/rfvr/dashboard.php


INTRODUCTION
The Regional Fishing Vessels Record (RFVR) Database is an online system to support the fishing vessel inspection to reduce the Illegal, Unreported and Unregulated (IUU) fishing vessels.
It is expected that RFVR will work as a practical tool for related authorities of the ASEAN Member States (AMSs) in checking and taking corrective actions against inappropriate behavior of its fishing vessels, thereby supporting the elimination of IUU fishing in the Southeast Asian Region.
For example, AMSs can take appropriate actions against "Stateless Vessels, IUU fishing vessels, pouching" by sharing information and identifying problematic vessels through the RFVR database. Moreover, the information in RFVR Database is planned to update time to time by AMSs that means AMSs emphasize to share information on fishing vessels for combat and eliminate IUU fishing in the region.
REGIONAL FISHING VESSELS RECORD (RFVR)
24 METERS IN LENGTH AND OVER
HOME
EDIT USER PROFILE
CHANGE USERNAME/PASSWORD
LOGOUT
WELCOME TO RFVR DATABASE
VESSEL FLAG :
VESSEL TYPE :
REGISTRATION NUMBER :
VESSEL NAME :
IRCS :
ITEMS PER PAGE :
SEARCH
RESET
SHOW ALL DATA

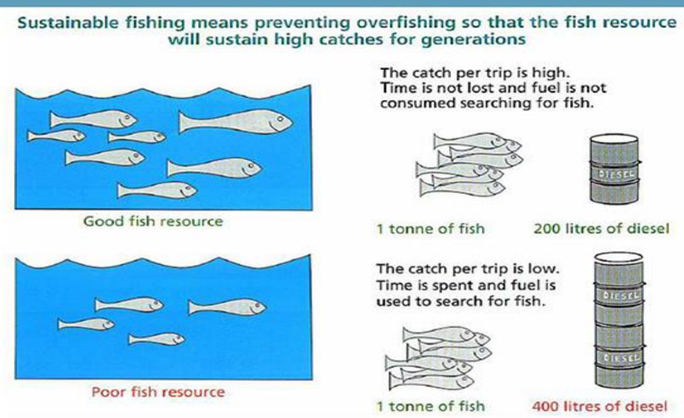

How to use RFVR Database
1.
1.1 Directly to
www.seafdec.or.th/rfvr/index.php OR
www.seafdec.or.th and select RFVR banner
1.2 Searching via www.google.com
2.
Searching for vessel information such as Vessel Flag, Vessel Type, Registration Number, Vessel Name, IRCS and etc.

http://www.seafdec.or.th/rfvr/dashboard.php

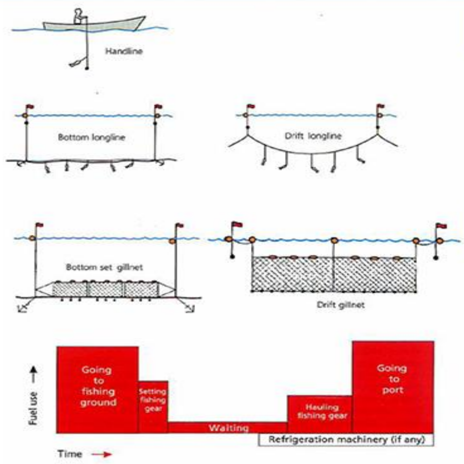
CURRENT SITUATION AND COMMON PROBLEMS ON ENERGY SAVING IN SOUTHEAST ASIA FOR SMALL FISHING BOATS

- Lack of information, knowledge and technology on energy saving/boats and engines/others.
- Less access to assistance from naval architects, engine supplies and others than do owners and operators of larger boats.
- Cost of fuels and poor fish resources.
- Fishermen behaviors and attitudes for energy saving.

THE FISH RESOURCE



FUEL USE – PASSIVE FISHING METHODS



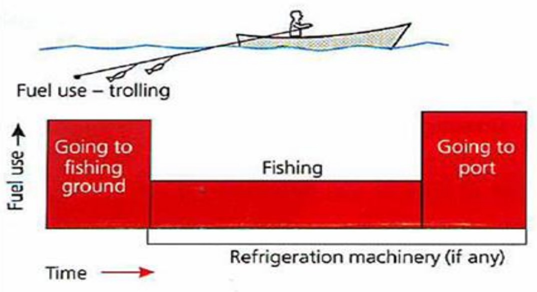
Fuel use – gilnetter or longliner

Most fuel is used to travel to and from fishing grounds. The setting and hauling of passive fishing gear can be done with Human power or low engine power with mechanical or hydraulic haulers.

To save fuel

1. Reduce service speed.
2. Keep the hull free from fouling.
3. Use high gear reduction and an efficient propeller.
4. Changeover from a petrol outboard engine to a diesel engine.

FUEL USE – TROLLING

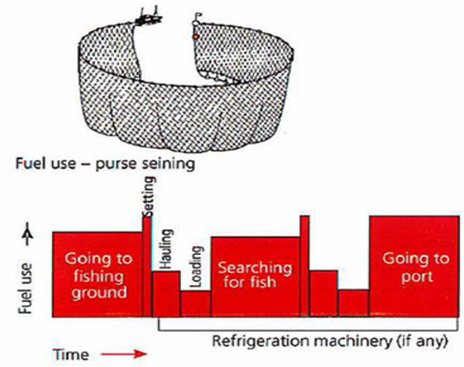


Fuel is used both for traveling and for fishing.

To save fuel

1. Change over to a diesel engine.
2. Reduce service speed (except when fishing for tuna which require high speed).
3. Keep the hull free from fouling.
4. Install a high gear reduction and large diameter propeller.

FUEL USE – PURSE SEINING

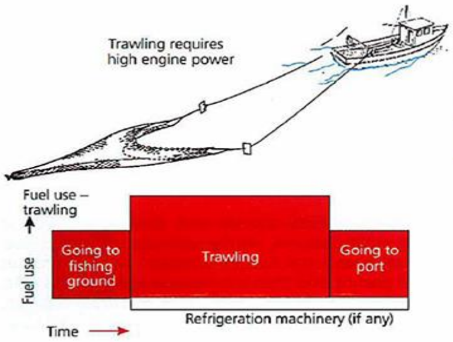


Most fuel is used going to and from fishing grounds and searching for fish.

To save fuel

1. Reduce service speed.
2. Install advanced fish-finding equipment.
3. Keep the hull free from fouling.
4. Install a high gear reduction and large diameter propeller.

FUEL USE – TRAWLING



Most fuel is drag the trawl along the bottom (bottom trawling) or above the bottom (pelagic trawling). Reduction power going to and from fishing grounds saves fuel.

To save fuel

1. Modify the trawl and trawl boards.
2. Install the highest gear reduction available and a large diameter propeller with a propeller nozzle (depending on stern aperture).
3. Install advanced fish-finding equipment.
4. Consider a changeover in fishing method to pair trawling or Danish seining

WAYS AND MEANS OF REDUCING THE USE OF FOSSIL FUEL IN FISHERIES

- Hull design
- Engine power and operation range
- Engine design
- Engine operation and maintenance
- Modification of fishing gear and methods
- Improvement of fish handling and post-harvest technology onboard fishing boats (Minimizing the fuel consumption for refrigeration/auxiliary engine through good fish handling processes and presentation)

WAYS AND MEANS OF REDUCING THE USE OF FOSSIL FUEL IN FISHERIES

- Alternative fuel use
  - LPG
  - LNG
  - CNG
  - Ethanol
  - Hydrogen
- Alternative energy use
  - Wind
  - Solar
  - Wave Energy

ENERGY USE IN FISHERIES IN SOUTHEAST ASAIN :
Promotion of Sail Fishing Boat for Small-scale Fisheries

INTRODUCTION

Promotion of Sail fishing boat was conducted in 2008

↓

Collaboration with

SEAFDEC

ENERGY USE IN FISHERIES IN SOUTHEAST ASAIN :
Promotion of Sail Fishing Boat for Small-scale Fisheries

OBJECTIVES

1. To assist local fishermen to reduce costs and increase revenue for small-scale fisheries;
2. To reduce fuel consumption, which is a major problem in the economy;
3. To improve technical support on utilize of wind energy for poverty elevate of local fishers without overheating the climate;
4. To transfer appropriate ship stability improvement and technique used; and
5. To introduce view and idea of small-scale fishers utilize of wind energy for fishing.

ENERGY USE IN FISHERIES IN SOUTHEAST ASAIN :
Promotion of Sail Fishing Boat for Small-scale Fisheries

ACTIVITIES

- To give knowledge all important part in using sailboat for fishing;
  - Installation of the sail's materials in small-scale fishing boats

    e.g.
    - sail construction
    - boom installation
    - arrangement of sail cloth
    - installation of mask
    - calculation for size of the sail cloth
    - etc.
  - Types of lines & knots using for sailing; and
  - Sailboat safety operating procedure

    e.g.
    - wind and weather affecting the sail
    - sailing techniques
    - safety onboard of sail boats
    - sitting position on board
    - etc.
- Demonstration, Practical Training, and Experiment on the use of sailboat

ENERGY USE IN FISHERIES IN SOUTHEAST ASAIN :
Promotion of Sail Fishing Boat for Small-scale Fisheries

PROMOTION OF SAILBOAT

OPTIMIZING ENERGY USE IN SMALL FISHING BOAT FOR FISH HANDLING

APPROPRIATE HANDLING AND GOOD MAINTENANC

Improve the system efficiency by good maintenance for reduction of post harvest loss.

The refrigeration system was installed for Tuna handline in the engine room, used the belt front drive from main propulsion engine, General Santos city

Multi-purpose refrigeration electrical driven squid chilling and freezing installed onboard squid lift net, Surat-thani Thailand


Sherbet ice onboard

FAO-SEAFDEC/TD ENERGY AUDITS PROJECT FOR THAI TRAWLERS (PHASE I & II)

Bundit Chokesanguan
SEAFDEC



OBJECTIVES

a)
- To apply energy audit process for characterizing fuel consumption pattern of Thai trawlers through six representative local trawl fishing vessels in both Gulf of Thailand and Andaman Sea

b)
- To investigate optimum fuel consumption condition of trawl fishing boats for minimizing fuel cost and green house gas emission delivered from fishing activities that impacting global warming

c)
- To disseminate energy audits results and techniques to local fishermen on how to reduce fuel consumption through measurement process and identifying optimum condition over their engine

METHODOLOGY


LOA<14 m, 14 m<LOA<18 m, and LOA>18 m

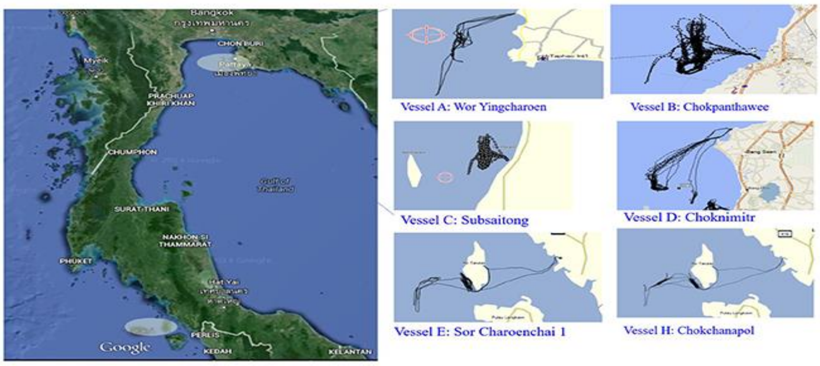

Navigation, fuel flow meter, tachometer


Sea trial test, Sea trail test with net, fishing operations

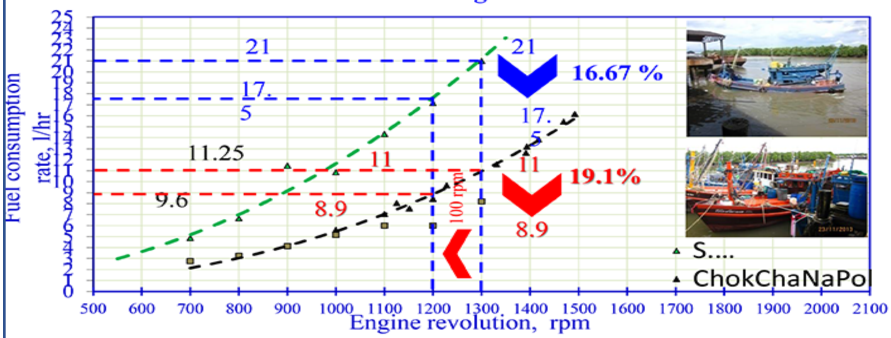

Characterize achieved data after field trip

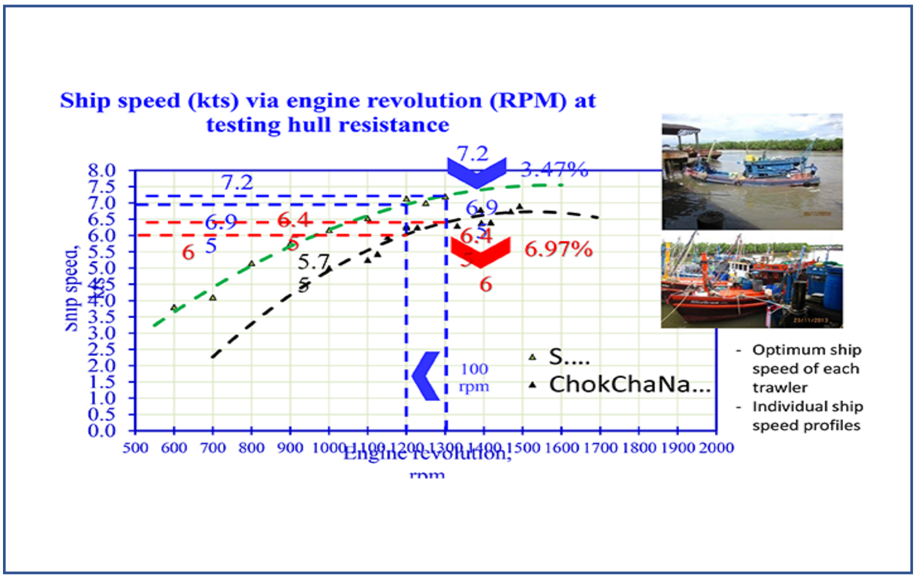

Unloaded catches and generated income

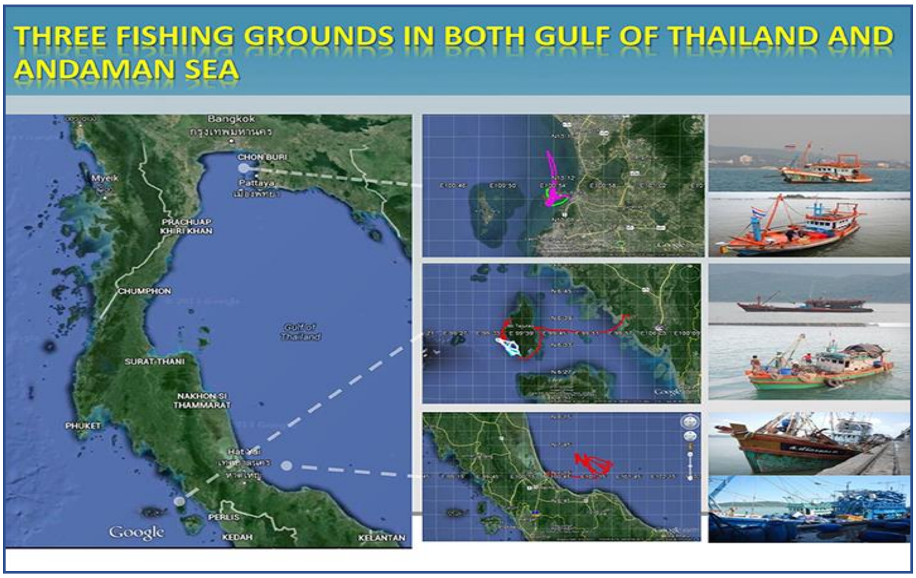
FISHING GROUND LOCATIONS OF SIX INVESTIGATED TRAWLERS IN THE PHASE I

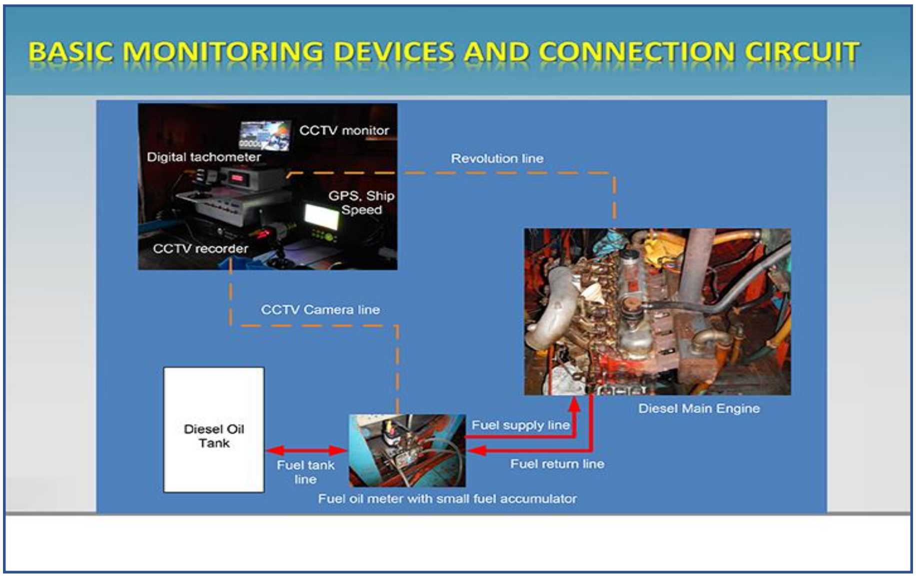


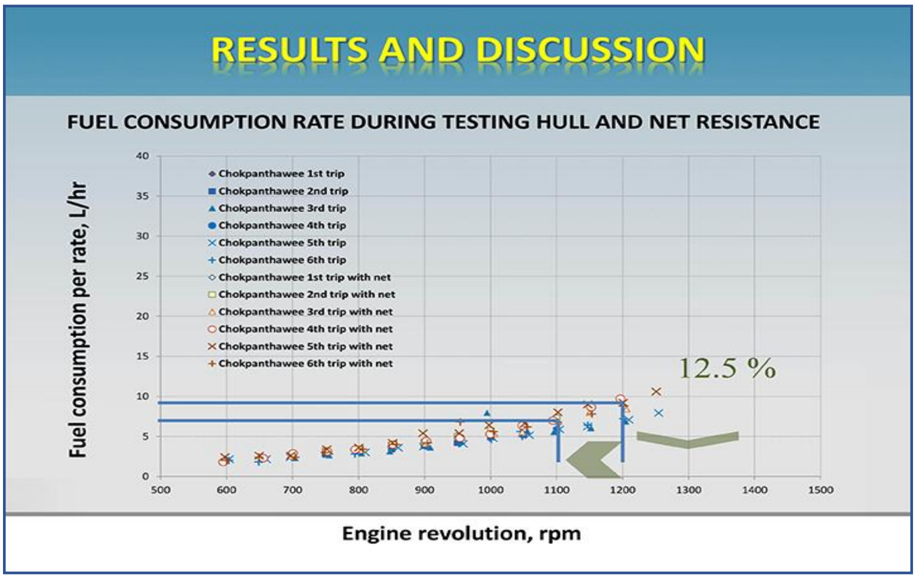
Fuel consumption rate (l/hr) via engine revolution (rpm) during sea trail of all investigated vessels

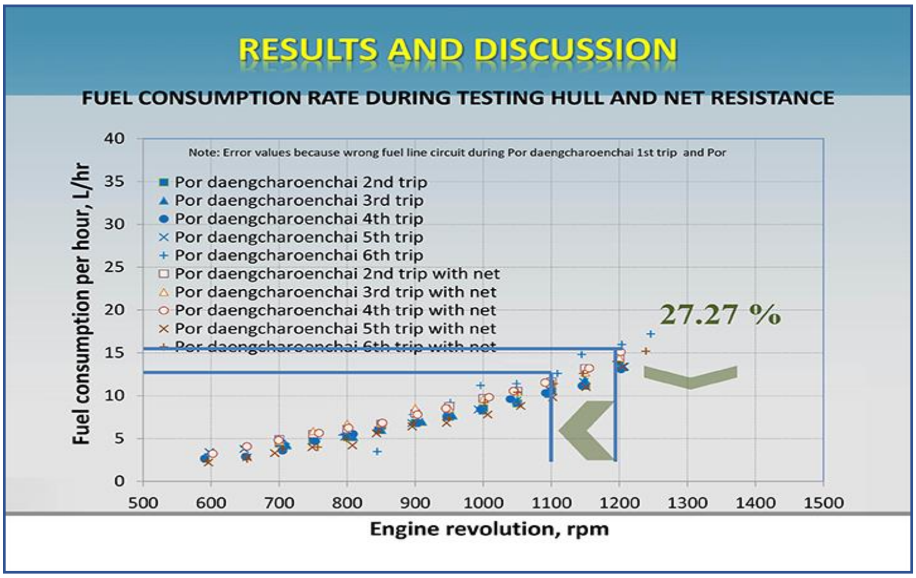


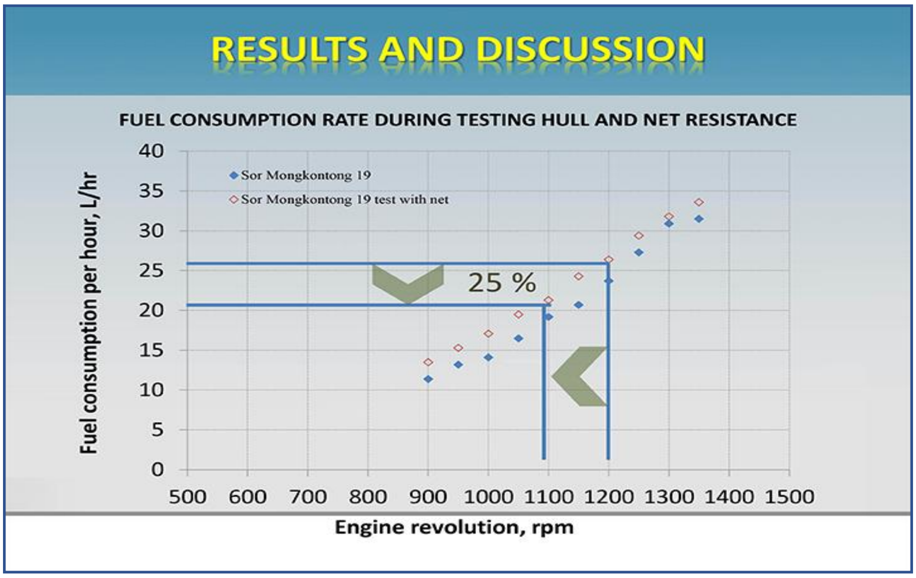

Ship speed (kts) via engine revolution (RPM) at testing hull resistance
Ship speed,
Engine revolution, rpm
7.2
3.47%
6.9
6.4
6.97%
5.7
100 rpm
S....
ChokChaNa...
- Optimum ship speed of each trawler
- Individual ship speed profiles


THREE FISHING GROUNDS IN BOTH GULF OF THAILAND AND ANDAMAN SEA
Bangkok
CHON BURI
Pattaya
PRACHUAP KHIRI KHAN
CHUMPHON
SURAT THANI
NAKHON SI THAMMARAT
PHUKET
Gulf of Thailand
Google


BASIC MONITORING DEVICES AND CONNECTION CIRCUIT
CCTV monitor
Digital tachometer
GPS, Ship Speed
CCTV recorder
Revolution line
CCTV Camera line
Diesel Main Engine
Diesel Oil Tank
Fuel tank line
Fuel supply line
Fuel return line
Fuel oil meter with small fuel accumulator


RESULTS AND DISCUSSION
FUEL CONSUMPTION RATE DURING TESTING HULL AND NET RESISTANCE
Chokpanthawee 1st trip
Chokpanthawee 2nd trip
Chokpanthawee 3rd trip
Chokpanthawee 4th trip
Chokpanthawee 5th trip
Chokpanthawee 6th trip
Chokpanthawee 1st trip with net
Chokpanthawee 2nd trip with net
Chokpanthawee 3rd trip with net
Chokpanthawee 4th trip with net
Chokpanthawee 5th trip with net
Chokpanthawee 6th trip with net
12.5 %
Fuel consumption per rate, L/hr
0 5 10 15 20 25 30 35 40
500 600 700 800 900 1000 1100 1200 1300 1400 1500
Engine revolution, rpm


RESULTS AND DISCUSSION
FUEL CONSUMPTION RATE DURING TESTING HULL AND NET RESISTANCE
Note: Error values because wrong fuel line circuit during Por daengcharoenchai 1st trip and Por
Por daengcharoenchai 2nd trip
Por daengcharoenchai 3rd trip
Por daengcharoenchai 4th trip
Por daengcharoenchai 5th trip
Por daengcharoenchai 6th trip
Por daengcharoenchai 2nd trip with net
Por daengcharoenchai 3rd trip with net
Por daengcharoenchai 4th trip with net
Por daengcharoenchai 5th trip with net
Por daengcharoenchai 6th trip with net
27.27 %
Fuel consumption per hour, L/hr
0 5 10 15 20 25 30 35 40
500 600 700 800 900 1000 1100 1200 1300 1400 1500
Engine revolution, rpm


RESULTS AND DISCUSSION
FUEL CONSUMPTION RATE DURING TESTING HULL AND NET RESISTANCE
Sor Mongkontong 19
Sor Mongkontong 19 test with net
25 %
Fuel consumption per hour, L/hr
0 5 10 15 20 25 30 35 40
500 600 700 800 900 1000 1100 1200 1300 1400 1500
Engine revolution, rpm

RESULTS AND DISCUSSION

Increase engine revolution (rpm) pay more fuel cost

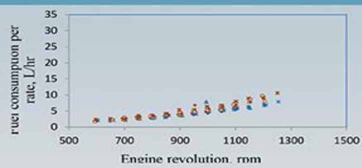
	Fuel cost THB/d	% increased	THB/d	THB/yr
Small trawler	2,000	12.5%	250.0	50,000.00

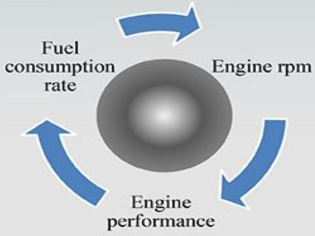
	Fuel cost THB/trip	% increased	THB/trip
Medium trawler	69,127	27.3%	18,850.9
Large trawler	244,836	25.0%	61,209.0

RESULTS AND DISCUSSION


Towing without trawl net in water


Towing with trawl net in water





Sorted catches in baskets

Total catch from W. Yincharoen, S. Charoenchai 1 and Chokchanapol

Result dissemination seminar in Satun

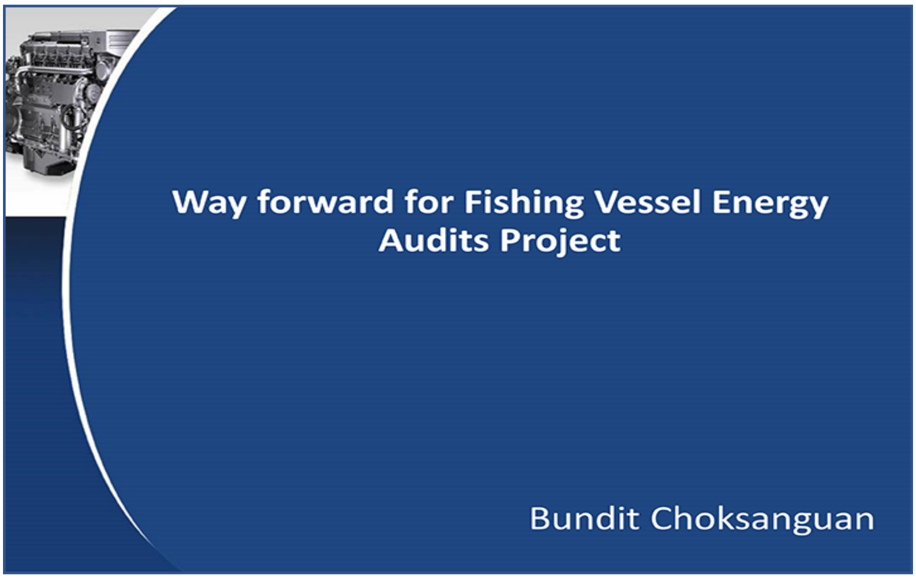
CONCLUSION

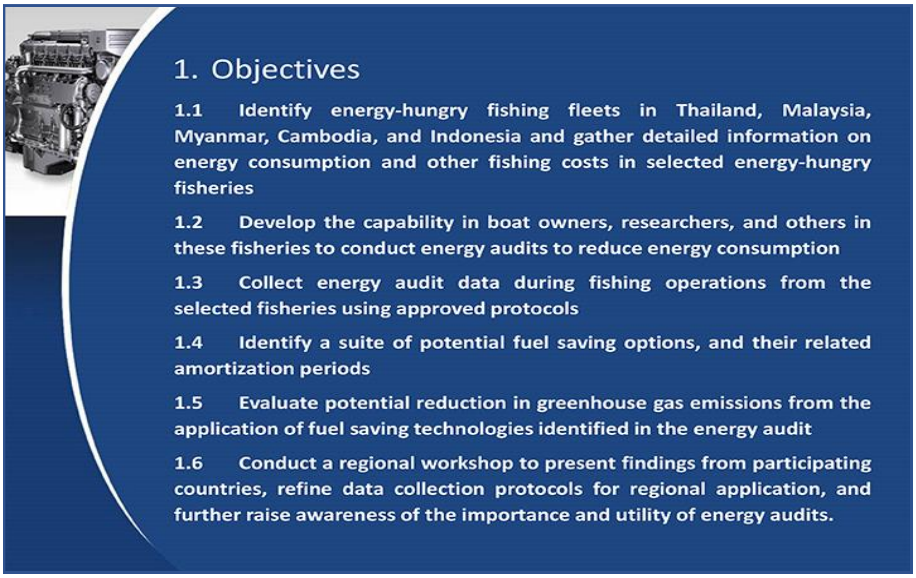
Reduce engine revolution contribute to decrease fuel consumption rate

Fuel consumption rate depend on engine performance

Bad cooling efficiency can drop engine performance and increase fuel consumption rate

Keep good condition of engine to maintain efficient fuel used


Way forward for Fishing Vessel Energy Audits Project
Bundit Choksanguan


1. Objectives
1.1 Identify energy-hungry fishing fleets in Thailand, Malaysia, Myanmar, Cambodia, and Indonesia and gather detailed information on energy consumption and other fishing costs in selected energy-hungry fisheries
1.2 Develop the capability in boat owners, researchers, and others in these fisheries to conduct energy audits to reduce energy consumption
1.3 Collect energy audit data during fishing operations from the selected fisheries using approved protocols
1.4 Identify a suite of potential fuel saving options, and their related amortization periods
1.5 Evaluate potential reduction in greenhouse gas emissions from the application of fuel saving technologies identified in the energy audit
1.6 Conduct a regional workshop to present findings from participating countries, refine data collection protocols for regional application, and further raise awareness of the importance and utility of energy audits.


2. Methodology and technical approach
2.1 SEAFDEC TD staff will inform national and regional institutions of this project and seek information related to the composition of fishing fleets and fuel consumption.
2.2 In each country fuel intensive fishing fleets will be identified and one fishery in each country will be selected for further analysis.
2.3 In each country a mini workshop will be held to i) raise awareness of the utility of an energy audit, including the results of past energy audits by the Thai trawl fleet ii) train attendees in relevant data collection technology and protocols.
2.4 Representatives from each country will then be responsible for collecting energy audit data from their respective fishery over a predetermined period of time.
2.5 Representatives will then meet at a regional workshop to present their findings, and facilitate the development of a regional guide to energy audits in fisheries

3. Expected Outputs

3.1 Regional audits of several fisheries in S. E. Asia

3.2 Reduced energy consumption through changes in fishing practice and vessel operation

3.3 Local and regional workshops on energy saving, data collection protocols

3.4 Regionally suitable data collection protocol to ensure accurate and effective audits of fishing boats.

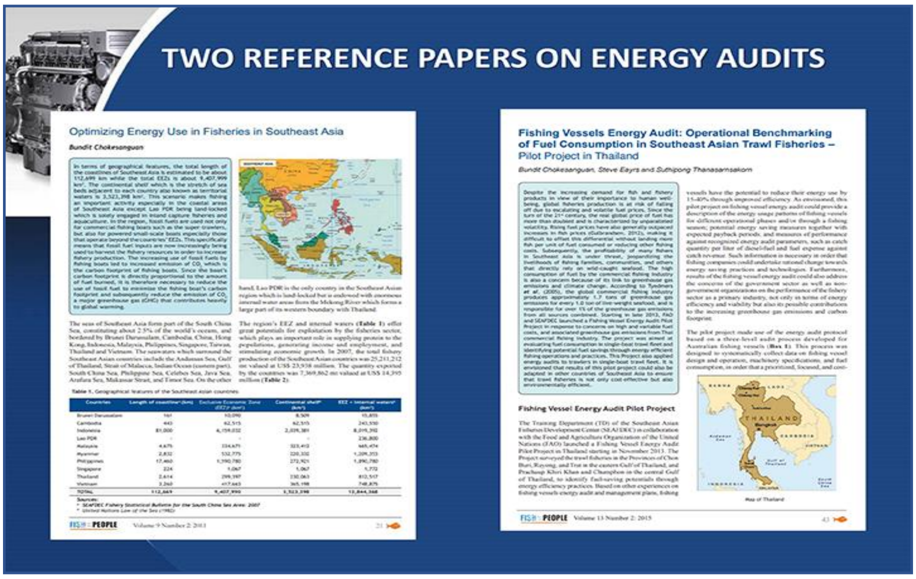
4. Expected Outcomes

4.1 Regional capacity in the conduct of energy audits in fisheries

4.2 Greater awareness of options to reduce energy consumption in fuel intensive fishing fleets,

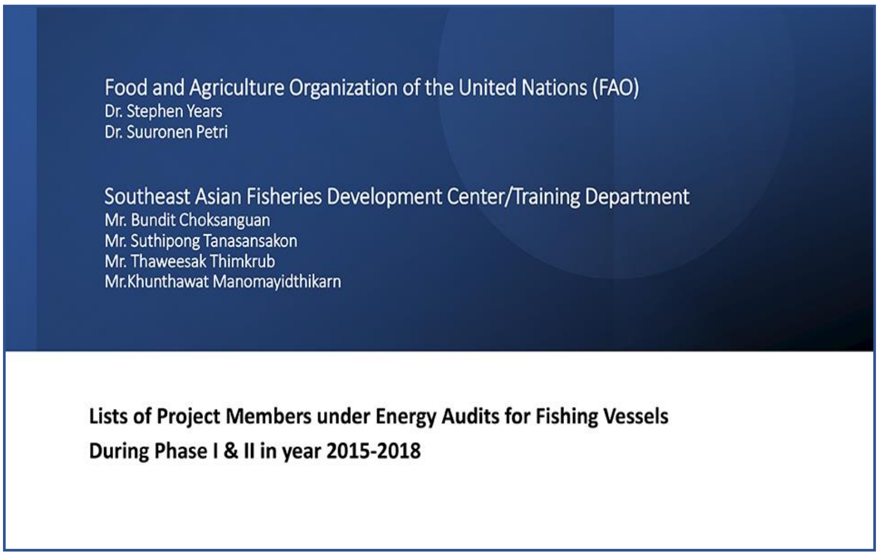
4.3 Reduced greenhouse emissions from local fisheries and improved air quality

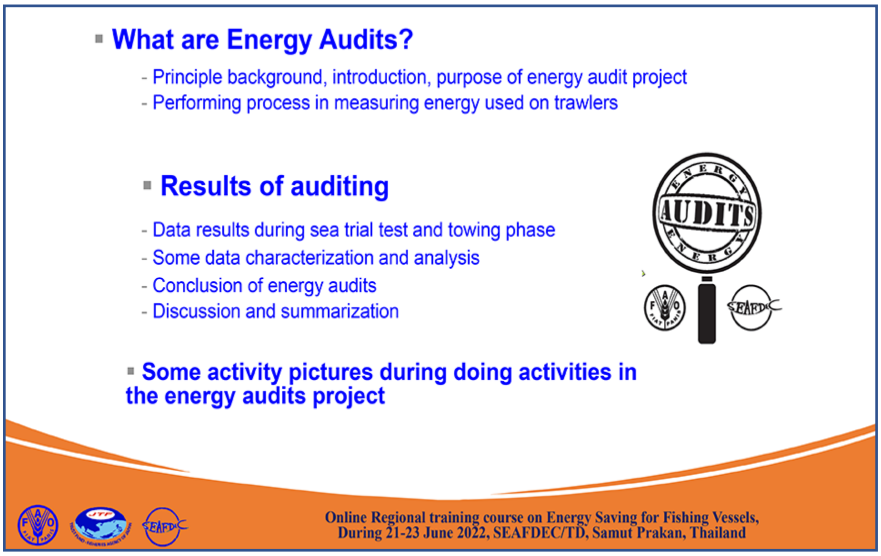
4.4 Greater resilience by local fishermen and communities and capacity respond to future increases in fuel price and impacts of global warming

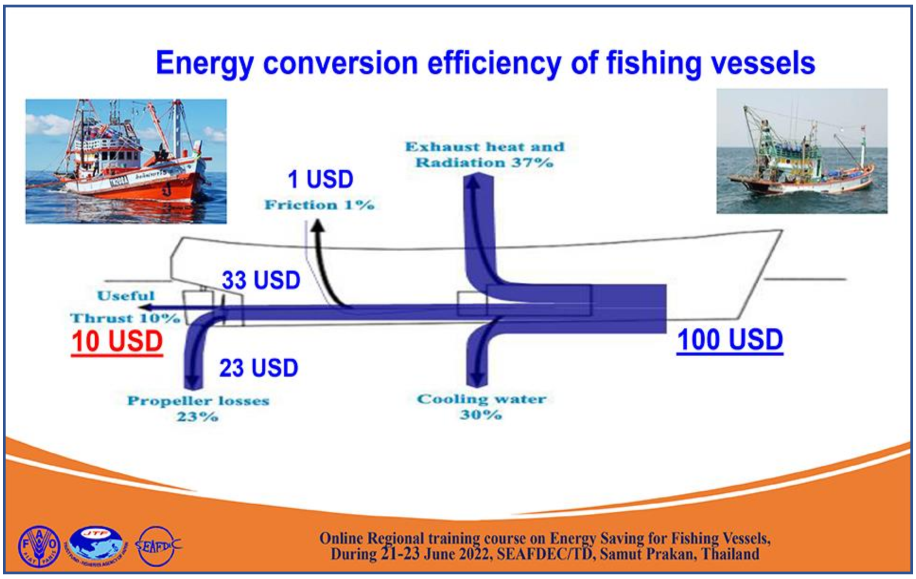

TWO REFERENCE PAPERS ON ENERGY AUDITS
Optimizing Energy Use in Fisheries in Southeast Asia
Bundit Chokesanguan
Fishing Vessels Energy Audit: Operational Benchmarking of Fuel Consumption in Southeast Asian Trawl Fisheries – Pilot Project in Thailand
Bundit Chokesanguan, Steve Eayrs and Suthipong Thanasansakorn
Fishing Vessel Energy Audit Pilot Project


Thank you for your attention

VII. Appendix 7 Presentation of SEAFDEC and FAO fishing vessels' energy audits for a pilot project on Thai trawl vessels (Mr.Khunthawat Manomayidthikarn)





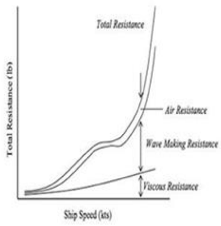


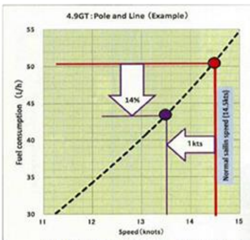
Why do we slow down?

It takes power to push a boat through the water. The engine provides the power, through the propeller, which overcomes the factors that slow down the boat. These are:

- Skin friction, the drag caused by water rubbing against the hull.
- Form drag, which is caused by water flowing around the hull, rudders and any appendages.
- Wave making resistance, which is the energy sapped from the vessel to make bow and stern waves as it moves through the water.

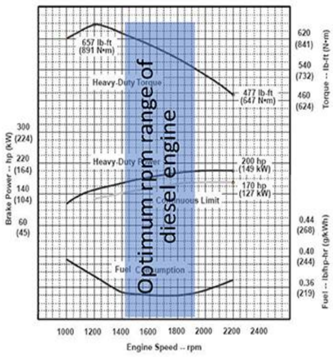
All three kinds of drag increase with speed, but for displacement vessels the wave making resistance is the biggest problem as it increases **exponentially with speed.**





Fuel consumption vs. ship speed

Characteristic curve of a diesel engine



Diesel engines have the lowest fuel consumption range during operation (Optimum rpm)

Brake Power, torque, and Fuel consumption tested from manufacturer of diesel engine

RECOMMENDATIONS FOR SAVING FUEL OF SMALL FISHING VESSELS

Impacts from external fishing vessels:

Water resistance, Wave making resistance, wind resistance:

- Reject excess weight
- Use optimum vessel speed
- Decrease water resistance
  - remodeling hull shape, appendages, bulbous bow, aerodynamic of upper deck, steam line of astern hull shape, low astern wage, etc.
  - bigger mesh size of fishing net
- Keep stability of fishing vessel

Impacts from internal fishing vessels:

Loss or low efficiency of fuel consumption and propulsion systems:

- Low efficiency of diesel engine
  - fuel injection system
  - cooling system: stocked in heat exchanger, malfunction of water pump, etc.
- Low efficiency of Propeller
  - chipped, broken
  - Cavity effect
  - suitable diameter of propeller
  - duct propeller
- Low efficiency of Refrigeration system
  - Leakage/degenerate of insulator of fish hold, etc.

OBJECTIVES

a) To apply energy audit process for characterizing fuel consumption pattern of Thai trawlers through six representative local trawl fishing vessels in both Gulf of Thailand and Andaman Sea

b) To investigate optimum fuel consumption condition of trawl fishing boats for minimizing fuel cost and green house gas emission delivered from fishing activities that impacting global warming

c) To disseminate energy audits results and techniques to local fishermen on how to reduce fuel consumption through measurement process and identifying optimum condition over their engine

Procedure in auditing energy on fishing vessels

Identifying representatives of fishing vessels (shrimp trawlers)

↓

Planning and doing energy measurement onboard during fishing trips
Traveling, modification and installation instruments, keep good health conditions of inspectors

↓

Recording parameters when sea trial/fishing net/doing fishing operations;
fuel flow, date, time, ship position, ship speed, wind current, wind direction, weight of catches, and income (at fishing port)

↓

Processing data, calculation, and analysis: achieved optimum fuel consumption/conditions of each fishing vessels (as trawlers)

↓

Conclusion, disseminating fuel auditing results to fishers through onsite meetings

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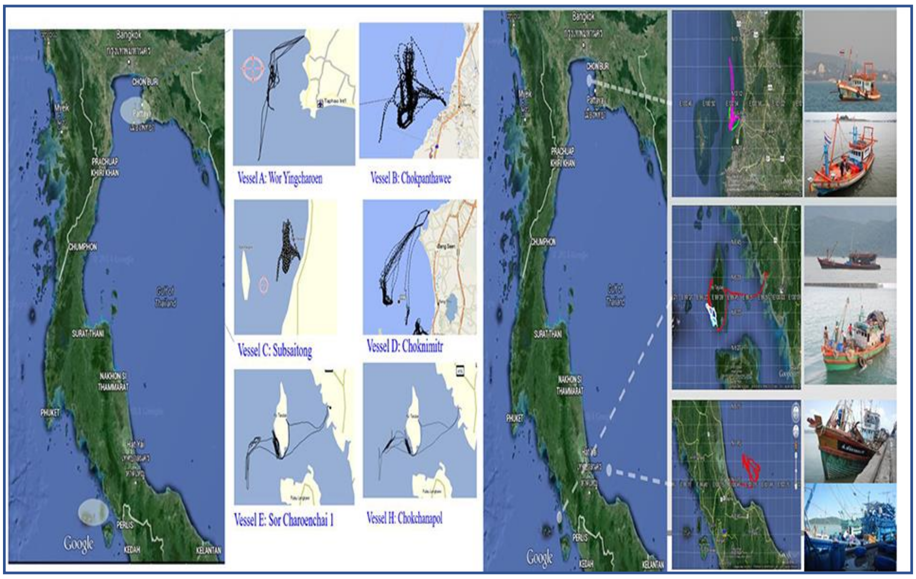
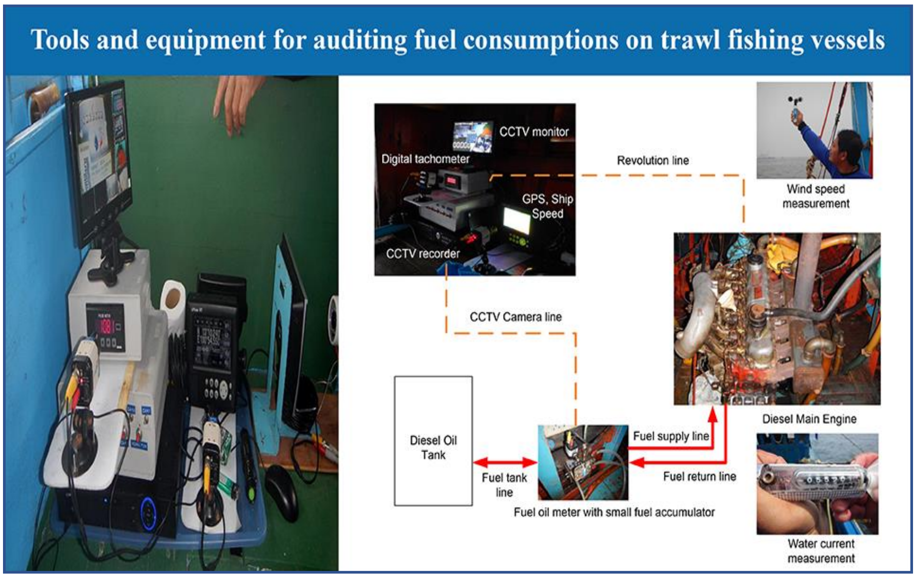
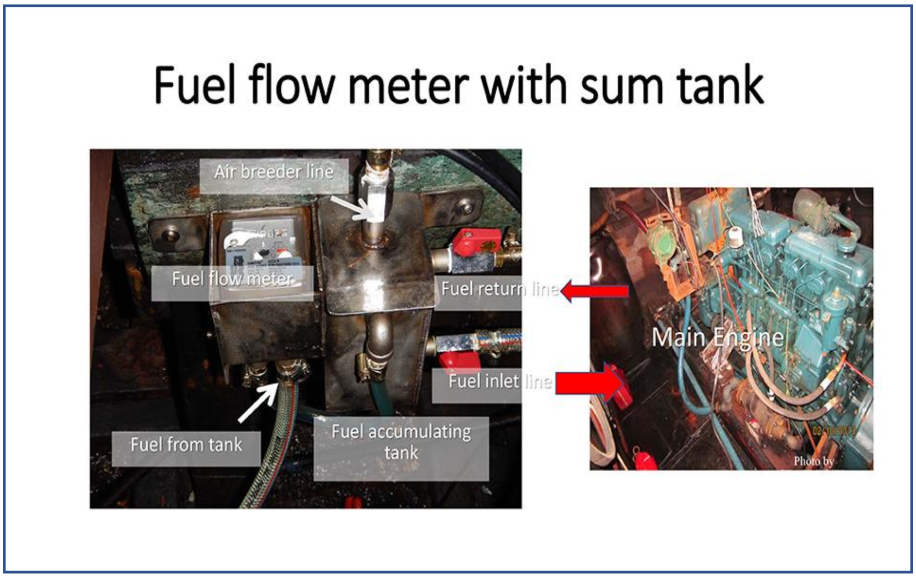
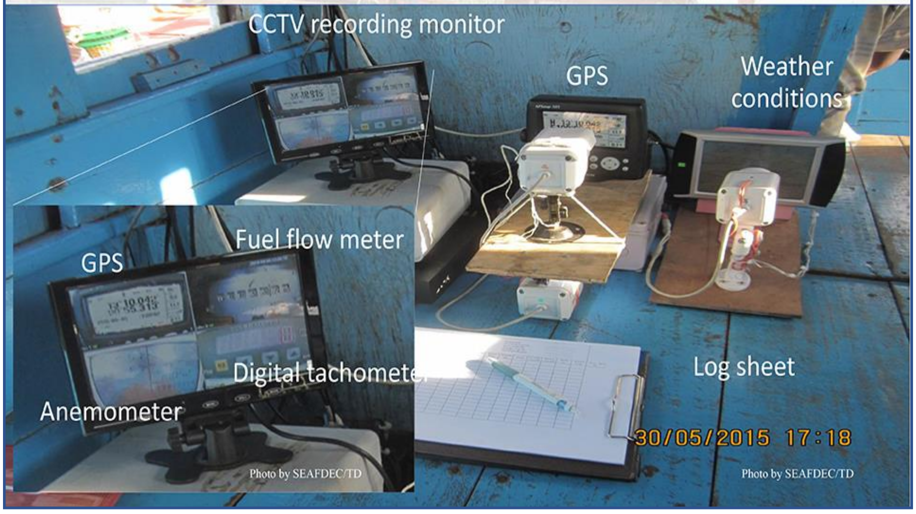

Vessel A: Wor Yingcharoen
Vessel B: Chokpanthawee
Vessel C: Subsaitong
Vessel D: Choknimitr
Vessel E: Sor Charoenchai 1
Vessel H: Chokchanapol

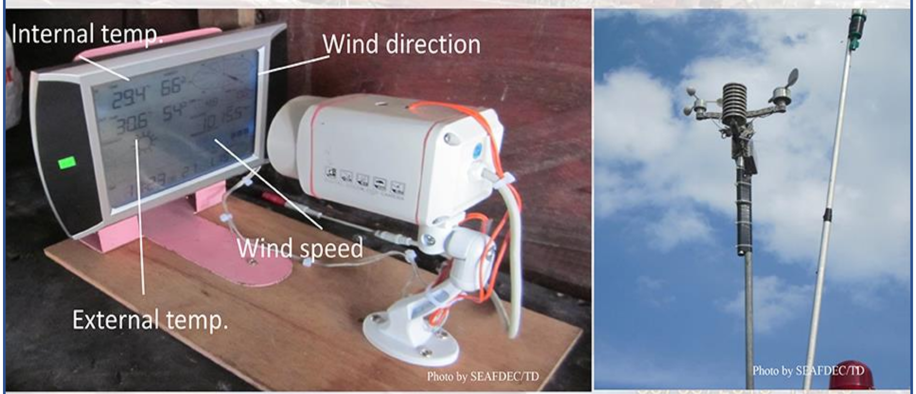

Tools and equipment for auditing fuel consumptions on trawl fishing vessels
CCTV monitor
Digital tachometer
GPS, Ship Speed
CCTV recorder
Revolution line
Wind speed measurement
CCTV Camera line
Diesel Main Engine
Diesel Oil Tank
Fuel tank line
Fuel supply line
Fuel return line
Fuel oil meter with small fuel accumulator
Water current measurement


Fuel flow meter with sum tank
Air breeder line
Fuel flow meter
Fuel return line
Fuel inlet line
Fuel from tank
Fuel accumulating tank
Main Engine
Photo by

Monitoring and recording devices with CCTV recording system



Measurement of weather conditions



TESTING CONDITIONS FOR SEA TRIAL TEST/FISHING NET RESISTANT MEASURES

Environmental testing area: Calm sea, less wind steam
Streaming fishing vessels with/without net in water:
Engine Rpm variation: 600, 700, 800, 900, 1000, 1100, 1200
(Interval variation of rpm and recording minutes: 50 or 100 rpm, 3-5 minutes, respectively)

Recorded values:

Date, time, fuel flow meter (cc, L, m^3), Engine revolution (rpm, rps), Ship speed (km/h, knot), Ship distance (km, nm), ship position (lat,long)

RECORDING TABLE FOR SEA TRIAL/FISHING NET WATER RESISTANCE

Water resistance test of hull

Date	time	Engine rev.	Flow meter	Latitude-Longtitude		Wind sp.	Wind dir.	Ship sp.	Dist.	Dist.	Fuel con.	Rate of fuel	Con. per dist.
		rpm		N	E			kt	m	nm	liter	L/hr	L/nm
30/3/2015	9:59:30	645	2790.9	06 33.293	99 36.479	6.5	SE	3.40	525.81	0.28	0.20	2.40	0.70
	10:04:30	644	2791.1	06 33.522	99 36.374	8.2	E	3.30					
	10:06	702	2791.17	06 33.522	99 36.330	2.7	E	3.60	588.70	0.32	0.24	2.88	0.76
	10:11	701	2791.41	06 33.936	99 36.206	0.0	E	3.80					
	10:12:30	746	2791.49	06 34.008	99 36.179	0.3	E	4.00	627.46	0.34	0.28	3.36	0.83
	10:17:30	743	2791.77	06 34.318	99 36.010	0.3	SW	4.00					
	10:19	808	2791.87	06 34.401	99 35.950	0.3	SW	4.30	656.88	[illegible]	0.31	3.72	0.87
	[illegible]	805	2792.18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
	[illegible]	853	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	704.57	[illegible]	0.36	4.32	0.95
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	751.07	0.41	0.47	5.64	1.16
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	781.99	[illegible]	0.49	5.88	1.16
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
	10:46	[illegible]	[illegible]	06 36.354	[illegible]	[illegible]	[illegible]	[illegible]	852.19	0.46	0.52	6.24	1.13
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	870.26	0.47	0.59	7.08	1.26
	[illegible]	1048	2795.3	[illegible]	[illegible]	6.1	E	[illegible]					
	10:58:30	1105	2795.49	06 37.499	99 35.132	5.8	E	5.90	922.82	0.50	0.70	8.40	1.40
	11:03:30	1103	2796.19	06 38.023	99 35.129	6.8	NE	6.00					
	11:05	1146	2796.38	06 38.140	99 35.135	6.5	E	6.10	970.90	0.52	0.76	9.12	1.45
	11:10	1148	2797.14	06 38.696	99 35.139	6.1	E	6.00					
	11:11:30	1196	2797.38	06 38.809	99 35.167	6.1	E	6.30	987.50	0.53	0.84	10.08	1.58
	11:16:30	1196	2798.22	06 39.366	99 35.235	7.8	E	6.40					

GPS Navigator | Tachometer | Flow meter | GPS Navigator | GPS Navigator | Anemometer | Anemometer | GPS Navigator | Calculation

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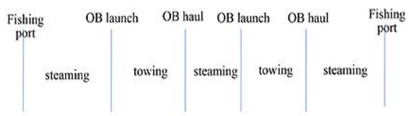
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand

TESTING CONDITIONS FOR FISHING OPERATION

Fishing Trips;

Fishing operation phase:



Recorded values:

Date, time, Value on fuel flow meter (cc, L, m^3), Engine revolution (rpm, rps), Ship speed (km/h, knot), Ship distance (km, nm), <u>weighing hauled catches</u>

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RECORDING TABLE FOR WHOLE FISHING TRIP

Stage	Date	time	Latitue-Longtitude		Eng. Rev.	Flow meter	Wind sp.	Wind dir.	Catch	Ship sp.	Dist.	Dist.	Fuel con.	Rate of Con.	Con. per dist.
			N	E	rpm				kg	kt	m	nm	liter	L/hr	L/nm
Cruising to fishing ground around Tarutao Island															
Start engine	28/3/2015	28/03/2015 04:51	06 33.792	99 37.271	750.00	2425.74	10.20	W		1.1	0.00	0.00	0.00	0.00	0.00
Arrive at fishing ground		05:07	06 33.096	99 36.092	679.00	2428.08	8.10	W		1.7					
Floating for 5 min.															
Otter board down		28/03/2015 05:08	06 33.098	99 36.098	723.00	2428.35	11.20	NW		2.3	2,734.34	1.48	2.61	9.21	1.77
Otter board up		28/03/2015 10:02	06 32.983	99 35.562	708.00	2481.10	9.50	W	80 kg	1	23,537.28	12.71	52.75	10.77	4.15
Cod end upto deck															
Floating for 5 min.															
Stop engine															
Total fuel consumption															
[illegible]															
Start engine															
Arrive at fishing ground															
Floating for 5 min.															
Otter board down		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	18,686.49	10.09	[illegible]	9.36	3.96
Otter board up		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22,906.42	12.37	[illegible]	11.03	4.25
Cod end upto deck		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]					
Floating for 5 min.															
Stop engine		28/03/2015 19:39	06 31.137	99 38.509	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	1,826.29	0.99	[illegible]	2.83	1.67
Total fuel consumption	28/3/2015 4:51	[illegible]	[illegible]	[illegible]		[illegible]									
[illegible]															
Start engine	29/3/2015	[illegible]	[illegible]	[illegible]	1098.00	[illegible]	6.20	E		[illegible]	0.00	0.00	0.00	0.00	0.00
Arrive at fishing ground															
Floating for 5 min.															
Otter board down		29/03/2015 04:18	06 30.853	99 38.035	1140.00	2577.06	5.40	E		3	1,217.57	0.66	0.80	5.33	1.22
Otter board up		29/03/2015 9:43	06 32.035	99 36.129	826.00	2637.88	3.40	E		0.4	26,265.20	14.18	60.82	11.23	4.29
Cod end upto deck		9:51	06 32.029	99 36.064	717.00	2638.17	7.10	E	60 kg	0.6					
Floating for 5 min.															
Stop engine															
Total fuel consumption															

GPS navigator | GPS navigator | GPS navigator | Tachometer | Fuel flow meter | Anemometer | Anemometer | Weight scale | GPS navigator | Calculation

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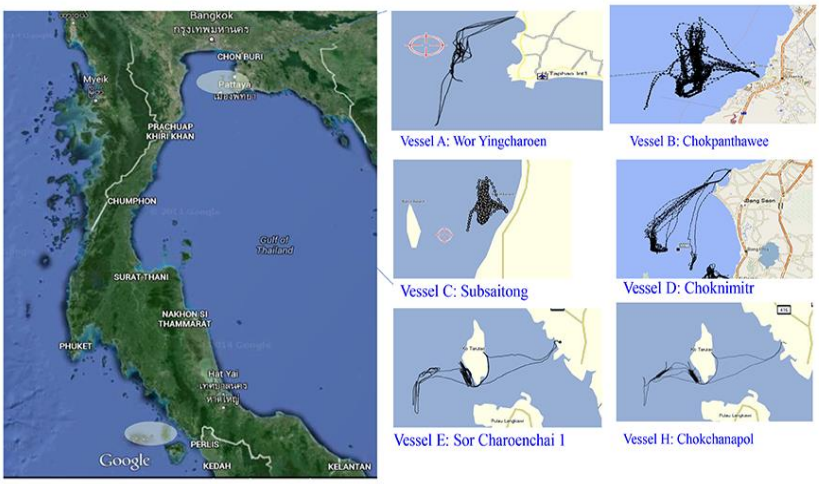
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand

FISHING GROUND LOCATIONS OF SIX INVESTIGATED TRAWLERS IN THE PHASE I

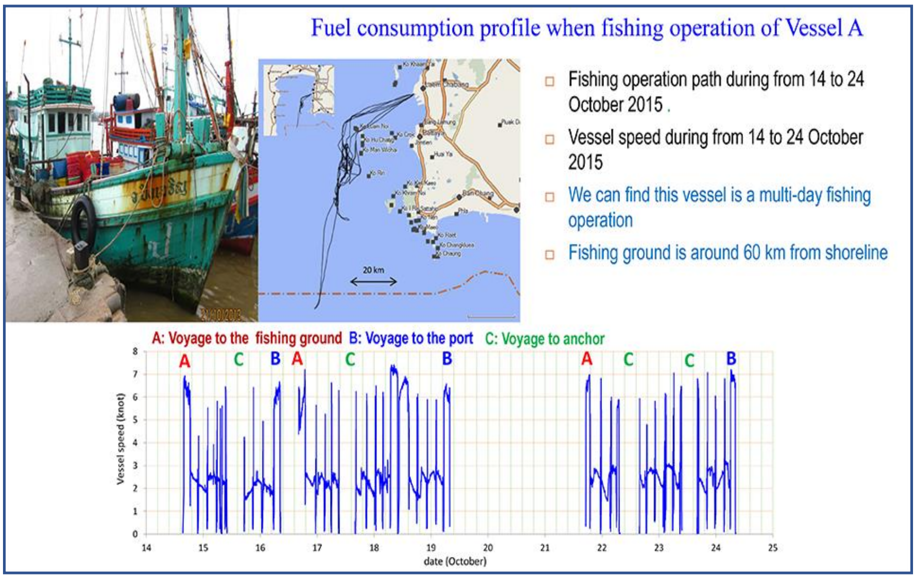


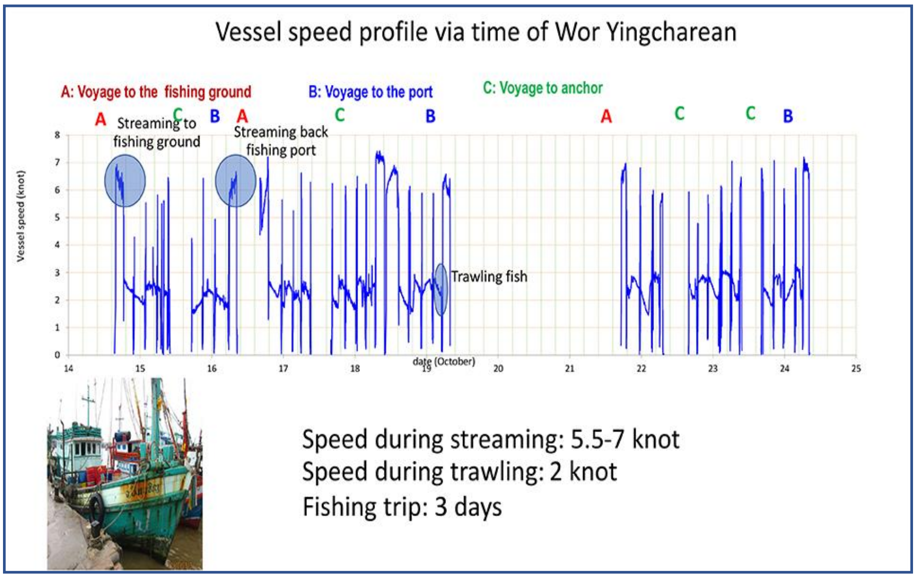
Six investigated trawlers

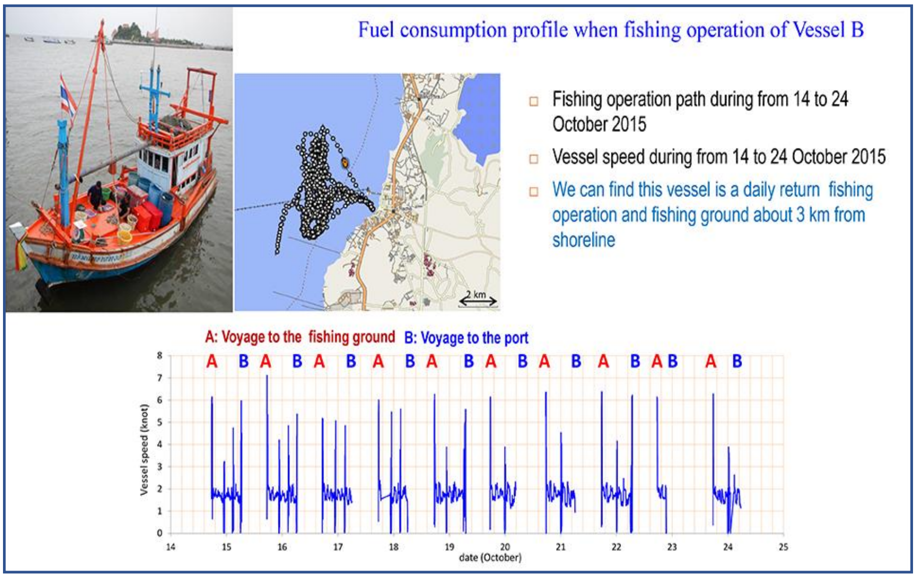
General Information of Selected Fishing Vessels

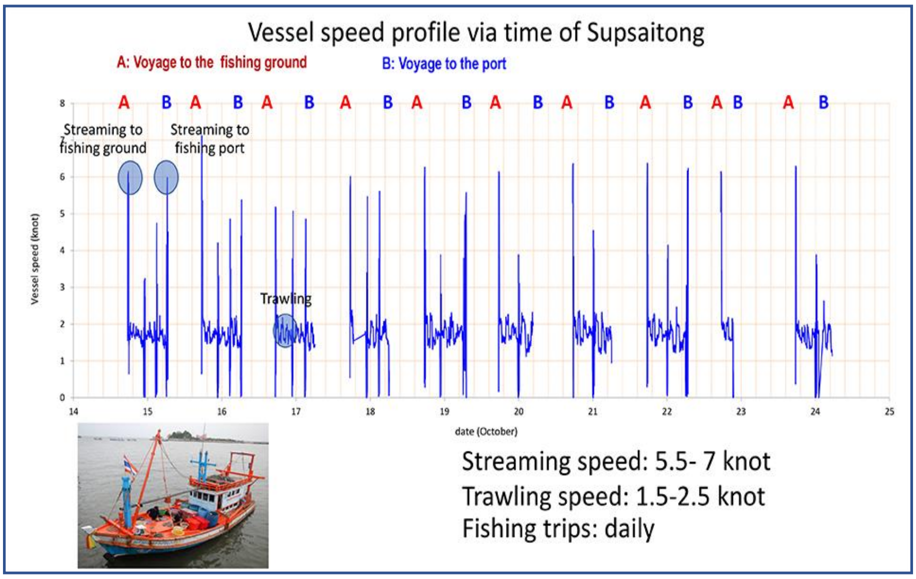
Table 1 General information of trawlers used for energy audits ordered by horse power

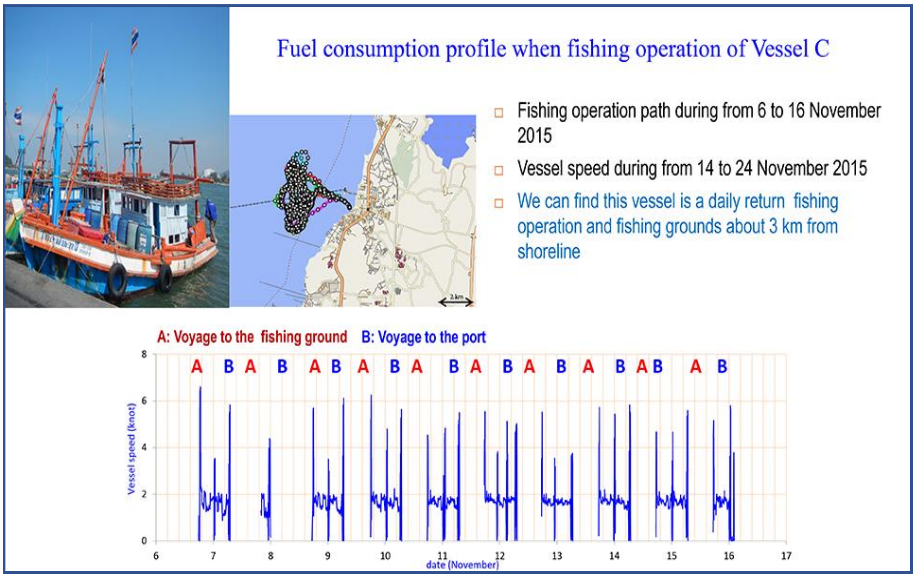
Boat Name	W. YingChaRoen	ChokPanThaWee	SupSaiTong	ChokNiMitr	ChokChaNaPol	S. ChaReanChai1
Fishing Gear	Shrimp trawl	Shrimp trawl	Shrimp/fish trawl	Shrimp/fish trawl	Shrimp/squid trawl	Shrimp/squid trawl
Engine	GARDNER 180Hp	Hino 130 Hp	Hino 168 Hp	Hino 180 Hp	Hino 190 Hp	Commins EK 275 Hp
Reduction gear ratio	6:1	6:1	4:1	4:1	5:1	5:1
Length overall	17m	11.2m	11m	12m	14.0 m	13.2m
Length water line	16m	10.4m	10m	11m	13.0 m	12.2m
Breadth	4.6m	3.7m	3.7m	3.7m	3.6 m	3.1m
Draft	1.5~1.8m	1.38m	1.5m	1.5m	1.3 m	1.5m
Fuel oil price	25.52 THB/l	29.96 THB/l	29.96 THB/l	29.96 THB/l	23 THB/l	23 THB/l
Propeller dia.	50 inch	44 inch	38 inch	39 inch	42 inch	52 inch
Duration date	14-24/10/2013	6-16/11/2013	14-24/10/201	6-16/11/2013	23-31/11/2013	23-31/11/2013

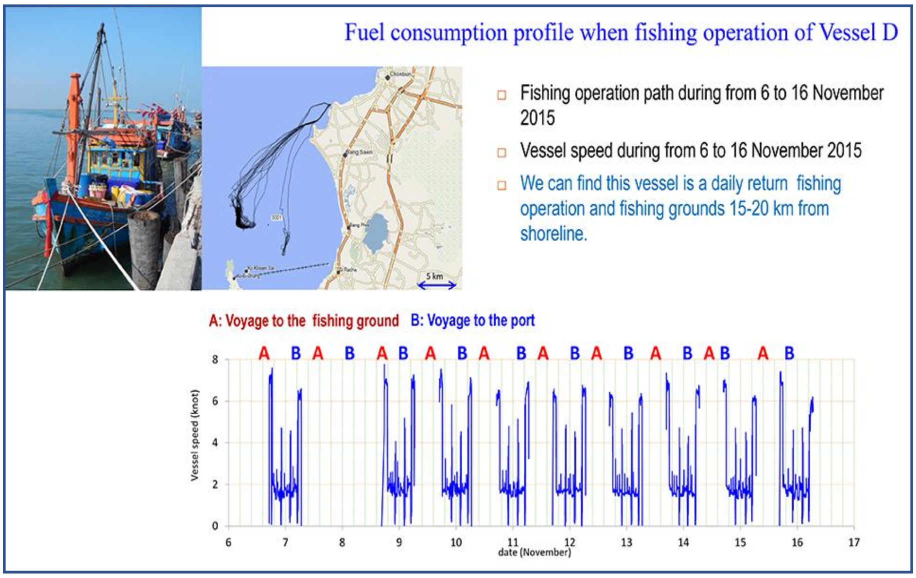

Fuel consumption profile when fishing operation of Vessel A
Fishing operation path during from 14 to 24 October 2015 .
Vessel speed during from 14 to 24 October 2015
We can find this vessel is a multi-day fishing operation
Fishing ground is around 60 km from shoreline
20 km
A: Voyage to the fishing ground
B: Voyage to the port
C: Voyage to anchor
Vessel speed (knot)
date (October)

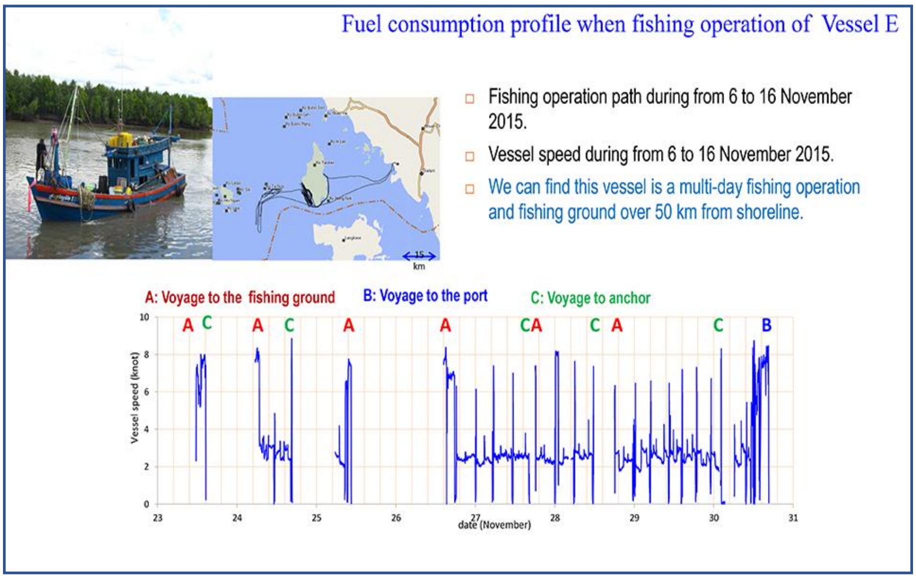

Vessel speed profile via time of Wor Yingcharean
A: Voyage to the fishing ground
B: Voyage to the port
C: Voyage to anchor
Streaming to fishing ground
Streaming back fishing port
Trawling fish
Vessel speed (knot)
date (October)
Speed during streaming: 5.5-7 knot
Speed during trawling: 2 knot
Fishing trip: 3 days

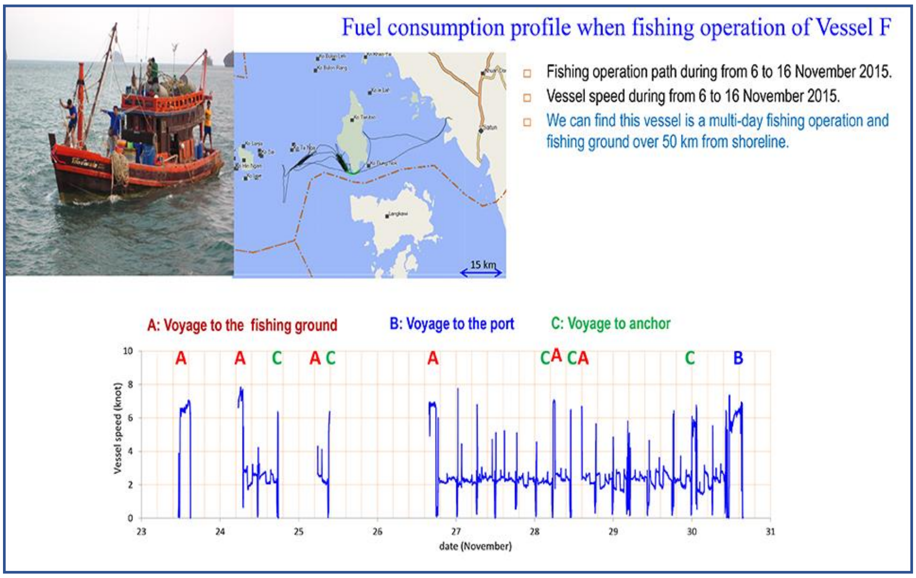

Fuel consumption profile when fishing operation of Vessel B
Fishing operation path during from 14 to 24 October 2015
Vessel speed during from 14 to 24 October 2015
We can find this vessel is a daily return fishing operation and fishing ground about 3 km from shoreline
2 km
A: Voyage to the fishing ground
B: Voyage to the port
Vessel speed (knot)
date (October)

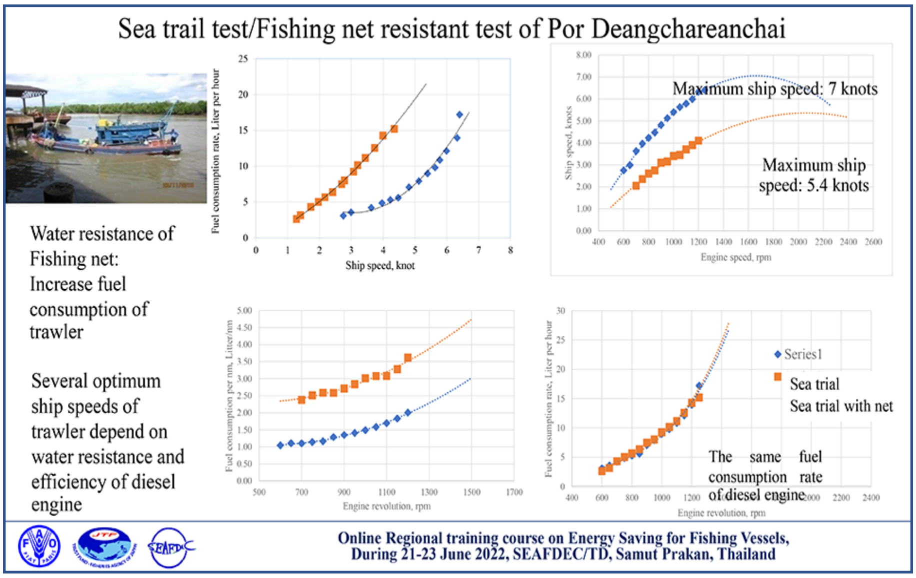

Vessel speed profile via time of Supsaitong
A: Voyage to the fishing ground
B: Voyage to the port
Streaming to fishing ground
Streaming to fishing port
Trawling
Vessel speed (knot)
date (October)
Streaming speed: 5.5- 7 knot
Trawling speed: 1.5-2.5 knot
Fishing trips: daily

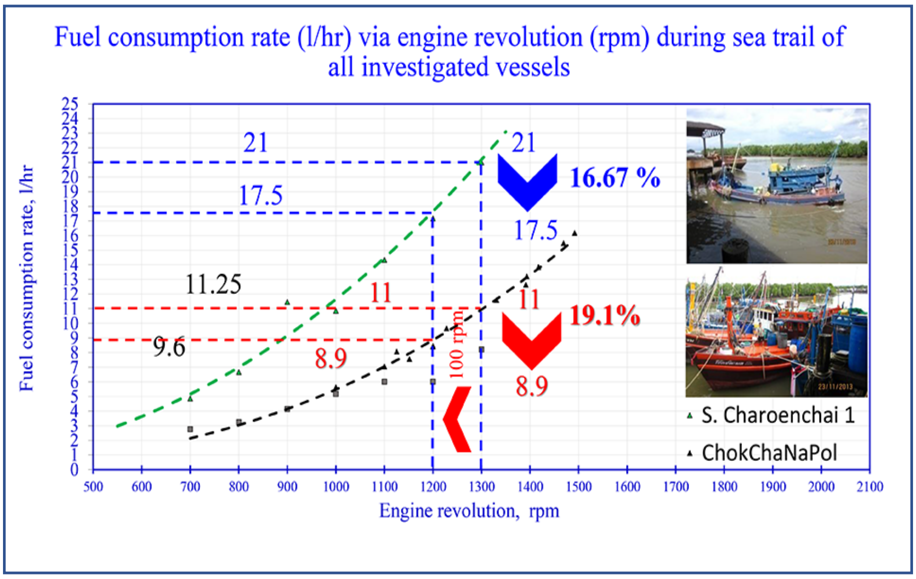

Fuel consumption profile when fishing operation of Vessel C
Fishing operation path during from 6 to 16 November 2015
Vessel speed during from 14 to 24 November 2015
We can find this vessel is a daily return fishing operation and fishing grounds about 3 km from shoreline
A: Voyage to the fishing ground
B: Voyage to the port
Vessel speed (knot)
date (November)

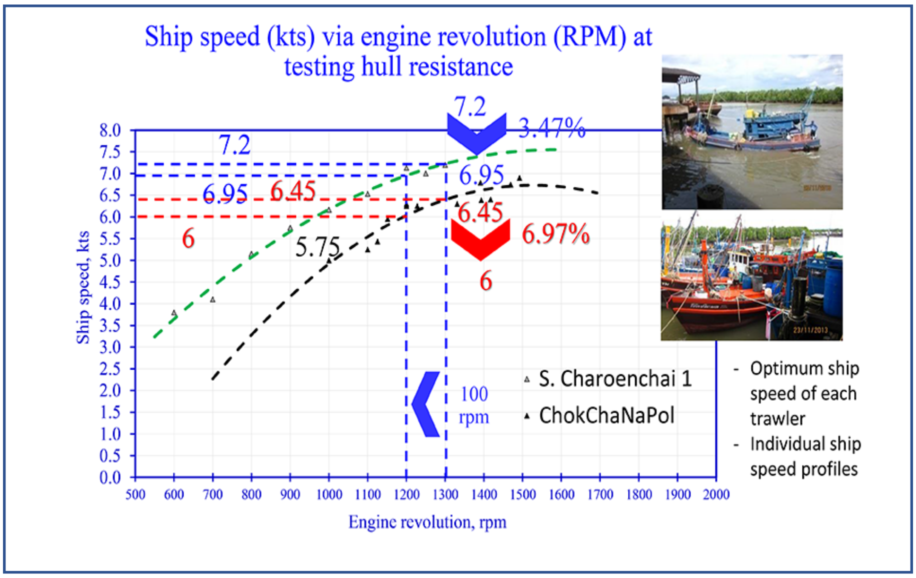

Fuel consumption profile when fishing operation of Vessel D
Fishing operation path during from 6 to 16 November 2015
Vessel speed during from 6 to 16 November 2015
We can find this vessel is a daily return fishing operation and fishing grounds 15-20 km from shoreline.
5 km
A: Voyage to the fishing ground
B: Voyage to the port
Vessel speed (knot)
date (November)

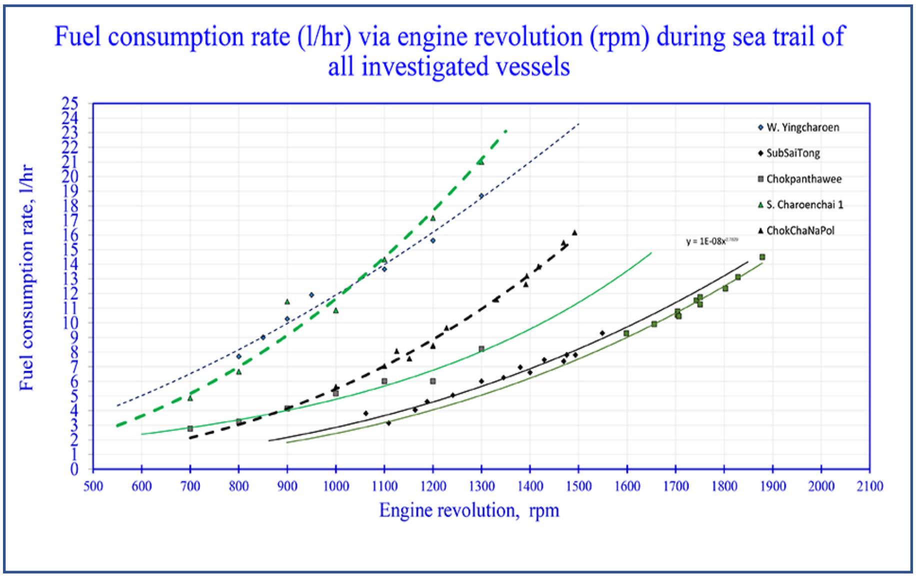

Fuel consumption profile when fishing operation of Vessel E
Fishing operation path during from 6 to 16 November 2015.
Vessel speed during from 6 to 16 November 2015.
We can find this vessel is a multi-day fishing operation and fishing ground over 50 km from shoreline.
15 km
A: Voyage to the fishing ground
B: Voyage to the port
C: Voyage to anchor
Vessel speed (knot)
date (November)

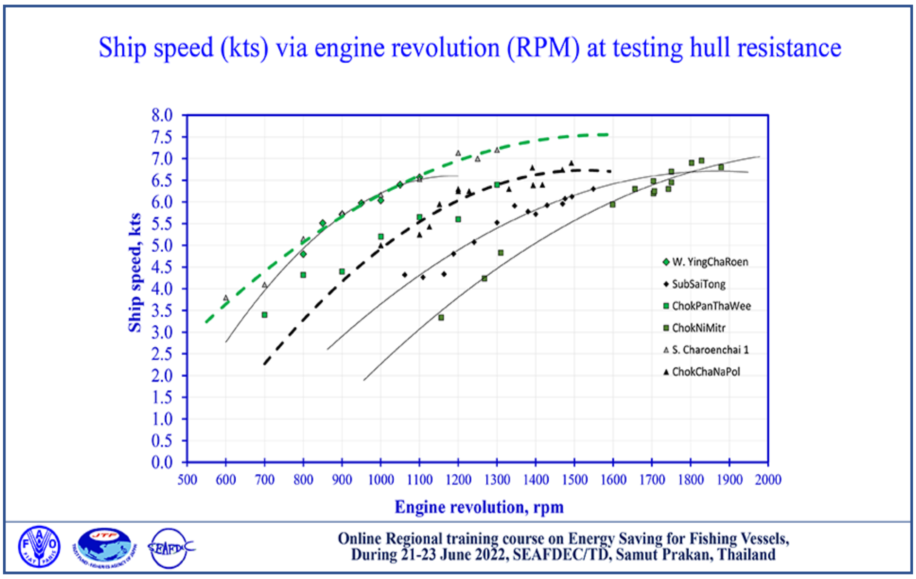

Fuel consumption profile when fishing operation of Vessel F
Fishing operation path during from 6 to 16 November 2015.
Vessel speed during from 6 to 16 November 2015.
We can find this vessel is a multi-day fishing operation and fishing ground over 50 km from shoreline.
15 km
A: Voyage to the fishing ground
B: Voyage to the port
C: Voyage to anchor
Vessel speed (knot)
date (November)

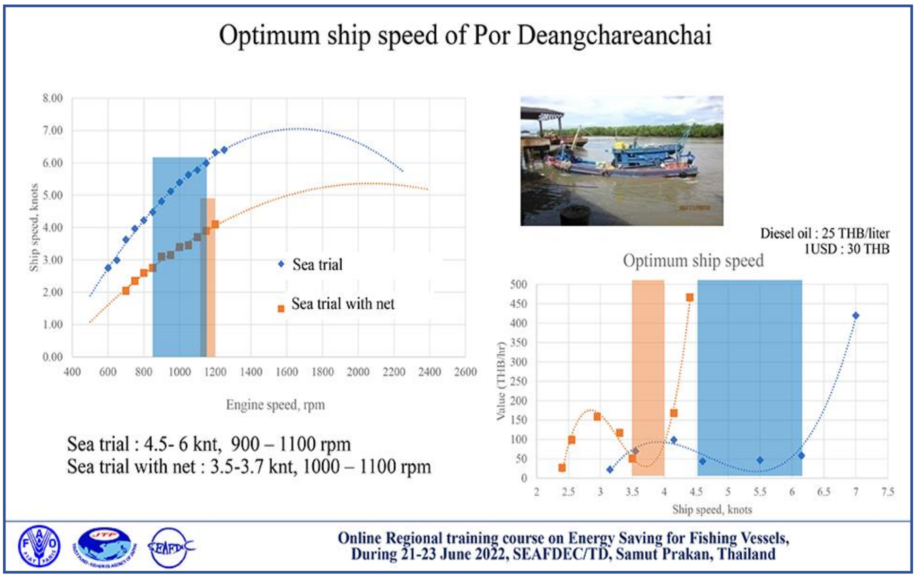

Sea trail test/Fishing net resistant test of Por Deangchareanchai
Water resistance of Fishing net: Increase fuel consumption of trawler
Several optimum ship speeds of trawler depend on water resistance and efficiency of diesel engine
Fuel consumption rate, Liter per hour
Ship speed, knot
Maximum ship speed: 7 knots
Maximum ship speed: 5.4 knots
Ship speed, knots
Engine speed, rpm
Fuel consumption per nm, Liter/nm
Engine revolution, rpm
Series1
Sea trial
Sea trial with net
The same fuel consumption rate of diesel engine
Online Regional training course on Energy Saving for Fishing Vessels,
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand

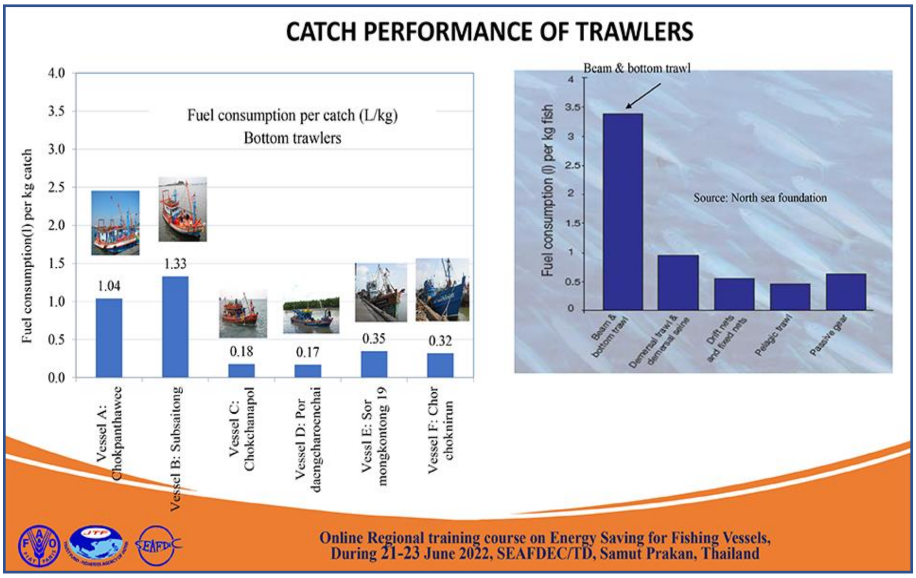

Fuel consumption rate (l/hr) via engine revolution (rpm) during sea trail of all investigated vessels
Fuel consumption rate, l/hr
Engine revolution, rpm
21
17.5
11.25
9.6
11
8.9
21
16.67 %
17.5
11
19.1%
8.9
100 rpm
S. Charoenchai 1
ChokChaNaPol

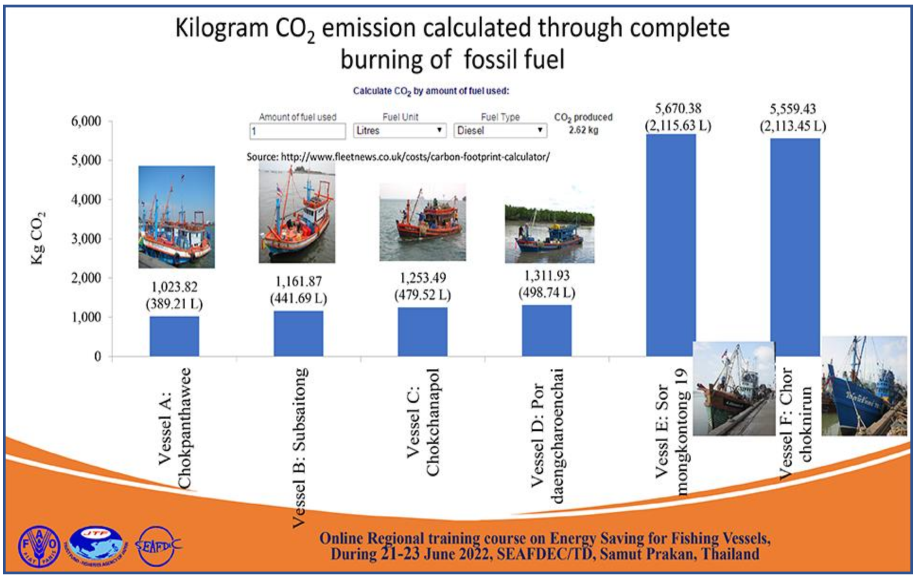

Ship speed (kts) via engine revolution (RPM) at testing hull resistance
Ship speed, kts
Engine revolution, rpm
7.2
3.47%
7.2
6.95
6.45
6.95
6.45
6
5.75
6.97%
6
100 rpm
S. Charoenchai 1
ChokChaNaPol
- Optimum ship speed of each trawler
- Individual ship speed profiles

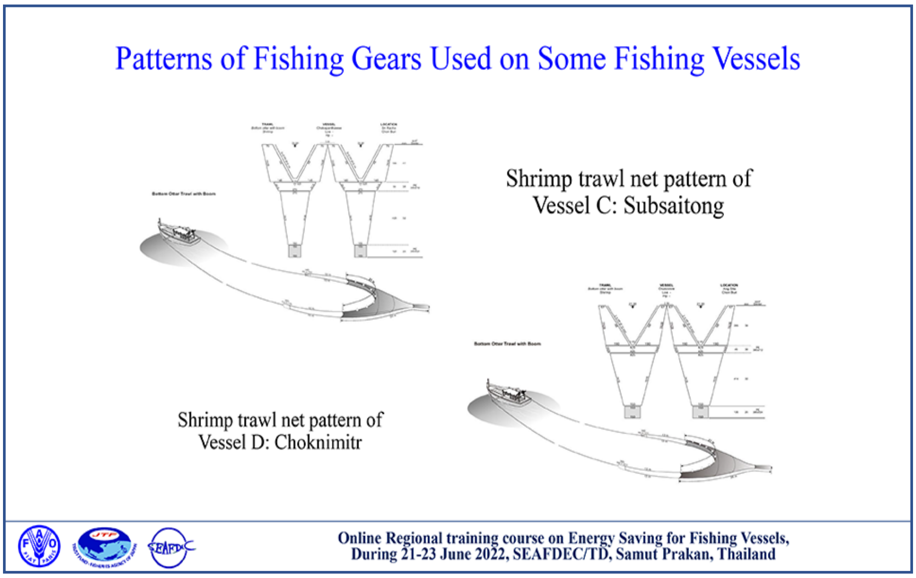

Fuel consumption rate (l/hr) via engine revolution (rpm) during sea trail of all investigated vessels
Fuel consumption rate, l/hr
Engine revolution, rpm
W. Yingcharoen
SubSaiTong
Chokpanthawee
S. Charoenchai 1
ChokChaNaPol

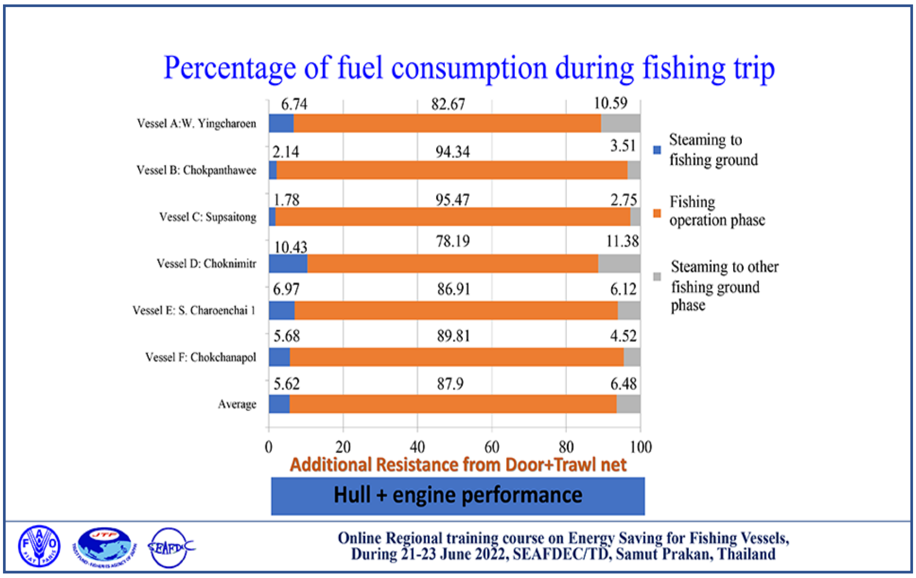

Ship speed (kts) via engine revolution (RPM) at testing hull resistance
Ship speed, kts
Engine revolution, rpm
W. YingChaRoen
SubSaiTong
ChokPanThaWee
ChokNiMitr
S. Charoenchai 1
ChokChaNaPol
Online Regional training course on Energy Saving for Fishing Vessels,
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand

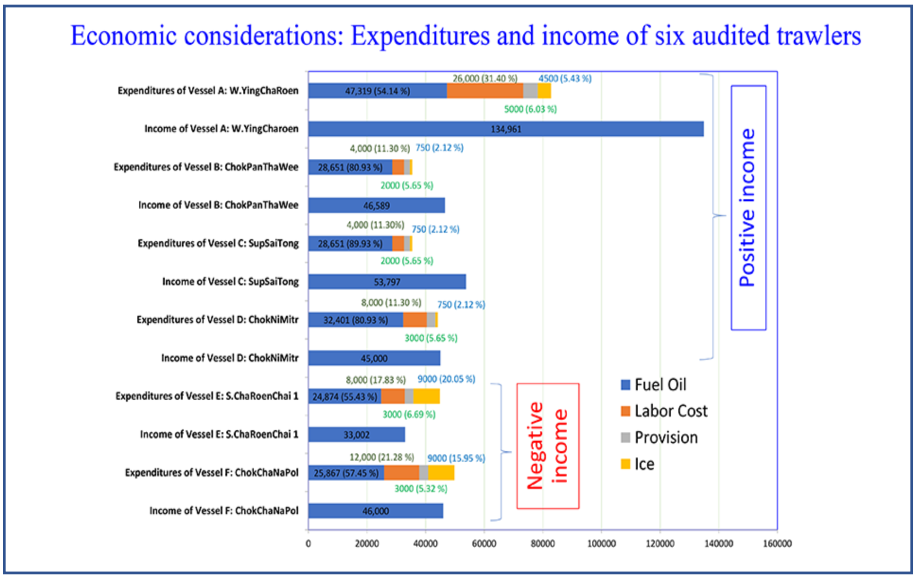

Optimum ship speed of Por Deangchareanchai
Ship speed, knots
Engine speed, rpm
Sea trial
Sea trial with net
Sea trial : 4.5- 6 knt, 900 – 1100 rpm
Sea trial with net : 3.5-3.7 knt, 1000 – 1100 rpm
Diesel oil : 25 THB/liter
1USD : 30 THB
Optimum ship speed
Value (THB/hr)
Ship speed, knots
Online Regional training course on Energy Saving for Fishing Vessels,
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand

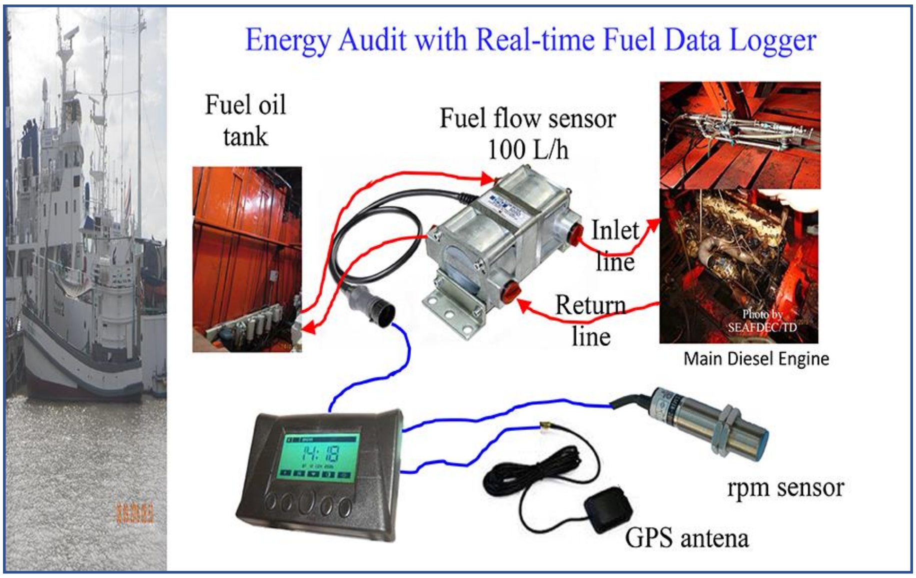

CATCH PERFORMANCE OF TRAWLERS
Fuel consumption per catch (L/kg)
Bottom trawlers
Fuel consumption(l) per kg catch
1.04
1.33
0.18
0.17
0.35
0.32
Vessel A: Chokpanthawee
Vessel B: Subsaitong
Vessel C: Chokchanapol
Vessel D: Por daengcharoenchai
Vessl E: Sor mongkontong 19
Vessel F: Chor choknirun
Beam & bottom trawl
Fuel consumption (l) per kg fish
Source: North sea foundation
Beam & bottom trawl
Demersal trawl & demersal seine
Drift nets and fixed nets
Pelagic trawl
Passive gear
Online Regional training course on Energy Saving for Fishing Vessels,
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand

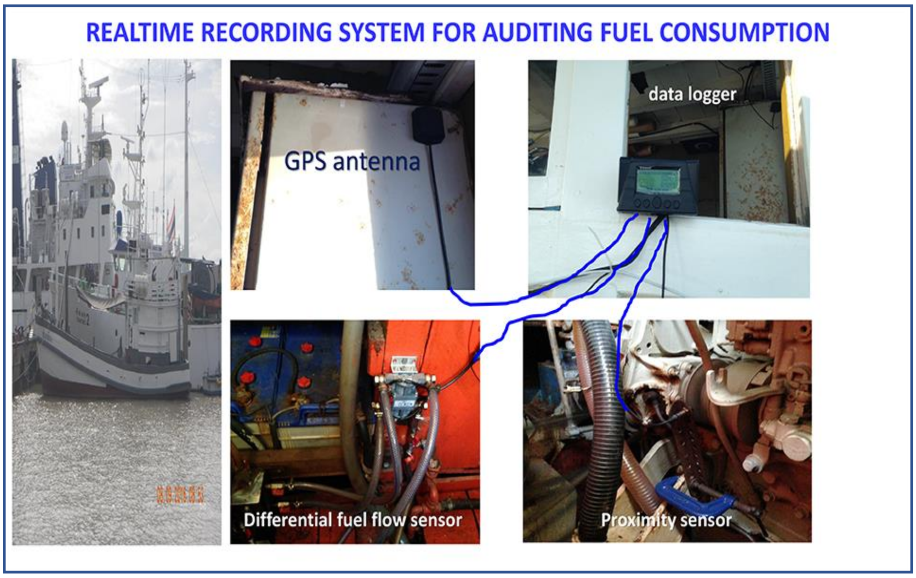

Kilogram CO_2 emission calculated through complete burning of fossil fuel
Calculate CO_2 by amount of fuel used:
Amount of fuel used
Fuel Unit
Fuel Type
CO_2 produced
2.62 kg
Litres
Diesel
Source: http://www.fleetnews.co.uk/costs/carbon-footprint-calculator/
Kg CO_2
6,000
5,000
4,000
3,000
2,000
1,000
0
1,023.82 (389.21 L)
1,161.87 (441.69 L)
1,253.49 (479.52 L)
1,311.93 (498.74 L)
5,670.38 (2,115.63 L)
5,559.43 (2,113.45 L)
Vessel A: Chokpanthawee
Vessel B: Subsaitong
Vessel C: Chokchanapol
Vessel D: Por daengcharoenchai
Vessl E: Sor mongkontong 19
Vessel F: Chor choknirun
Online Regional training course on Energy Saving for Fishing Vessels,
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand


Patterns of Fishing Gears Used on Some Fishing Vessels
Shrimp trawl net pattern of
Vessel C: Subsaitong
Shrimp trawl net pattern of
Vessel D: Choknimitr
Online Regional training course on Energy Saving for Fishing Vessels,
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand

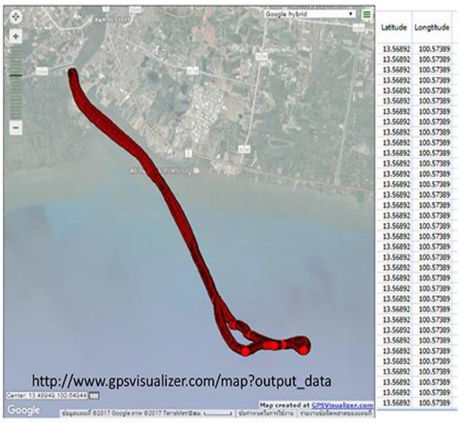

Percentage of fuel consumption during fishing trip
Vessel A:W. Yingcharoen 6.74 82.67 10.59
Vessel B: Chokpanthawee 2.14 94.34 3.51
Vessel C: Supsaitong 1.78 95.47 2.75
Vessel D: Choknimitr 10.43 78.19 11.38
Vessel E: S. Charoenchai 1 6.97 86.91 6.12
Vessel F: Chokchanapol 5.68 89.81 4.52
Average 5.62 87.9 6.48
0 20 40 60 80 100
Steaming to fishing ground
Fishing operation phase
Steaming to other fishing ground phase
Additional Resistance from Door+Trawl net
Hull + engine performance
Online Regional training course on Energy Saving for Fishing Vessels,
During 21-23 June 2022, SEAFDEC/TD, Samut Prakan, Thailand


Economic considerations: Expenditures and income of six audited trawlers
Expenditures of Vessel A: W.YingChaRoen
47,319 (54.14 %)
26,000 (31.40 %)
4500 (5.43 %)
5000 (6.03 %)
Income of Vessel A: W.YingCharoen
134,961
Expenditures of Vessel B: ChokPanThaWee
28,651 (80.93 %)
4,000 (11.30 %)
750 (2.12 %)
2000 (5.65 %)
Income of Vessel B: ChokPanThaWee
46,589
Expenditures of Vessel C: SupSaiTong
28,651 (89.93 %)
4,000 (11.30%)
750 (2.12 %)
2000 (5.65 %)
Income of Vessel C: SupSaiTong
53,797
Expenditures of Vessel D: ChokNiMitr
32,401 (80.93 %)
8,000 (11.30 %)
750 (2.12 %)
3000 (5.65 %)
Income of Vessel D: ChokNiMitr
45,000
Expenditures of Vessel E: S.ChaRoenChai 1
24,874 (55.43 %)
8,000 (17.83 %)
9000 (20.05 %)
3000 (6.69 %)
Income of Vessel E: S.ChaRoenChai 1
33,002
Expenditures of Vessel F: ChokChaNaPol
25,867 (57.45 %)
12,000 (21.28 %)
9000 (15.95 %)
3000 (5.32 %)
Income of Vessel F: ChokChaNaPol
46,000
0
20000
40000
60000
80000
100000
120000
140000
160000
Positive income
Negative income
Fuel Oil
Labor Cost
Provision
Ice


Energy Audit with Real-time Fuel Data Logger
Fuel oil tank
Fuel flow sensor 100 L/h
Inlet line
Return line
Photo by SEAFDEC/TD
Main Diesel Engine
rpm sensor
GPS antena


REALTIME RECORDING SYSTEM FOR AUDITING FUEL CONSUMPTION
GPS antenna
data logger
Differential fuel flow sensor
Proximity sensor

Traveling profile of MV Plalung 1 based on Latitude and Longitude from real-time data logger



Calculated data of MV Plalung from fuel flow data logger

Vehicle HINO 12345 Period from 20.01.17 7:30:09 till 20.01.17 18:20:01

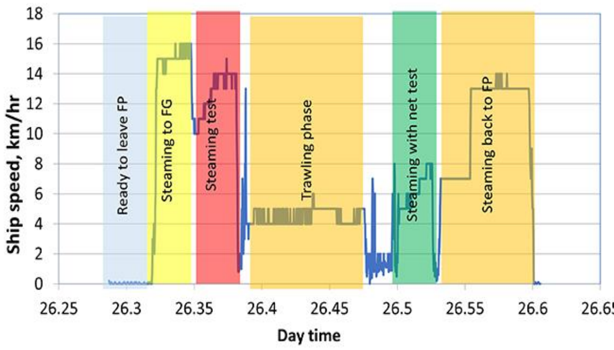
READTIME	READTIME	delta time (h)	Day	Mannual entry	Day time	FUE	FUE	Day time	SPEED (km/hr)	FUEL0	RACE	Day time
20.01.17 07:30:11	42755.31263		20	7.5030556	20.3126273			20.3126273	13.7	0.055	0.019	20.3126273
20.01.17 07:30:16	42755.31269	0.001388889			20.3126852			20.3126852	13.7	0.045	0.019	20.3126852
20.01.17 07:30:21	42755.31274	0.001388889			20.3127431			20.3127431	13.7	0.04	0.019	20.3127431
20.01.17 07:30:26	42755.31280	0.001388889			20.3128009			20.3128009	13.0	0.045	0.018	20.3128009
20.01.17 07:30:31	42755.31286	0.001388889			20.3128588			20.3128588	13.0	0.04	0.018	20.3128588
20.01.17 07:30:36	42755.31292	0.001388889			20.3129167			20.3129167	12.2	0.04	0.017	20.3129167
20.01.17 07:30:41	42755.31297	0.001388889			20.3129745			20.3129745	13.7	0.04	0.019	20.3129745
20.01.17 07:30:46	42755.31303	0.001388889			20.3130324			20.3130324	13.0	0.04	0.018	20.3130324
20.01.17 07:30:51	42755.31309	0.001388889			20.3130903			20.3130903	15.1	0.045	0.021	20.3130903
20.01.17 07:30:56	42755.31315	0.001388889			20.3131481			20.3131481	10.1	0.04	0.014	20.3131481
20.01.17 07:31:01	42755.31321	0.001388889			20.3132060			20.3132060	13.7	0.04	0.019	20.3132060
20.01.17 07:31:06	42755.31326	0.001388889			20.3132639			20.3132639	13.0	0.035	0.018	20.3132639
20.01.17 07:31:11	42755.31332	0.001388889			20.3133218			20.3133218	13.0	0.05	0.018	20.3133218
20.01.17 07:31:16	42755.31338	0.001388889			20.3133796			20.3133796	15.8	0.04	0.022	20.3133796
20.01.17 07:31:21	42755.31344	0.001388889			20.3134375			20.3134375	10.8	0.04	0.015	20.3134375
20.01.17 07:31:26	42755.3135	0.001388889			20.3134954			20.3134954	13.7	0.04	0.019	20.3134954
20.01.17 07:31:31	42755.31355	0.001388889			20.3135532			20.3135532	13.0	0.04	0.018	20.3135532
20.01.17 07:31:36	42755.31361	0.001388889			20.3136111			20.3136111	13.7	0.04	0.019	20.3136111
20.01.17 07:31:41	42755.31367	0.001388889			20.3136690			20.3136690	13.0	0.04	0.018	20.3136690
20.01.17 07:31:46	42755.31373	0.001388889			20.3137269			20.3137269	13.7	0.045	0.019	20.3137269
20.01.17 07:31:51	42755.31378	0.001388889			20.3137847			20.3137847	13.0	0.04	0.018	20.3137847
20.01.17 07:31:56	42755.31384	0.001388889			20.3138426			20.3138426	13.7	0.04	0.019	20.3138426
20.01.17 07:32:01	42755.3139	0.001388889			20.3139005			20.3139005	13.0	0.04	0.018	20.3139005
20.01.17 07:32:06	42755.31396	0.001388889			20.3139583			20.3139583	14.4	0.04	0.02	20.3139583
20.01.17 07:32:11	42755.31402	0.001388889			20.3140162			20.3140162	13.7	0.045	0.019	20.3140162
20.01.17 07:32:16	42755.31407	0.001388889			20.3140741			20.3140741	16.6	0.04	0.023	20.3140741
20.01.17 07:32:21	42755.31413	0.001388889			20.3141319			20.3141319	13.7	0.04	0.019	20.3141319
20.01.17 07:32:26	42755.31419	0.001388889			20.3141898			20.3141898	12.2	0.04	0.017	20.3141898
20.01.17 07:32:31	42755.31425	0.001388889			20.3142477			20.3142477	13.7	0.04	0.019	20.3142477
20.01.17 07:32:36	42755.31431	0.001388889			20.3143056			20.3143056	13.7	0.045	0.019	20.3143056
20.01.17 07:32:41	42755.31436	0.001388889			20.3143634			20.3143634	13.7	0.04	0.019	20.3143634
20.01.17 07:32:46	42755.31442	0.001388889			20.3144213			20.3144213	13.7	0.04	0.019	20.3144213
20.01.17 07:32:51	42755.31448	0.001388889			20.3144792			20.3144792	14.4	0.04	0.02	20.3144792
20.01.17 07:32:56	42755.31454	0.001388889			20.3145370			20.3145370	10.8	0.035	0.015	20.3145370
20.01.17 07:33:01	42755.31459	0.001388889			20.3145949			20.3145949	16.6	0.045	0.023	20.3145949
20.01.17 07:33:06	42755.31465	0.001388889			20.3146528			20.3146528	14.4	0.04	0.02	20.3146528

1mile=1609.34 m

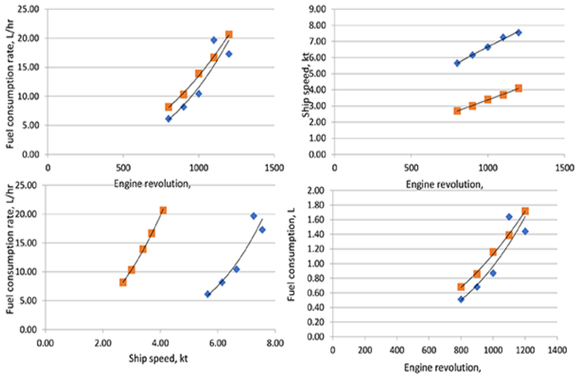
READTIME	FUELPH (L/hr)	ENGINERI	BATTEF	LATITUDE	LONGITUDE	Distance(miles)	Distance (m)	Speed (m/s)	Day time	Speed (km/h	ALTITUDE
20.01.17 07:30:11	39.6	1554.0	10.8	13.55597	100.57686				20.3126273		cc
20.01.17 07:30:16	32.4	1560.0	10.8	13.55583	100.57694	0.0110678	17.8119144	3.5623829	20.3126852	12.8245784	cc
20.01.17 07:30:21	28.8	1480.0	10.8	13.55567	100.57703	0.0126026	20.2818067	4.0563613	20.3127431	14.6029006	cc
20.01.17 07:30:26	32.4	1480.0	10.8	13.55553	100.57711	0.0110677	17.8116613	3.5623323	20.3128009	12.8243962	cc
20.01.17 07:30:31	28.8	1480.0	10.8	13.55538	100.57717	0.0124207	19.9891744	3.9978349	20.3128588	14.3922055	cc
20.01.17 07:30:36	28.8	1472.0	10.8	13.55522	100.57725	0.0110678	17.8119144	3.5623829	20.3129167	12.8245784	cc
20.01.17 07:30:41	28.8	1476.0	10.9	13.55508	100.57731	0.0104812	16.8678781	3.3735756	20.3129745	12.1448722	cc
20.01.17 07:30:46	28.8	1468.0	10.8	13.55492	100.57736	0.0115564	18.5981652	3.719633	20.3130324	13.3906789	cc
20.01.17 07:30:51	32.4	1472.0	10.8	13.55475	100.57744	0.0129196	20.7919714	4.1583943	20.3130903	14.9702194	cc
20.01.17 07:30:56	28.8	1476.0	10.8	13.55464	100.5775	0.0086047	13.8478645	2.7695729	20.3131481	9.9704624	cc
20.01.17 07:31:01	28.8	1468.0	10.8	13.55447	100.57756	0.0124207	19.9891744	3.9978349	20.313206	14.3922055	cc
20.01.17 07:31:06	25.2	1480.0	10.8	13.55431	100.57764	0.0122942	19.7856073	3.9571215	20.3132639	14.2456373	cc
20.01.17 07:31:11	36.0	1476.0	10.8	13.55417	100.57772	0.0110677	17.8116613	3.5623323	20.3133218	12.8243962	cc
20.01.17 07:31:16	28.8	1472.0	10.8	13.554	100.57781	0.013213	21.2642789	4.2528554	20.3133796	15.3102793	cc
20.01.17 07:31:21	28.8	1472.0	10.9	13.55389	100.57789	0.0093101	14.9831011	2.9966202	20.3134375	10.7878328	cc
20.01.17 07:31:26	28.8	1476.0	10.9	13.55375	100.57797	0.0110678	17.8119144	3.5623829	20.3134954	12.8245784	cc
20.01.17 07:31:31	28.8	1468.0	10.8	13.55358	100.57806	0.013213	21.2642789	4.2528554	20.3135532	15.3102793	cc
20.01.17 07:31:36	28.8	1480.0	10.8	13.55344	100.57814	0.011068	17.8121675	3.5624335	20.3136111	12.8247606	cc
20.01.17 07:31:41	28.8	1476.0	10.8	13.55331	100.57825	0.0116331	18.7216236	3.7443247	20.313669	13.479569	cc
20.01.17 07:31:46	32.4	1472.0	10.8	13.55317	100.57833	0.0110678	17.8119144	3.5623829	20.3137269	12.8245784	cc
20.01.17 07:31:51	28.8	1472.0	10.8	13.55303	100.57844	0.0121747	19.5932738	3.9186548	20.3137847	14.1071572	cc
20.01.17 07:31:56	28.8	1476.0	10.8	13.55289	100.57853	0.0114092	18.3612828	3.6722566	20.3138426	13.2201236	cc
20.01.17 07:32:01	28.8	1468.0	10.9	13.55275	100.57864	0.0121746	19.5930437	3.9186087	20.3139005	14.1069915	cc
20.01.17 07:32:06	28.8	1480.0	10.8	13.55261	100.57875	0.0121747	19.5932738	3.9186548	20.3139583	14.1071572	cc
20.01.17 07:32:11	32.4	1468.0	10.8	13.55247	100.57883	0.0110677	17.8116613	3.5623323	20.3140162	12.8243962	cc
20.01.17 07:32:16	28.8	1480.0	10.8	13.55231	100.57897	0.0145166	23.3621061	4.6724212	20.3140741	16.8207164	cc
20.01.17 07:32:21	28.8	1468.0	10.9	13.55217	100.57906	0.0114092	18.3612828	3.6722566	20.3141319	13.2201236	cc
20.01.17 07:32:26	28.8	1480.0	10.8	13.55203	100.57914	0.0110678	17.8119144	3.5623829	20.3141898	12.8245784	cc
20.01.17 07:32:31	28.8	1480.0	10.8	13.55192	100.57925	0.0106023	17.0625616	3.4125323	20.3142477	12.2851163	cc
20.01.17 07:32:36	32.4	1468.0	10.8	13.55178	100.57936	0.0121749	19.5935039	3.9187008	20.3143056	14.1073228	cc
20.01.17 07:32:41	28.8	1480.0	10.8	13.55161	100.57947	0.0138797	22.3371256	4.4674251	20.3143634	16.0827304	cc
20.01.17 07:32:46	28.8	1480.0	10.8	13.55147	100.57956	0.011409	18.3610373	3.6722075	20.3144213	13.2199468	cc
20.01.17 07:32:51	28.8	1480.0	10.8	13.55133	100.57967	0.0121749	19.5935039	3.9187008	20.3144792	14.1073228	cc
20.01.17 07:32:56	25.2	1480.0	10.8	13.55122	100.57972	0.0083112	13.375667	2.6751134	20.314537	9.6304083	cc
20.01.17 07:33:01	32.4	1480.0	10.8	13.55106	100.57986	0.0145167	23.362299	4.6724598	20.3145949	16.8208553	cc
20.01.17 07:33:06	28.8	1472.0	10.8	13.55092	100.57997	0.0121747	19.5932738	3.9186548	20.3146528	14.1071572	cc

E:\work\SEAFDEC\2016\Regional training on energy audit\CKPT31 recorded data\Export data\20 Jan 2017.xls

Results from real-time data logger



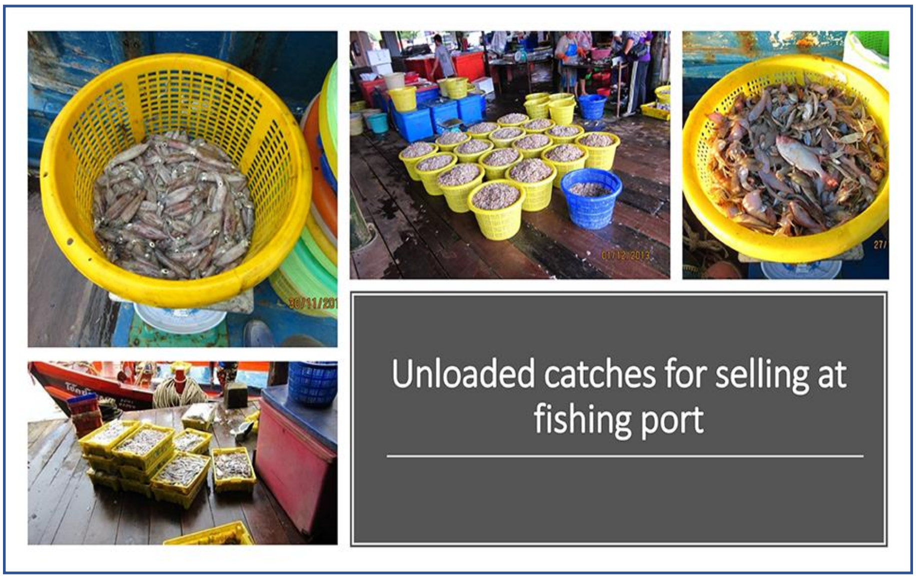
Results from the real-time logger



Benefits of using real-time data logger

- More reliable data or less interference from human error during doing auditing fuel consumption of fishing vessels
- Safe time when doing energy audits based on Australian process on fishing vessels
- Efficient real-time monitoring fuel consumption rate when known optimum speed measured by auditor contributing to save fuel
- Know the operating conditions of the engine and vessel in realtime

Fishing activities on Sor charoenchai


Unloaded catches for selling at fishing port


Fishing activities of Wor yingcharoen


Onsite training on Energy Audits For Fishing Vessels

Onsite training on Energy Audits For Fishing Vessels


Onsite training on Energy Audits For Fishing Vessels Cambodia, Philippines, Malaysia





Advantages of Energy Audits for Fishing Vessels

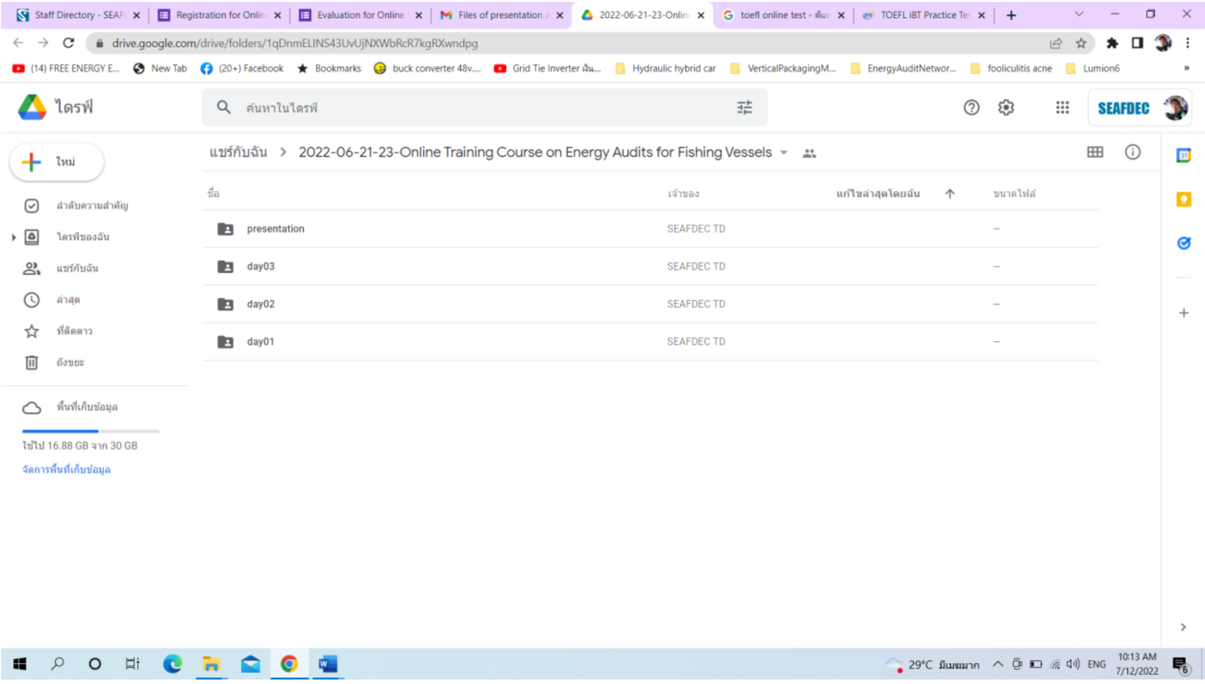
- Acknowledge an optimum operation condition of each fishing vessel with understanding recent efficiency of fishing vessels for decision making both recent or future improvements
- Raise up awareness on fuel saving, carbon emission, understanding on economic estimation for fishers leading to alleviate poverty

Acknowledgement:

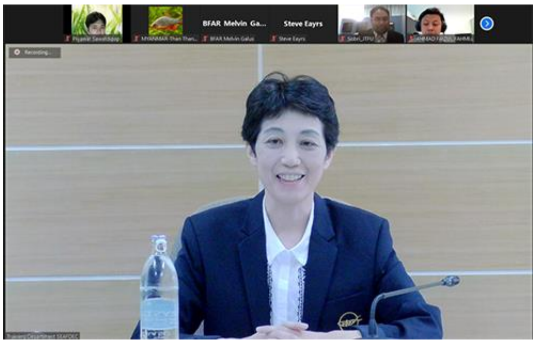
This study is a collaborative project executed by Southeast Asian Fisheries Development Center (SEAFDEC) and supported by funding from Food and Agriculture Organization (FAO) of the United Nations, entitled "Energy Audits for Food Agriculture Organization Fishing Vessel Energy Audit Pilot Project Phase I and II". We would also like to thank the officers of DOF of Thailand, fishing workshop, the skippers and the crews of the six investigated trawlers for their cooperation and support in doing measurement and experiment in the fieldwork.

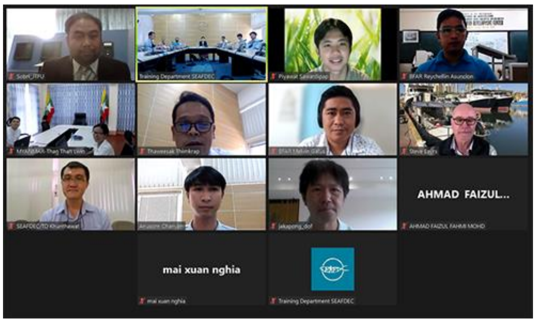
VIII. Appendix 8 Materials provied in the training course

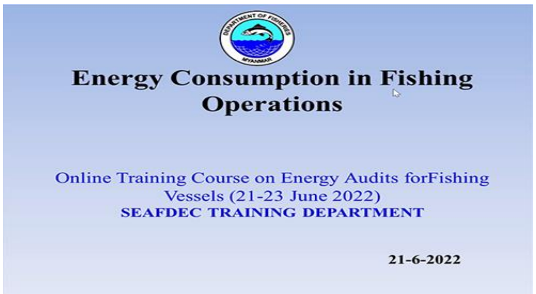
https://drive.google.com/drive/folders/1qDnmELINS43UvUjNXWbRcR7kgRXwndpg



IX. Appendix 9 Photos of activities in the training



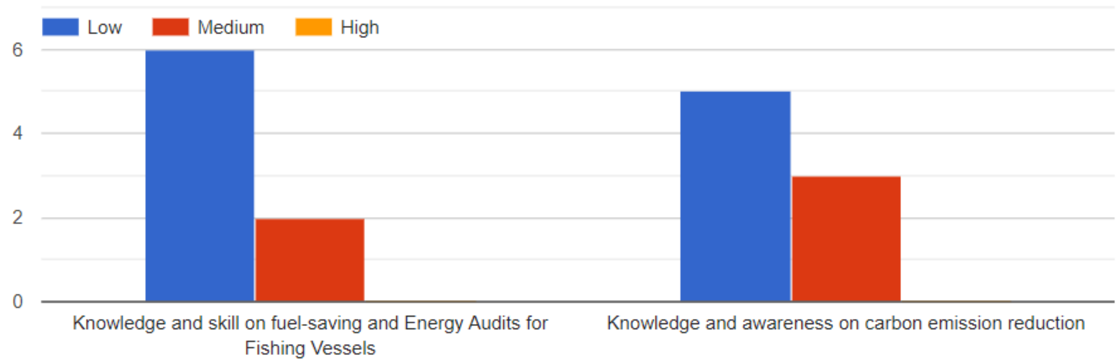




X. Appendix 10 Google form evaluation

Before the training course

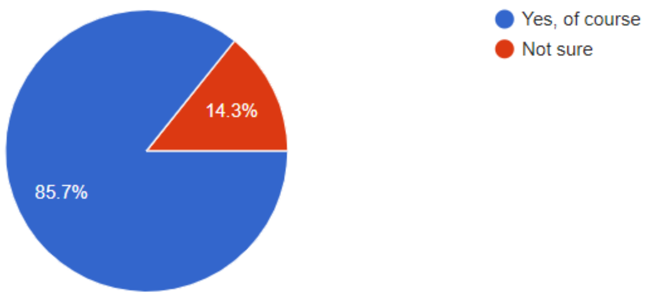
The Understanding of Energy Audtis for Fishing Vessels คัดลอก



After passing the training

The knowledge/ experience from this training course can be apply to your job? คัดลอก

คำตอบ 7 ข้อ



After the training course, your understanding of Energy Audits for Fishing Vessels คัดลอก