For this reason, the ASEAN-SEAFDEC Member Countries developed the "Joint ASEAN-SEAFDEC Declaration on Combating IUU Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products" with the main objective of enhancing regional cooperation in sustainable fisheries development in light of the unification of the ASEAN Economic Community. After obtaining support and agreement during the Special SOM-36th AMAF (August 2015), the Joint ASEAN-SEAFDEC Declaration on Regional Cooperation for Combating Illegal, Unreported and Unregulated (IUU) Fishing and Enhancing the Competitiveness of ASEAN Fish and Fishery Products was adopted during the "High-level Consultation on Regional Cooperation in Sustainable Fisheries Development Towards the ASEAN Economic Community" in Bangkok, Thailand in August 2016 (**Box 13**). The Joint Declaration is envisioned to encourage all AMSs to implement the regional initiatives towards managing fishing capacity and combating IUU fishing in the Southeast Asian waters.

5.2 Management of Inland Capture Fisheries

Fish resources are renewable natural resources that can be used sustainably through rational exploitation which could be maintained under appropriate fisheries management measures. There are many successful examples of sustainable fisheries management in marine fisheries but the much needed systematic management measures in inland fisheries are still limited.

Fisheries management is defined as the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources, and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities to ensure continued productivity of the resources and accomplishment of other fisheries objectives (FAO, 1997). There are many measures and methods used to regulate the fisheries activities, especially in marine fisheries, *e.g.* regulating the mesh size and types of fishing gears, regulating the maximum number of fishers entering the fishing grounds, introducing closed seasons and areas, establishing fish sanctuaries, promulgating fisheries decrees, and so on. For inland fisheries in the Southeast Asian region, which could be closely related to the fishers' and fishing communities' livelihoods, management measures should be considered not only on the resources but also on the socio-economic aspects of the relevant stakeholders.

In the Southeast Asian region, there are many types of fisheries management measures that could be applicable for inland fisheries, *e.g.* co-management, community-based fisheries management, adaptive co-management, rights-based management, integrated management, government-based management, and Ecosystem Approach to Fisheries Management (EAFM). EAFM is one of the latest methods on managing fisheries activities with consideration given on the surrounding conditions around the fishery sector (Staples *et al*., 2014). Successful cases of the introduction of EAFM concept in marine fisheries could be adapted as appropriate, in inland fisheries.

Nonetheless, there are a variety of challenges that confront the promotion of inland fisheries management in the Southeast Asian region. These include lack of data and information, environmental degradation, overexploitation of resources and habitats, rapidly increasing population, and increasing demands for fish and freshwater. These challenges should be addressed while awareness building on the value of inland fisheries and inland waters in this region should be intensified and continued.

5.3 Responsible Fishing Practices

5.3.1 Management and Reduction of By-catch from Trawl Fisheries

In the Southeast Asian region, there have been discussions and debates over the need to reduce by-catch from fishing activities, particularly in trawl fisheries where catch is multi-species, and the amount of by-catch could be as much as or even more than the target species. There are also evidences of decreasing average sizes of landed fish and declining Catch Per Unit Effort (CPUE) demonstrating that overfishing occurs in several trawl fishing grounds in the region. Moreover, conflicts between fleet segments also commonly occur when zoning regulations are not enforced, *e.g.* larger trawlers encroaching on waters reserved for small-scale fishers. In Southeast Asia, although catch from trawl fisheries tends to be fully utilized and the concept of by-catch may not be fully relevant, it could be observed that some parts of the catch may be considered undesirable due to the poor quality and inadequate management.

By definition, by-catch is the catch of fish or other aquatic animals and plants that a fisher does not intend or want to catch, does not use, or which should not have been caught in the first place. However, in most of the region's fisheries, the latter part of the definition is more relevant than the former since it includes catch of juveniles of commercial species. A wide range of problems on by-catch have emerged in specific fisheries, including the capture of species that are protected, endangered or threatened, as well as juvenile fish. In some fisheries sectors, there is an increasing trend towards retention of by-catch consisting of juveniles and small-sized fish for human consumption or for utilization as aquafeed. Therefore, there is a need to address the by-catch and discard problems in the Southeast Asian region.

Several research and development programs have been established to support management options for trawl fisheries and reduction of by-catch, *e.g.* fishing gear and practices selectivity, area-season management, control of fishing effort or fishing capacity, enhanced data collection (data at landing sites and onboard fishing vessels, mapping of fishing ground characteristics; and development of socio-economic procedures to monitor the management impacts). In support of by-catch management, the FAO International Guidelines on Bycatch Management and Reduction of Discards were developed and adopted for the promotion of responsible fisheries by minimizing the capture and mortality of species and size, and provide guidance on measures that contribute towards more effective management of by-catch and reduction of discards.

Based on the International Guidelines on Bycatch Management and Reduction of Discards (FAO, 2011), a range of tools could be used to manage by-catch. These include:

- Input and output control (*e.g.* fishing capacity and effort control catch quotas)
- Improvement of design and use of fishing gears and by-catch mitigation devices
- Spatial and temporal measures
- Limits and quotas on by-catch
- Ban on discards (provided retained catch is utilized in manner that is consistent with the Code of Conduct for Responsible Fisheries)
- Incentive for fishers to compile with measures

To address the issues on by-catch from trawl fisheries, SEAFDEC collaborated with FAO since 2002, to implement the Project "Reduction of Environmental Impact from Tropical Shrimp Trawling through the Introduction of Bycatch Reduction Technologies and Change of Management" or "REBYC." The Project aimed to reduce capture of immature or juveniles of commercial species; and the harvest of other by-catch fish and non-fish species, *e.g.* turtles, sharks, marine mammals, and others. An important output of this Project was the development of Turtle Excluder Device (TED) together with enhanced awareness on responsible trawl fisheries. The Juvenile and Trash Excluder Devices (JTEDs) were also developed by SEAFDEC and promoted for application in the Member Countries. However, it was also recognized that modifications of fishing gear and practices alone would not be adequate for effective management of by-catch, as this needs to be supported by appropriate legal and incentive frameworks.

To continue the momentum on reduction of by-catch from trawl fisheries, the second phase of REBYC was implemented during 2012-2016 with the objective of contributing to more sustainable use of fishery resources and healthier marine ecosystems by reducing by-catch, discards and fishing impacts from trawl fisheries. This was carried out with the full recognition that the concept of trawl fisheries management should not be developed solely based on fishery perspectives but also from the holistic point of view taking into consideration the interaction among issues on trawl fisheries, *e.g.* fisheries resources, habitat, economic and social culture. Thus, the principles of EAFM were therefore promoted in trawl fisheries.

Considering that the various stakeholders engaged in trawl fisheries have varied objectives, the stakeholders' identification, prioritization, and engagement were among the first challenges that were addressed for the successful implementation of EAFM in trawl fisheries. Through stakeholders' engagement and looking at issues in trawl fisheries from the holistic viewpoint, integration of several management measures and tools were recommended in order to come up with regional strategy for by-catch management as well as area-specific management plan. Such measures and tools include:

- Gear-related measures, *e.g.* selective fishing gear and practices
- Area-based measures, *e.g.* zoning of fishing areas, spatial-temporal closure
- Obtaining better data on number of vessels, and recommendations for fishing effort and capacity management
- Identification of incentive packages to promote more responsible fishing

Furthermore, in order to deal with various stakeholders with multiple objectives, co-management has been applied along with the management plan, from implementation to monitoring, evaluation, and planning adaptation. In order to support management options in trawl fisheries management, it was also recommended that scientific studies and research works, *i.e.* on fishing gear and practices selectivity, area-season management, control fishing effort or fishing capacity, should be carried out. Catch data collection, *e.g.* at landing sites and onboard fishing vessels, and mapping of fishing ground characteristics, and establishment of socio-economic monitoring procedures are important processes to monitor the result of management. Standardized methods for catch and by-catch data collection should therefore be developed. Activities to support, not only adequate but also accurate data collection, are necessary and important to the SEAFDEC Member Countries. This is considering that the major hindrance encountered by some Member Countries is the inadequate support of national policies in developing data collection activities to obtain the necessary data set, which could be due to less priority or less concern given on data collection. Stock assessment is also a very important

tool to determine the abundance of the fishery resources, and research studies on socioeconomics and incentives in trawl fisheries should also be undertaken.

Nevertheless, since research works by researchers alone may not generate acceptance from the fishers and stakeholders, collaboration with fishers is therefore necessary in order to fill the gaps in their indigenous knowledge. Promotion, awareness building on trawl fisheries management issues and how they relate to sustainability, as well as the measures available to make fishing more responsible comprise another important part of the by-catch management story. Private sector, fishers, policy makers, fisheries managers, officials, extension officers, and NGOs should therefore be provided with necessary training through workshops to enhance their knowledge on the best management practices and responsible trawl fisheries. In addition, IEC materials should also be developed to support trawl fisheries management for sustainable utilization of the fishery resources.

5.3.2 Optimizing Energy Use in Fisheries and Reducing Carbon Emission

Despite the importance of fish and fishery products for food security and well-being of people, the global fisheries production has been at risk of being unsustainable because fuel which is one of the most important inputs in fishing, has become costly and unaffordable for most small-scale fishers engaged in capture fisheries. During the past decade, drastic fluctuation of global oil prices could be observed (**Figure 75**), and such changes are caused by the demand and supply conditions for oil as well as other factors such as the changing policies and geopolitical tensions within the Organization of the Petroleum Exporting Countries (OPEC), which are beyond the control of the fisheries sector.

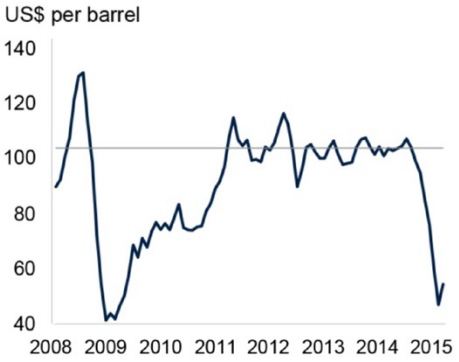

Figure 75. Recent development in oil price
Source: *World Bank, 2015*

Considering that the rising fuel prices have generally outpaced the increase in fish prices (Gulbrandsen, 2012), it has become difficult to offset the difference without landing more fish per unit of fuel used or reducing other fishing operation costs. Subsequently, the profitability of fishing operations in Southeast Asia is under threat, putting the sustainability of livelihoods of fishing families, communities, and others relying heavily on wild-caught seafood, in peril.

In order to reduce the impacts from changes in oil price to the profitability of fisheries sector, technologies to optimize energy use in fisheries are therefore necessary. One of the regional initiatives launched in late 2013 was the FAO-SEAFDEC "Fishing Vessel Energy Audit Pilot Project." The Project was meant to address the concerns not only on high and variable fuel costs but also on the associated greenhouse gas emissions from the commercial fishing industry. With particular focus in Thailand, the Project evaluated the fuel consumption of single-boat trawl fleet and identified the potential fuel savings through energy efficient fishing operations and practices.

The results of the Project indicated that fuel cost could range from approximately 35% up to more than 90% of total expenditures of trawling operations, small or large trawlers. Fuel consumption rate also depends on the engine's rotational speed (revolutions per minute or rpm) and speed in free-running or steaming condition, as well as on the use of refrigerating machinery. In addition, differences in hull design and propulsion systems also form part of the contributing factors. Based on the initial assessment from at-sea data collection, judicious use of engine's rpm is a key for reducing fuel consumption in fishing operations. This factor also provides immediate fuel savings and requires no installation cost as many trawlers are already equipped with tachometer. Another relatively inexpensive option is the installation of fuel flow meter which allows fishers to analyze the relationship between the engine's rpm and fuel consumption. In most cases, fishers are often surprised by how much fuel could be saved through modest throttle adjustments.

For other types of vessels and gears that are common in the Southeast Asian countries, the energy use pattern and energy saving options are summarized in **Box 14**.

The issue on high consumption of fuel by the commercial fishing industry is also a big concern because of its link to greenhouse emissions and climate change. According to Tyedmers *et al*. (2005), the global commercial fishing industry produces approximately 1.7 metric tons of greenhouse gas emissions for every 1.0 metric ton of live-weight seafood, and is responsible for just over 1% of greenhouse gas emissions from all sources combined. It has also been established that the boat's carbon footprint is directly proportional to the amount of fuel burned, *i.e.* one gallon of gasoline (approximately 3.79 L) could generate a carbon footprint of about 9 kg CO2 (IPCC, 2009).

Box 14. Energy use pattern and energy saving options for some types of fishing operation

Fishing operations	Energy use pattern	Energy saving options
Trawling	Most fuel is used for dragging of trawl along the bottom (bottom trawling) or above the bottom (pelagic trawling). Less fuel is used for going to and from fishing grounds.	• Modify the trawls and trawl boards • Install the highest gear reduction available and a large diameter propeller with a propeller nozzle (depending on stern aperture) • Install advanced fish-finding equipment • Consider a changeover in fishing method to pair trawling or Danish seining
Passive fishing methods (*e.g.* gillnetter and longliner)	Most fuel is used for travelling to and from fishing grounds. The setting and hauling of passive fishing gear can be done with human power or low engine power using mechanical or hydraulic haulers.	• Reduce service speed • Keep the hull free from fouling • Use high gear reduction and an efficient propeller • Changeover from a petrol outboard engine to diesel engine
Trolling	Fuel is used both for traveling and for fishing.	• Changeover to diesel engine • Reduce service speed (except when fishing for tuna which require high speed) • Keep the hull free from fouling • Install a high gear reduction and large diameter propeller
Purse seining	Most fuel is used for going to and from fishing grounds and searching for fish.	• Reduce service speed • Install advanced fish-finding equipment • Keep the hull free from fouling • Install a high gear reduction and large diameter propeller

Source: *Gulbrandsen, 2012*

Box 15. Ways and means of reducing the use of fossil fuel in fisheries

Hull design

Reduction in engine power can be achieved by increasing the length of the waterline (LWL), making it possible to obtain a sharper bow and thereby reduce the resistance when other dimensions are kept the same. Although the weight of a boat itself is increased by the prolonged length, the overall effect on the hull resistance is beneficial. A limiting factor is the increased cost of the hull, which must be balanced against the fuel saving. Reducing the boat weight and utilization of sustain boat displacement should also be considered.

Engine power and operation range

Engine power refers to the way power delivery is measured. Usually, for fishing boats only the rating power is continuously measured. An internal combustion engine does not operate at its peak throughout the whole range of rpm of output. From a specific fuel consumption curve, the specific fuel consumption in the range 70-80% of maximum rpm shows that an engine burns fuel most efficiently.

Engine design

• ***Economical engine power and optimized fuel consumption***

The accepted guidelines for trawlers on economical engine power to reduce fuel consumption for small fishing vessels, suggested that a vessel should not be equipped with engines larger than 5 Hp/tonnage displacement (continuous duty DIN 6270 "A") and that it should be operated in service condition at about 3 Hp/tonnage actual output at maximum of about 80% rpm.

• ***Power margin definition***

Power margin is the excess capacity of a propulsion engine for sailing a boat at designed service speed. Therefore, it is necessary, but the question is how big such power margin should be. The recommended optimized margin requires about 1.6 to 1.7 of continuous rating power.

• ***Definition of engine size***

Engine power used for fishing boats is defined as the ship's displacement at service condition speed multiplied by economic service rate power per ton and margin power.

• ***Reduction of gear and propeller***

It is clear that a large reduction gear ratio can contribute to considerable fuel saving while the boat speed is kept constant. Higher thrust is available by adopting larger reduction ratios while fuel saving is in the inverse proportion to speed. In this case, higher reduction gear ratio means larger propeller diameter and increased draught. In shallow harbor entrances, this might be a limiting factor unless a certain type of limiting propeller is used. As a general rule, the maximum available reduction gear ratio should be chosen.

Engine operation and maintenance

When an engine is badly operated or not well maintained, loss in efficiency will be as high as 30% to 40%. Thus, it is necessary to operate the engine at properly maintained condition, such as maintaining the engine at ambient temperature through the use of cooling systems and ventilations. Cleaning operation of the engine must be carried out by replacing injectors or filters, and strainers regularly, and performing engine periodical check maintenance and inspection of the transmission system. Most especially, lubrication oil must be changed at certain grades and at intervals recommended by the engine manufacturer. To avoid dirt and water contaminating the fuel, an extra fuel oil filter and a water separator should be installed between the daily fuel tank and the engine.

Box 15. Ways and means of reducing the use of fossil fuel in fisheries (Cont'd)
Modification of fishing gear and methods The amount of fuel used to catch and land a metric ton of fish varies greatly with the type of fishing gear and methods as well as the fish resource including the distance to fishing grounds. The strength of the fish source (good fishing grounds) is of major importance in terms of fuel use. A poor resource or poor fishing ground means more fuel used per metric ton of fish landed.
Alternative fuel use Alternative fuels to petro-diesel include bio-diesel, LPG, LNG, CNG, ethanol, and hydrogen. A right choice of fuel may reduce fuel costs and improve business liability, as well as reduce greenhouse gas emission. This issue could have a bearing on the net cost of converting an alternative fuel (Sterling and Goldsworthy, 2006).
Alternative energy use Utilization of alternative energy relates to moving away from the use of chemical energy in the form of fuel and the conversion of the heat of combustion into mechanical work using a heat engine. Among the alternatives that have practical possibilities are wind, solar, and wave energies. However, there are two issues related to harnessing such energy, namely: collection and conversion of the energy to more usable form and storing the energy until it is required in fishing operations. For all these forms of energy, it seems unlikely that either or all of them combined would be able to satisfy the total energy demand of a typical fishery operation at least in the foreseeable future. Nonetheless, utilization of both wind and solar energy in fishing could be easily conceptualized based on the already proven and well-known technologies, although the practicalities and performance of such systems on fishing boats would depend on the exact application of the correct or emerging technologies used. Nevertheless, the utilization of wave energy could not yet be easily conceptualized as of the moment.

Source: *Chokesanguan, 2011*

It is therefore necessary for the fishery sector to explore and adopt energy saving technologies and practices that reduce reliance on fossil fuel and eventually achieve improved national financial economy. Toward this end, fuel and energy source alternatives should be identified while R&D on environment-friendly and efficient capture technologies should be pursued. Projects have already been initiated in the Southeast Asian region concerning measures to reduce fossil energy dependence in capture fisheries. There are many ways of reducing the use of fossil fuel in fisheries and fishing operations as shown in **Box 15**.

Involvement of and awareness-raising in addressing issues on energy use in fisheries, especially on the part of the private sector, should continue to be enhanced with the objective of reducing the use of fossil fuels in fishing operations. Meanwhile, relevant programs should be promoted in collaboration with concerned institutions including the academe, NGOs, research institutions, especially in developing advocacies relative to minimizing the contribution of fisheries to climate change.

5.4 Community-based Fisheries Management Approach

The coastal and inland areas of Southeast Asia provide the means of livelihood to coastal and inland dwellers, where hundreds of thousands of coastal and inland families are directly engaged in fishing activities and aquaculture including related activities such as fish processing, marketing, boat building, and net making, among others. The fishers' overdependence on the coastal fishery resources without appropriate rescue management, however, leads to overexploitation and degradation of the resources. Conflict on the multiple-use of the resources also threatens the livelihoods of dwellers in coastal fishing communities. In addition, communities have to pay more for fuel, food, and services, while the income generated from their production activities remains low. Unsustainable utilization of the fishery resources by coastal dwellers is one of the reasons that drive fishers in coastal communities to continuously intensify their fishing efforts to sustain their livelihoods.

Confronted with degrading fishery resources and without having any knowledge of appropriate resource management, coastal dwellers have to cope with low living standard and poverty. Considering that many fishing communities are outside of any social safety net systems that may exist in other areas of a country, it has become urgent to strengthen community fisheries organizations and build capacity for better development and management of the coastal and inland fishery resources and sustain the livelihoods in coastal communities. It is indeed important that appropriate coastal resource management and stable alternative livelihoods should be put in place.

Appropriate resource management is an indispensable activity that keeps fishery resource utilization sustainable. Autonomous resource management by community fishers' groups is the most effective and efficient way rather than the top-down management of coastal and inland fisheries by the government. However, community fishers alone can hardly establish and implement community-based resource management (CBRM) without governments' support and initiative.

In 2014, the ASEAN Regional Workshop for Facilitating Community-based Resource Management in Coastal and Inland Fisheries was organized in Phnom Penh, Cambodia to review the national activities on fishery resource management in coastal and inland fisheries, and share the