FISH for the PEOPLE

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Advancing Sustainable Fisheries Management in Southeast Asia

SEAFDEC Southeast Asian Fisheries Development Center

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Editorial

FAO has adopted a working definition of fisheries management, which refers to "*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 in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives*." Guided by such principles of fisheries management, the Southeast Asian Fisheries Development Center (SEAFDEC) has been implementing programs and projects in the Southeast Asian region that aim to promote fisheries management in the whole fisheries value chain for the sustainability of the region's fisheries sector. The efforts of SEAFDEC to promote sustainable fisheries management in the region was triggered by the adoption of the FAO Code of Conduct for Responsible Fisheries (CCRF) by its member states in 1995. To enable the Southeast Asian countries to adopt the CCRF, SEAFDEC initiated in 1998 its program on the Regionalization of the CCRF (RCCRF) with generous support from the Government of Japan through the Japanese Trust Fund in SEAFDEC. Under the framework of the CCRF, the RCCRF took into consideration the specific regional concerns of Southeast Asian fisheries and came up with a series of four Regional Guidelines for Responsible Fisheries in Southeast Asia, one of which focused on Responsible Fisheries Management.

Since its publication by SEAFDEC in 2003, the Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Fisheries Management has facilitated the formulation and implementation by the ASEAN Member States (AMSs) of national codes of practice for responsible fisheries management. This is because the Regional Guidelines has addressed the issues and concerns with respect to small-scale fisheries as well as coastal fisheries that prevail in the Southeast Asian region, and also clarified the specificity of the region's fisheries in terms of culture and structure, and the scenario of the Southeast Asian ecosystems.

Included in this issue of the Special Publication *Fish for the People* are few of the many articles that summarize the continuing effort of SEAFDEC in advancing the sustainable management of the region's fisheries. Established from the recent programs and projects of SEAFDEC, these articles add up to what SEAFDEC had already amassed while discharging its long-term commitment of ensuring the sustainable development and management of the region's fisheries and coastal resources.

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CONTENTS

Regional Initiatives

- Showcasing the Application of Ecosystem Approach to Fisheries Management: a case study in Nainang Village, Muang Krabi, Thailand 2
- Strengthening the Capacity of Local Communities for Fostering Community-based Resources Management/Co-management: a case study in Khammouane Province, Lao PDR 8
- Benchmarking the Adoption of Fish Enhancing Devices in Southeast Asian Waters: the coastal waters of Thailand in focus 12
- Upgrading the Purse Seine Fishing Vessels to Promote Responsible Fishing Operations: a pilot study in Pattani Province, Thailand 18
- Boosting the Traceability of ASEAN Fish and Fishery Products through the eACDS 23
- Towards Reviving the Production of Philippine Native Aquatic Species 29

Special Reports

- Development of Albacore Tuna Fishery and Estimation of Allowable Biological Catch for Resource Management in the Indian Ocean 34
- Utilization of the tropical almond tree leaves in aquaculture 41

Calendar of Events 44

Call for Articles

FISH for the PEOPLE is a policy-oriented special publication of SEAFDEC. Now on its 17th year, the Publication is intended to promote the activities of SEAFDEC and other relevant fisheries concerns in the Member Countries. We are inviting contributors from the SEAFDEC Departments, Member Countries, and partner organizations to submit articles that could be included in the forthcoming issues of the special publication. The articles could cover fisheries management, marine fisheries, aquaculture, fisheries postharvest technology, fish trade, gender equity in fisheries, among others. Written in popular language and in layman's terms for easy reading by our stakeholders, the articles are not intended to provide detailed technical and typical scientific information as it is not a forum for research findings. Please submit your articles to the Editorial Team of Fish for the People through the SEAFDEC Secretariat at *fish@seafdec.org*. The article should be written in Microsoft Word with a maximum of 10 (ten) pages using Times New Roman font 11 including tables, graphs, maps, and photographs.

FISH for the PEOPLE is a special publication produced by the Southeast Asian Fisheries Development Center (SEAFDEC) to promote sustainable fisheries for food security in the Southeast Asian region.

Showcasing the Application of Ecosystem Approach to Fisheries Management: a case study in Nainang Village, Muang Krabi, Thailand

Panitnard Weerawat and *Parnpan Worranut*

The FAO Code of Conduct for Responsible Fisheries (CCRF) sets the principles and international standards of behavior and practices to ensure effective conservation, management, and development of living aquatic resources, with due respect for the ecosystem and biodiversity (FAO, 1995). As stated in the CCRF, "the purpose of the ecosystem approach to fisheries is to plan, develop, and manage fisheries in a manner that addresses the multiple needs and desires of societies without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems." While specifically focusing on fisheries, the ecosystem approach to fisheries (EAFM) is concerned with the relationship between fishing activities and the ecosystem as a whole, including the social and economic implications, as well as management requirements. Moreover, it also considers non-target species, endangered species, minimizing waste and pollution, biodiversity, and welfare of coastal communities, small-scale fisheries and subsistence fishers. Overall, EAFM "strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within meaningful boundaries" (FAO, 2003).

An EAFM is a practical, participatory way to manage fisheries by continually striving to achieve a balance between ecological well-being and human well-being through good governance. FAO defines an Ecosystem Approach to Fisheries (EAF) as "an approach to fisheries management and development that strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to management of fisheries within ecologically meaningful boundaries" (FAO 2003). It endeavors to plan, develop, and manage fisheries in a manner that addresses the multiple needs and desires of diverse stakeholders and the broader societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems (Garcia *et al*., 2003; FAO 2003, 2012; Heenan *et al*., 2015). EAFM includes seven key principles that are in line with the CCRF (**Box 1**).

Box 1. Key principles of an Ecosystem Approach to Fisheries Management

Principle 1:	Good governance
Principle 2:	Appropriate scales (across ecological, socio-economic, temporal, and legal/jurisdictional levels)
Principle 3:	Participation with stakeholder involvement throughout the planning and management processes
Principle 4:	Multiple objectives of different stakeholder groups
Principle 5:	Cooperation and coordination across sectors/groups/institutions and management levels (*e.g.* regional, national, provincial, municipal, and village)
Principle 6:	Adaptive management
Principle 7:	Precautionary approaches to ensure that management is able to address threats under conditions of uncertainty over time

The Southeast Asian Fisheries Scenario

Most of the fisheries in the Southeast Asia region have declined, especially over the past 30 years. Conventional approaches to manage the target fish stocks and species in isolation from their supporting ecosystem have largely been ineffective and inequitable, and unable to address the challenges of complex multi-species and multi-gear fisheries as well as counter the impacts of illegal, unreported and unregulated (IUU) fishing. In addition, the reality that fisheries are dependent on ecosystems affected by both natural and anthropogenic factors is oftentimes ignored, considering the wide range of societal objectives for fishery resources and marine ecosystems among diverse stakeholder groups. Therefore, the need for more effective and equitable management that balances ecological well-being and societal benefits has become very evident in order to ensure the long-term sustainable uses of the fishery resources. Such management measures need to take into account good governance and ecosystem dynamics of which people are involved with very important roles in the management.

Since the ASEAN Member States (AMSs) are signatory to the 1995 FAO Code of Conduct for Responsible Fisheries which calls for the promotion of an Ecosystem Approach to Fisheries Management (EAFM), the AMSs also considered it important to promote the EAFM concept in the region, as demonstrated by their adoption of the ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020" (SEAFDEC, 2011). Specifically, Resolution (RES No. 6) encourages SEAFDEC and the AMSs to "*Implement effective management of fisheries through an ecosystem approach to fisheries that integrates habitat and fishery resource management aimed at increasing the social and economic benefits to all stakeholders, especially* *through delegating selected management functions to the local level and promoting co-management as a partnership between government and relevant stakeholders*,” while Plan of Action (POA No. 8) directs SEAFDEC and the AMSs to “*Accelerate the development of fisheries management plans based on an ecosystem approach, as a basis for fisheries conservation and management*,” and (POA No. 10) to “*Establish and implement comprehensive policies for an ecosystem approach to fisheries management through effective systems (i) to provide licenses to fish (boats, gear and people); (ii) for community fishing rights/ rights-based fisheries; (iii) that provide for the development of supporting legal and institutional frameworks; (iv) encourage and institutional cooperation; and (v) that aid in streamlining co-management*.” In this regard, SEAFDEC in collaboration with other regional and international organizations has promoted the EAFM concept in various ways to enable the AMSs to practice sustainable and responsible fisheries in their respective countries and across the Southeast Asian region.

Figure 1. EAFM pilot site in Cambodia (between Prey Nup 2 in Sihanoukville Province and Trapeang Ropov in Kampot Province)
Source: Google maps

Piloting the EAFM Concept in Selected AMSs

With support from the Japanese Trust Fund (JTF), the SEAFDEC Training Department (SEAFDEC/TD) implemented the project “Human Resource Development for Sustainable Fisheries” in 2013-2019, to address the priority actions stipulated in the ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020. Through this Project, the concept of an EAFM has been promoted in pilot sites in the AMSs, *i.e.* in Cambodia, Lao PDR, Myanmar, and Thailand. At the end of the Project implementation, key successes were achieved that include: 1) establishment of EAFM core team in the concerned countries; 2) integration of EAFM in fishery management plans at community level; 3) enhanced ability of EAFM core team to organize EAFM training courses in their respective countries; 4) strengthened capacity of fishery officers in conservation of the ecosystem; and 5) broader coverage of fisheries management in respective countries, *i.e.* the environment, stakeholders, alternative livelihoods, and governance. The lessons learned from the pilot sites are summarized below, with the impacts of the adoption of the EAFM concept in the pilot site in Thailand provided with more details.

Cambodia

The implementation of EAFM in Cambodia started in 2017 with the training course on EAFM for officers of the Fisheries Administration (FiA) organized by SEAFDEC/TD. The pilot site was between Trapeang Ropov in Kampot Province and Prey Nup 2 in Sihanoukville Province (**Figure 1**), and co-managed by the two provinces. The fishery resources in the pilot site include fish, blue swimming crab, sea grass, blood cockle, and mangroves, and the major fishing gears operated by fishers are crab trap, mullet gill net, gill net, and push net. The area also serves as habitat for endangered species such as dugong, sea turtles, and sea horses. Prior to the promotion of the EAFM concept, the pilot site in Cambodia was confronted with ecological issues and concerns, *i.e.* destruction of mangrove areas due to the operation of trawls in shallow waters and sea grass beds, coastal development, and aquatic pollution; as well as declining fishery resources because of the increasing number of fishers and rampant use of destructive fishing gears.

In human dimension, the fishers in the pilot site had been earning low income considering that the prices of fish are often dictated by middlemen, while fishers do not have alternative livelihoods to fishing, and their skills are inadequate to perform other jobs aside from fishing. In addition, fish processing and market facilities had also been inadequate. In terms of governance, law enforcement had been ineffective to reduce IUU fishing mainly due to insufficient budget to address the issues concerning IUU fishing, cooperation among stakeholders had been weak, and knowledge of fishers about the fisheries laws and regulations had been very limited. As a result, participation and capability of fishers in fishery resource management was very inadequate.

Lao PDR

From 2015 to 2017, several training sessions on EAFM concept were conducted by SEAFDEC/TD for the fisheries officers in Lao PDR. The pilot site was in Aung Nam Kadun Reservoir established in 2001 in Paksan District, Bolikhamxay Province (**Figure 2**) with an area of 53 km^2. The Reservoir is surrounded by seven villages, namely: Nasavanh, Pakadun, Phongnam, Thana, Nahouaphou, Phonesavang, and Hatxaykhoun. The total population of the seven villages was 4,139 involving 817 households and 232 fishers.

Figure 2. EAFM pilot site in Lao PDR (Ang Nam Kadun Reservoir, Paksan District, Bolikhamxay Province)
Source: Google maps

Before the promotion of the concept of EAFM, the pilot site was confronted with several ecological problems that include declining fishery resources because of rampant destructive fishing practices (*e.g.* use of dynamite and poison (cyanide), electric fishing), frequent occurrence of flooding, and increasing number of fishers. In human aspects, fishers in the pilot site were faced with issues and concerns that include low income because of low fish catch and inefficient marketing system. In governance, the pilot site experienced insufficient human resources, ineffective fisheries regulations and management measures, and low awareness of communities on fisheries and management measures.

In an effort to address the said concerns, consultation meetings with local authorities and key stakeholders were convened by SEAFDEC/TD with the cooperation of the Department of Fisheries and Local Government of Lao PDR, resulting in the establishment of the Fisheries Management Committee (FMC). Meanwhile, the fisheries conservation zone (FCZ) in the Reservoir was also defined. The FMC mapped its plans that include installation of fish shelters in the FCZ using locally-available materials, promotion of fish stock enhancement in the Reservoir, as well as creation of alternative livelihood programs, *e.g.* fish culture and fish processing as alternative livelihoods. Nonetheless, the FMC would seek funding sources to be able to implement its plans.

Myanmar

The implementation of EAFM started with the training course on EAFM organized by SEAFDEC/TD in 2015 in the pilot site in Thahton Township, Mon State (**Figure 3**). This led to the establishment of the EAFM core team to facilitate the development of the Fisheries Management Plan.

Figure 3. EAFM pilot site in Myanmar (Thahton Township, Mon State)
Source: Google maps

The pilot site was chosen considering the several issues and concerns that confronted the area. In the ecological aspect, the area had declining fishery resources due to overfishing; and in human well-being, the fishers had low income due to decreasing fish catch and low market price, while the fishers had limited technical knowhow in adding value to fish and fisheries products. Moreover, there had been ineffective enforcement of fisheries regulations while the fishers' awareness of fisheries regulations was very limited.

When the EAFM concept was promoted in the pilot site, establishment of the mangrove plantation farm was initiated by the fishers, the women's groups were established as means of promoting alternative livelihoods and one of their projects was the installation of fish drying racks. Meanwhile, the EAFM Handbook was translated into the Myanmar language and disseminated to all stakeholders for increased understanding of the EAFM concept.

As a result, the fishery resources of the pilot site had improved, as well as the socio-economic condition of the communities. The awareness of local people on the fisheries regulations had been raised. After the project implementation in the pilot site, SEAFDEC was requested to conduct more EAFM trainings throughout the country.

Promotion of EAFM in Nainang Village, Muang Krabi, Thailand

The pilot site was located in Nainang Village in Muang Krabi District, Krabi Province (**Figure 4**) where people's lives depend on the ecosystem. Located beside the sea, Nainang Village is host to people practicing eco-friendly careers, such as fishers, rubber plantation caretakers, and palm gardeners. The Village also has an environmental conservation tourist program which is managed and serviced by the local people. However, in this Village, there existed a conflict between groups of people, such as the bamboo stake traps operators and the mackerel gillnet fishers, over the concerned issues on the proposed dismantling of the bamboo stake traps, prohibition of illegal fishing gear, and the overlapping fishing areas that resulted in decreasing aquatic animal resources and small-scale fishers' income. When the EAFM concept was introduced to the pilot site, the existing fisheries management plan of the Village was redesigned according to the EAFM principles to encourage the stakeholders to participate in fishery resources management. As a result, the conflicting atmosphere had cleared out and the people understood the adverse impacts of illegal fishing gear on the fishery resources. The concerned stakeholders have also recognized the importance of the Village's participatory fisheries management plan and are willing to take part in the implementation of the plan.

Figure 4. EAFM pilot site in Thailand (Nainang Village, Krabi Province)

Source: Google maps

Furthermore, some programs that had been partly implemented by various groups were revised following the EAFM principles. These include programs spearheaded by the Ban Nainang Product Processing Group, Bee Farmers Group, Local Thai Dessert Group, Integrated Farming Group, Thai Souvenir Group, Garbage Ban and Tree Bank, and Environmental Conservation Tourist Group.

Issues and Concerns

Enforcing a fisheries law (*e.g.* top-down management) to combat IUU fishing could not be an effective means of addressing the problems in the pilot site, especially that the use of illegal fishing gears had been rampant, the conflict between fishers using bamboo stake traps (**Figure 5**) and mackerel gillnets over the boundary of fishing grounds had escalated, and the operation of fishing gears had been overlapping beyond their designated areas of operation. It was in 1993 that the fishers came to recognize the fishery resource disaster that was happening in Ban Nainang community, *i.e.* the amount of resources had radically decreased that adversely affected the local artisanal fishers.

Figure 5. Bamboo stake traps considered as one of the illegal fishing gears in Nainang Village

Although the government sector attempted to address the problems, yet illegal fishing operations were still observed. After the core team of experts from the Department of Fisheries (DOF) of Thailand and SEAFDEC/TD promoted the EAFM principles in the Village, (*e.g.* increase participation, coordination, and precautionary approach), the issues and concerns have been dealt with successfully resulting in increased aquatic animal resources and clear atmosphere between the conflicting groups. More particularly, the issues and concerns grouped into ecological, human well-being, and governance (**Box 2**) had been addressed.

Box 2. Issues and concerns that were encountered by the fisheries stakeholders in Nainang Village		
Ecological	**Human well-being**	**Governance**
Bamboo stake traps, which have high potential to trap every size of aquatic animals, were set along the coastal area that led to the decreasing number of aquatic animals	Fishers continue to get low income	Ineffective enforcement of the law, as the boundary of fishing area was not clear, while the fishing ground for the fishers operating the bamboo stake traps and the mackerel gillnet, was overlapping that led to conflict between bamboo stake traps and mackerel gillnet fishers

Promotion of the EAFM Concept

The EAFM concept was introduced in the Village to address the issues and concerns that confront the fishers. This involved capacity building to increase people's participation, engagement, and coordination with key stakeholders, in decision-making process and setting up of a resource management plan. Through regular consultations, an agreement to comply with the fisheries law to combat IUU fishing was reached, and finally dismantling of the illegal bamboo stake traps was carried out. In addition, precautionary approach was adopted by designating the environmental conservation area for aquatic species, *e.g.* for blood cockles. Moreover, the regular organization of meetings and public consultations (**Figure 6**), and capacity building (**Figure 7**) led to enhanced knowledge and increased understanding of the related laws and community's regulations, and strengthened the relationship between the groups of people in the Village. The overall result was increased amount and diversity of aquatic animal resources in the pilot site that led to increased income of fishers. The local fishing community set up a community project plan (**Box 3**) that was supported by funds from the Government.

Figure 6. Public hearing of stakeholders on dismantling of the bamboo stake traps along the coastal areas of Nainang Village

Figure 7. Engagement of stakeholders in developing the fisheries management plan based on the EAFM process

Box 3. Community project plan developed by the fishing community of Nainang Village

- Area of conservation and rehabilitation for blood cockles: 10 rai
- Area of conservation and rehabilitation for wing shell: 50 rai
- Area of conservation and rehabilitation for mud crab and periwinkle: 500 rai
- Blue swimming crab bank: 2 branches
- Fish bank: 7 branches
- Fish stock enhancement program

Conclusion and Recommendations

Based on the experience in the promotion of EAFM concept in Nainang Village, strict law enforcement could not be immediately applied in any situation. The people should be allowed to adjust their mindset and attitude first before introducing any laws or regulations. Before interventions are introduced, it is necessary to know the whereabouts of particular communities, especially the community leaders, who would be tasked to acknowledge the problems that had been identified and who would serve as conduit to encourage the stakeholders to participate in the process of finding solutions to the problems. The success of EAFM promotion in Nainang Village could also be due to the long history of fisheries management implementation in Krabi Province that had already lasted for a decade. In the near future, the Provincial Government and DOF Thailand would extend and apply the EAFM concept to the whole Krabi Province.

Participatory stakeholders' engagement in co-management programs plays an important role in the promotion of the EAFM concept in Nainang Village, serving as basis of the adoption of the EAFM principles. This has made the application of EAFM in Nainang Village easy because the community plan developers just revised their fisheries management plans that have been implemented before. Changes were then made while other aspects were added following the EAFM framework.

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Strengthening the Capacity of Local Communities for Fostering Community-based Resources Management/Co-management:
a case study in Khammouane Province, Lao PDR

Thanyalak Suasi and *Isao Koya*

In the Southeast Asian region, it has been recognized that fishery statistics in coastal and inland fisheries are under-reported due to the multi-species nature of the fisheries and the large number of small-scale fishers. In order to address such concern, the ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Change Environment," which was adopted in 2011, includes provisions encouraging the ASEAN Member States (AMSs) and SEAFDEC to: (Resolution No. 11) *Enhance the awareness of the contribution that inland fisheries makes to food security and sustainable livelihoods, and include consideration of fisheries stakeholders when undertaking development projects that may impact inland fisheries*; (Plan of Action No. 11) *Adopt co-management at all levels and with all relevant stakeholders in the process of planning and policy formulation for management, conservation and rehabilitation of habitats and protective geographical features, as well as policy formulation on the use and management of natural and human resources to ensure that climate change responses are integrated into fisheries policy frameworks*; (Plan of Action No. 13) *Enhance and promote the participation of local communities, fisheries associations and other stakeholders in fisheries management and co-management*. In addition, communities should take part in fisheries and stock assessments by providing data, local ecological knowledge, and status of the stocks. Taking into consideration such provisions, the SEAFDEC Training Department (SEAFDEC/TD) implemented the project "Enhancing the Compilation and Utilization of Fishery Statistics and Information for Sustainable Development and Management of Fisheries in Southeast Asian Region: Facilitating Fisheries Activity Information Gathering through Introduction of Community-based Resources Management/Co-management" in 2013-2019 with funding support from the Japanese Trust Fund. The Project was meant to: improve the compilation of fisheries and socio-economic information on small-scale coastal and inland fisheries in the Southeast Asia; support the AMSs in applying CBRM/Co-management; and facilitate better understanding and enhance the knowledge of stakeholders on the condition of small-scale coastal and inland fisheries at national and local levels. Several activities were therefore implemented at pilot sites in selected AMSs, *e.g.* Lao PDR where training courses on CBRM/Co-management were conducted in the northern, central, and southern part of the country in order to support the fishery officers of the Department of Livestock and Fisheries (DLF). In this article, the activities in an inland fishing community as one of the Project's pilot sites, which is in Mai Nam Pakan Village in Hinboun District, Khammouane Province, Lao PDR, is discussed, especially on how the enhanced capacity of local people in managing the fishery resources has improved their incomes through the adoption of alternative livelihoods.

The inland waters in Lao PDR cover an area of more than 1.2 million ha and categorized into: 1) Mekong River and main tributaries and five north-eastern rivers; 2) large reservoirs or hydropower plants; 3) shallow lakes, natural pools, peat swamps, and wetlands; 4) irrigation reservoirs and irrigation weirs; and 5) rice-fields, small streams, and floodplains. These inland water ecosystems serve as capture fisheries resource for the people in local communities who consume fishery products as source of animal protein (Singkham, 2013).

Mai Nam Pakan Village in Hinboun District of Khammouane Province (**Figure 1**), as one of the Project's pilot sites, is located along the Nam Pakan River (**Figure 2**) which directly discharges into the Mekong River and inhabited by many important aquatic species. The village was established in 1992 and currently has a population of 435 people (234 females and 201 males) including 93 families who are mainly engaged in inland fisheries and agriculture. Baseline information were collected in the pilot site in December 2016 to gain better understanding of the condition and identify the main problems and needs of Mai Nam Pakan Village for the development of

Figure 1. Mai Nam Pakan Village in Hinboun District, Khammouane Province, Lao PDR
Source: Google maps

Figure 2. Nam Pakan River, Khammouane Province, Lao PDR

Box. Steps and processes in the establishment of Fisheries Management Committee (FMC) in accordance with the Fisheries Law of Lao PDR

1. Consultation meeting involving the local people and situation analysis on the roles, responsibilities, and benefits of FMC including the establishment of the fishery conservation zone (FCZ)
2. Election of Committee members assigned to three units: A) guidance and advice; B) regulation, control, and mediation; and C) security and patrolling
3. Drafting of the regulation and FCZ demarcation/mapping
4. Submission of the draft regulation and FCZ demarcation/mapping to District Office for approval
5. Public announcement of FMC establishment to all stakeholders through meetings and consutations (**Figure 3**)

the appropriate activities and work plan that are suitable to the local conditions. One of the findings from the information compiled is that most of the local people had low income while alternative livelihoods to augment such income had been very limited.

Establishment of the Fisheries Management Committee

In the Fisheries Law of Lao PDR, Fisheries Management Committee (FMC) serve as local fisheries management organization at the community level with corresponding roles and responsibilities established for specific water bodies such as rivers, reservoirs, community ponds, and wetlands. FMC indicates the need to enhance the participation of fishers to ensure that effective management of the fishery resources is promoted with the involvement of government authorities. The FMC in Mai Nam Pakan Village was therefore established taking into consideration the prescribed steps and processes (**Box**).

Figure 3. Fisheries Management Committee of Mai Nam Pakan Village *(top)* and Security and Patrolling Unit *(bottom)*

Fisheries Conservation Zone

The fisheries conservation zone (FCZ), established concurrently with the FMC, is located at the Nam Pakan River with an area of about 50,000 m^2 and length of around 1,000 m. Sign board (**Figure 4**) which indicates the regulation, prohibited fishing gears, penalty for illegal fishing, and map was installed at the Nam Pakan River as well as the marking signs that indicate the demarcation area of the FCZ. The FMC implemented surveillance activities by establishing the Security and Patrolling Unit consisting of four groups with 5-6 members in each group to monitor the illegal fishing activities in the FCZ, on rotational basis within 24 hours. The Project provided the equipment needed by the Security and Patrolling Unit such as boat with engine, binoculars, life jacket, camera, and torch.

Figure 4. The sign board for the fisheries conservation zone in Nam Pakan River

Fish releasing

The FMC members of Mai Nam Pakan Village, in collaboration with SEAFDEC, organized the fish releasing activity during the National Fish Releasing Day on 13 July 2018 to build the awareness of the community members on the need to conserve the fishery resources. The activity was attended by government officers, community members, fishers from neighboring villages, and students. Around 10,000 fingerlings of silver barb (*Barbonymus gonionotus*) were released into the FCZ in Nam Pakan River (**Figure 5**).

Figure 5. Fish releasing activity at the fisheries conservation zone in Nam Pakan River

Study tour for FMC members

Study tour was organized to strengthen the capacity of the FMC members of Mai Nam Pakan Village on the management of the FCZ (**Figure 6**). They visited Bolikhamsai Province to discuss fisheries management in FCZ with the FMC members of the Ban Don Xay Village and observe the FCZ in Pak Ka Ding River. The members of both FMCs shared and exchanged their knowledge and experiences on the management of FCZ. In addition, the FMC members of Nam Pakan Village also visited Nam Lo Village to observe the fish processing activities including the production of fermented fish, dried fish, and smoked fish.

Figure 6. Study tour of Fisheries Management Committee of Mai Nam Pakan Village in Bolikhamsai Province

Statistical, market, and fish species surveys

Statistical surveys were conducted to collect the data on fisheries catch from Nam Pakan River and to understand the status of the fishery resources in the River. The survey team, comprising the provincial and district fisheries officers and FMC members, interviewed the full-time and part-time fishers in 2017-2019. Fish market surveys were also conducted to understand the current fish marketing system and trend of fish prices in Khammouane Province. The provincial and district fisheries officers collected the data by interviewing the retail sellers of fresh fish and processed products in markets in Hinboon District and Thakhaek District, Khammouane Province in 2017-2019. Analysis of the data collected from both surveys is still ongoing.

In addition, survey on commercial fish species was conducted to identify the fish species caught from Nam Pakan River (**Figure 7**). The data which were collected from the local fish market near the village indicated that there are 49 fish species belonging to 15 families found in the River. The most diverse species belongs to the Family Cyprinidae (carps) with 22 species followed by the Family Bagridae (catfishes) with 9 species (Pattarapongpan, 2018).

Figure 7. Identification of commercial fish species at local fish market in Mai Nam Pakan Village

Promotion of fish processing techniques

In promoting alternative livelihoods to generate additional income for fishers, the FMC of Mai Nam Pakan Village established the women's fish processing group (**Figure 8**) in July 2018. The study tour for the group which was supported by the Project, took the women's fish processing group to Nakhon Phanom Province in Thailand to visit the Chaiburi women's group to learn various fish processing techniques. In return, representatives from the Chaiburi women's group were invited to Mai Nam Pakan Village to serve as resource persons for the training course on fish processing organized later. The training course covered lectures on the safe use of processing equipment (meat grinder machine and mix machine), raw materials, packaging, and group management (allocation of profit and recording of detailed information on the accounting logbook). The women's fish processing group started fish

Figure 8. Women's fish processing group established by the Fisheries Management Committee of Mai Nam Pakan Village

processing in December 2018 but encountered problems on teamwork and recording because of lack of experience, so the local fisheries officers and head of the village provided interventions and advice as well as assistance in the detailed recording of the operating costs and expenses, as well as income in the accounting book. The group had produced various products (*e.g.* dried fish, fish sauce, fermented fish in rice bran) sold in nearby markets. The group agreed to allocate their profit to FMC, group funds, and group members.

Promotion of aquaculture techniques

The FMC of Mai Nam Pakan Village established the men's aquaculture group (**Figure 9**) in July 2018. The training course on fish aquaculture technique was organized in May 2019 attended by the men's aquaculture group and community members. The resource person was from the Nam Xouang Aquaculture Center, Vientiane, Lao PDR who lectured on catfish culture including culture system, types of culture, fish feed, pond cleaning, and marketing. Moreover, culture of other species such as silver barb, Indian carp, common carp, as well as frogs was also introduced during the training. In November 2019, four cement ponds were constructed at the community center, with about 1,000 catfish fingerlings cultured in each pond. The group members share the responsibilities in feeding and cleaning the pond and agreed to allocate their profit to FMC, group fund, and group members.

Figure 9. Men's aquaculture group established by the Fisheries Management Committee of Mai Nam Pakan Village (above) and concrete ponds for catfish culture (right)

Way Forward

In order to promote the CBRM/Co-management concept in fisheries, the AMSs could apply the lessons learned from Mai Nam Pakan Village. For future CBRM/Co-management projects, the ecosystem approach to fisheries management (EAFM) and gender concepts would be integrated. Furthermore, SEAFDEC would emphasize on the importance of CBRM/Co-management in the development of regional fisheries policy frameworks, *e.g.* RES&POA 2030.

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Benchmarking the Adoption of Fish Enhancing Devices in Southeast Asian Waters: the coastal waters of Thailand in focus

Nopporn Manajit, Nakaret Yasook, Santiphong Putsa, Rattana Tiaye, Taweekiet Amornpiyakrit, Isara Chanrachkij, and *Virgilia T. Sulit*

The coastal waters of Southeast Asia are blessed with high productivity of fishery resources because of rich ecosystems such as dense mangrove forests and sea grass beds, as well as extensive coral reefs with clean tropical sea environment. These waters are critical to a broad range of aquatic organisms during their life cycle, *i.e.* from breeding, spawning, nursing to growing, hosting the feeding zones of aquatic species that are economically important, and serving as important source of recruitment of a wide diversity of fishery resources. However, most of the commercially important fishery resources in the coastal waters of the region had declined due to many factors that include overfishing, illegal fishing, destructive fishing practices, and environmental degradation. Fish aggregating devices, like artificial reefs had been established as significant tool for fishing ground development and for increasing the fish production from coastal areas, but the cost of installation of such devices is considerably high, especially in terms of investment, and necessitated that the management of such installations should be the responsibility of government agencies. Many artisanal fishers have therefore been adopting much cheaper types of resource enhancement devices and managing such devices by themselves with assistance from the public and private sectors.

Upon the adoption of the 2001 Resolution (RES) and Plan of Action (POA) on Sustainable Fisheries for Food Security in the New Millennium (SEAFDEC, 2001), and specifically following on the need to: "*work towards the conservation and rehabilitation of aquatic habitats essential to enhancing fisheries resources*" (RES#9), and to "*optimize the use of inshore waters through resource enhancement programs such as promoting the installation of artificial reefs and structures, encouraging coordinated and effective planning for coastal fisheries management programs, …*" (POA#4), SEAFDEC embarked on several programs and projects that aim to address overfishing and environmental degradation in the Southeast Asian waters, which include among others, programs on enhancing the coastal fishery resources through the development of strategies for the modification of coastal habitats to restore and increase their productivity (Ebbers, 2003). Modification of fishing grounds to increase fish production, *e.g.* installation of artificial reefs and other man-made structures has long been practiced in the Southeast Asian region for the rehabilitation and enhancement of degraded fish habitats. This article which focuses on the use of fish enhancing devices in Thailand (Manajit, *et al*., 2019), is based on the paper presented during the "International Conference on Fisheries Engineering 2019: Realizing a Healthy Ecosystem and Sustainable Use of the Seas and Oceans" organized by the Japanese Society of Fisheries Engineering, 21-24 September 2019, Nagasaki University, Japan.

From artificial reefs to fish enhancing devices

Various designs of the artificial reefs (ARs), also sometimes known as stationary fishing gear (SFG) or fish aggregating devices (FADs), had been developed and adopted in the Southeast Asian region with the main objective of enhancing the fishing grounds and improving fish production. Generally in Southeast Asia, however, the deployment and installation of ARs are the responsibility of the respective governments considering the high cost involved in construction, installation, and management of the ARs.

In Malaysia, for example, its ARs Program which is mainly under the Department of Fisheries Malaysia (DoFM) had been allocated a total budget of about 155 million Malaysian Ringgits (RM) from 1976 to 2010 (Ali and Sulit, 2012), where at the time of reporting USD 1.00 = RM 3.30. Such ARs Program is intended mainly for fishery use (conservation and fishing), as well as for non-fishery use (resource enhancement). Results from the monitoring of such ARs have indicated that the coastal fishery resources have been enhanced, as the ARs provide firm substrates for fauna and flora to grow. The ARs have also served as protection against encroachment of the inshore fishing grounds by trawlers (Ali *et al*., 2011). In order that ARs would continue to play the role of enhancing and conserving the fishery resources, it is necessary that proper management of the AR sites is sustained (Zainudin, 2016). Meanwhile, big ARs have also been deployed in the waters of Malaysia to eliminate trawler encroachments in nearshore areas while allowing more species of marine flora and fauna to settle outside and within big ARs (Ali *et al*., 2013).

In the case of Thailand, installation of ARs had been deployed in its coastal waters through the effort of the Royal Initiative Project on Coastal Fishery Resource Rehabilitation with the involvement of various stakeholders including the public and private sectors, and the academe, and making use of concrete pipes, concrete blocks, train cars, military tanks, and garbage trucks as ARs. Results of the monitoring carried out by the Department of Fisheries (DOF) of Thailand have shown that through the deployment of ARs, the fishery resources in Pattani and Narathiwat Provinces of Thailand had been restored. The DOF would continue to monitor the situation of the ARs to make sure that these structures attain the objective of contributing to the sustainability of the resources and improvement of the socio-economic conditions of fishing communities (Somchanakij *et al*., 2016).

In a study he carried out, Ali (2004) suggested that the actual combination of ARs and FADs would continue to allow the aggregation of several varieties of fish species. Introduced in the coastal waters of Peninsular Malaysia by researchers from the SEAFDEC Marine Fishery Resources Development and Management Department (SEAFDEC/MFRDMD) in collaboration with the Department of Fisheries Malaysia, this modified structure called the Artificial Reef Fish Aggregating Devices (ARFADs) had shown to be more durable and provide more stable and enriched fish habitats, so that ARFADs (**Figure 1**) is meant not only to aggregate multiple fish species but also to enhance the fishery resources in coastal areas. Although construction of ARFADs could also be costly because of the materials used but not as expensive as the big ARs, in the long run, it would still turn out to be more economical. In the development of ARFADs, expensive but durable materials are necessary, such as the anchor, line, and aggregating devices that are able to withstand strong wind, waves, and currents, and resist the corrosive action of seawater.

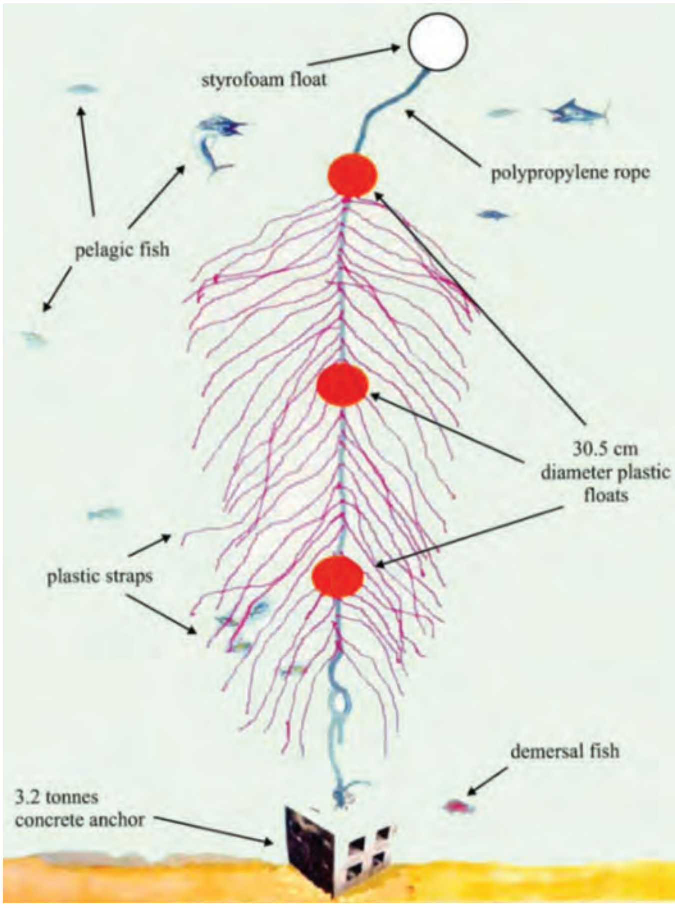

Figure 1. Suggested design of an ARFAD
Source: Ali (2004)

Generally, an ARFAD has three components: floats, attractors, and anchored mooring (**Figure 1**). The upper part of the structure, consisting of the floats, appendages and mooring line, is commonly referred to as a fish aggregating device. It is used to attract pelagic fishes because of the presence of attractors made of plastic strips and attached to the mooring line, also known as anchor line and made of polyethylene rope. The anchor line connects the floats to a heavy molded concrete anchor set at the bottom of the sea. This anchor not only keeps the FAD in position but also serves as an AR to demersal fishes.

ARFADs could therefore be effective for artisanal fisheries as fishing effort is relatively low, and once deployed in suitable sites, ARFADs could function like ARs turning unproductive areas into rich ecosystems that are beneficial to the fishing communities for subsistence fishing and recreational purposes. Nevertheless, in order to guarantee the sustainability of the ARFADs and ensure that their resource enhancement functions outweigh their contribution to resource harvesting, fishing effort must be strictly regulated in areas with ARFADs (Ali, 2004). The use of selective fishing gear, *e.g.* hook and line, is encouraged for catching the marketable sized fishes that have aggregated at the ARFADs.

Through the SEAFDEC/MFRDMD as well as SEAFDEC Training Department (SEAFDEC/TD), the task to explore the development of appropriate tools that would enhance the coastal fishery resources had continued through the years. Moreover, SEAFDEC also made sure that the awareness of stakeholders is enhanced, especially on community management of the fisheries that aim to, among others, shift the stakeholders' role from being resource users to resource managers through the installation of fish aggregating devices (FADs) that requires cheaper investment than artificial reefs.

Thus, the development of an innovative fisheries management tool had been explored in the Philippines and other countries in Southeast Asia including Thailand, which is a form of FAD and is known as fish enhancing devices (FEDs). Although the use of FEDs still involves the deployment of FADs in fishing grounds, fishing is regulated, if not totally prohibited, especially in the area of the FADs. Also called "floating artificial reefs," FEDs have additional structures other than those of the standard anchored FADs. Currently, many countries in the Southeast Asian region, *e.g.* Philippines, Malaysia, Indonesia, Thailand, have been adopting FEDs for fishery resources enhancement. **Table 1** summarizes the differences and similarities of the various structures used to enhance the fisheries habitats in coastal waters of the region.

FADs which are recognized as one type of ARs had been used to lure fish in large quantities and facilitate the efficient capture of fish. Placed at the surface or mid-depth of sea water, FADs which originated from small-scale fishers in the Oceanic-Pacific countries, where these are also called

Table 1. ARs, FADs, ARFADs, FEDs used in Southeast Asia: differences and similarities

	Function	Materials used	Installation area	Type
ARs[1]	• Enhance the resources (flora and fauna) • Aggregate demersal fishes • Create fishing ground • Serve as habitat protection	• Concrete, ferroconcrete • PVC • Tires • Fiberglass • Metal • Others	• Shallow water	• Bottom structures
FADs[1]	• Aggregate pelagic fishes • Create fishing ground	• Sticks • Plastic strips • Bundle of bushes or fronds • Canvas • Concrete block or drum, sandbag, rocks, stones	• Shallow to deep water	• Floating, anchored
ARFADs[1]	• Enhance the resources (flora and fauna) • Aggregate pelagic and demersal fishes • Serve as habitat protection	• Concrete for anchor • Plastic strips for attractors	• Shallow water	• Floating and anchored
FEDs	• Supporting buoy maintains buoyancy and provides marking • Attract fishes through polyethylene (PE) ropes attached to main line • Serve as habitat protection through the shades and hiding places provided • Sinkers and anchors fix the position of the structure	• Plastic buoys, floats, plastic gallons, etc. • Polypropylene (PP) rope • PE or PP rope (branch line, appendages), and PE net panels • Concrete block or drum	• Shallow to deep water	• Floating and anchored

[1] *Source: Ali (2004)*

"payao," are made of floating bamboo raft and anchored by weight under the raft. Tree branches and coconut palm leaves are used as fish shelter especially for small fishes and the big fishes are lured to feed on the small fishes. At present, "payao" is commonly used in the Philippines, Indonesia and Thailand, although this type of FADs varies in each country considering the locally-available materials used to make the FADs, *e.g.* bamboo, tree branches, coconut palm leaves. The most expensive parts of FADs are the anchors and chains.

In the Philippines, "payao" is placed at water depths of more than 2,000 m, and used to lure tuna, *e.g.* yellow fin tuna that are

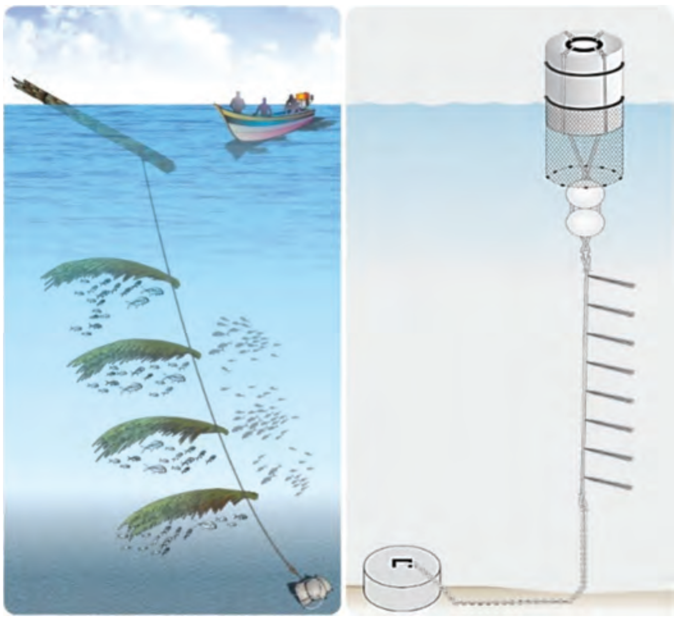

Figure 2. FADs *(left)* and FEDs *(right)*

then captured by purse seine. When SEAFDEC implemented the program "Rehabilitation of Fisheries Resources and Habitats/Fishing Grounds through Resource Enhancement" from 2001 to 2005, experiments were carried out on the suitable designs/models of the resources enhancement tools in collaboration with the SEAFDEC Member Countries. As a result, the program came up with a resource enhancement tool modified from FADs, which is now the so-called "Floating Artificial Reefs" or Fish Enhancing Devices (FEDs) for use in coastal areas (**Figure 2**). Thailand was reported to be the first Southeast Asian country to adopt the use of such FEDs.

Series of on-site training sessions on FEDs construction and installation had been carried out by SEAFDEC/TD since 2004, not only in the SEAFDEC Member Countries funded by the Japanese Trust Fund, *e.g.* Malaysia, the Philippines, Viet Nam, but also in the coastal areas of Thailand promoted and funded by the Department of Fisheries (DOF) of Thailand (*e.g.* Chonburi, Prachuab Kiri Khan, Chumporn and Phuket, Chanthaburi, and Trat Provinces) through the fishers' groups in the coastal zones. These sessions had provided the participants with the necessary information on FEDs that included the objectives, utilization, and methods of construction. The local fishers were also trained to monitor, manage the fishing activities near the FED areas, and repair the FEDs by themselves.

The training sessions also promoted the use of economical materials for FEDs, including used ropes and nets taken from abandoned fishing gears and nets for the accessory parts. This would make full use of discarded fishing equipment and reduce the cost of constructing the FEDs, an approach which is similar to the concept of constructing the traditional FADs that emphasizes on the use of locally-available materials. As a result, the utilization of FEDs with various designs has widely spread throughout the coastal provinces of Thailand.

Benchmarking the use of FADs in Thailand

In order to update the compiled information on the structure and design of FEDs, as well as the significant issues and concerns in FEDs construction and design in different types of fishing grounds, SEAFDEC/TD in cooperation with the DOF of Thailand conducted a survey on FEDs used in small-scale fisheries from October 2017 to January 2018, covering 47 fishing communities in 15 coastal provinces of Thailand, *i.e.* in the Gulf of Thailand and Andaman Sea (**Figure 3**). Coordinated by the Fisheries Provincial Officers, the survey was meant to obtain the general information on the FEDs installed in each province. Interviews with the local fisheries officers and fishers were carried out to obtain the necessary information including the designs, materials used, construction, installation areas, and utilization of FEDs. Photographs of existing FEDs were also taken and their dimensions measured.

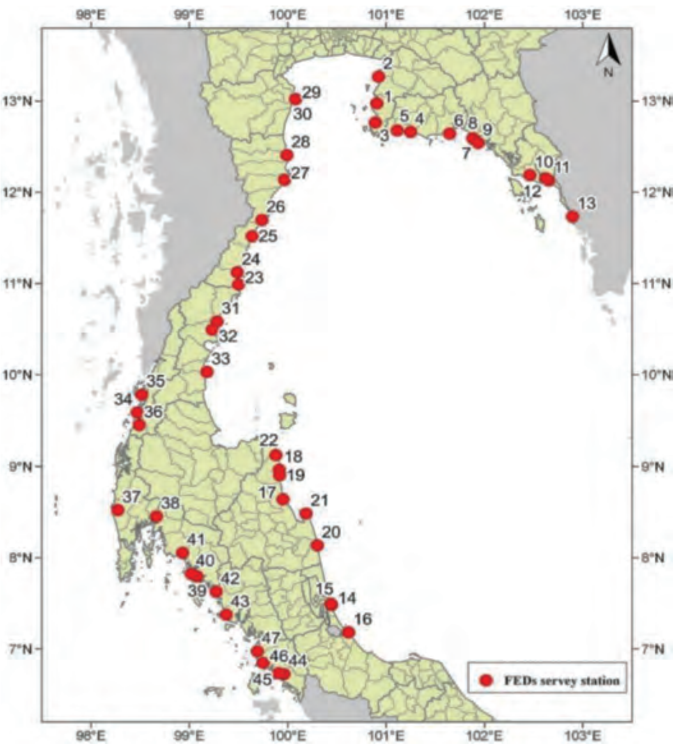

Figure 3. FEDs survey sites along the coastal areas of Thailand (indicated by red dots)

Results and Discussion

The results of the survey have confirmed that FEDs have been used by fishers as an innovative tool for fisheries management in the coastal communities of Thailand, and that the FEDs deployed were made of various materials and designs. The fishers' groups chose the patterns of their FEDs based on their artisanal fishers' wisdom, the objectives of installing FEDs, geography of the areas, water depth, and suggestions from supporting agencies, considering that the fishing communities received funding support from various agencies including private companies and government agencies, such as the Petroleum Authority of Thailand (PTT), Erawan Group, Amarin TV, DOF of Thailand, Department of Marine and Coastal Resources (DMCR) of Thailand, among others.

From the survey and actual observations, it was found that the FEDs were mostly placed in conservation areas at 0.1 to 1.6 nm away from the shoreline, and at water depths that range from 2 to 17 m. Moreover, it was also noted that the resource enhancing tools adopted in Thailand could be categorized into two types: the traditional FADs and the modern FEDs. For the traditional FADs, the materials for the buoy and attractor sections are made from locally available natural materials such as bamboo sticks which also function as buoy and marker, while coconut fronds or palm leaves are used as attractors and function also as provider of shades and hiding places for the fish. Although the materials used are low cost, these were found to be very effective in attracting fishes, but the life span of their use is only between 3 and 6 months. Furthermore, Anna *et al*. (1999) also reported that "palm leaves used in the traditional FADs provide less effective shelter than rope". The results from Ali *et al*. (2004) also indicated that the average lifespan of coconut leaves is 1-2 months. For the modern FEDs, instead of using natural materials, polyethylene, plastic or fiberglass materials are used for buoys. Although such materials contribute to high investment costs, their lifespan is longer compared with that of the traditional FADs.

Figure 4. Types of enhancing devices found in Thailand

Box 1. The types of enhancing devices used in Thailand (see **Figure 4**)

1. **Traditional FADs:** the attracting parts are made of natural materials such as coconut leaves, palm leaves and bamboo pole
2. **Anchored FEDs (Emerged type):** the attracting devices are synthetic rope (PE or PP rope)
3. **Anchored FEDs (Submerged type):** a kind of rope FEDs set up at mid-water layer or at a desired depth
4. **Pillar FEDs:** the attracting parts are made of synthetic rope tied up with a pillar and submerged to settle at seabed
5. **Other types of FEDs** including the AR-FEDs such as concrete pipe FEDs: could be either a single concrete pipe or multi-pipes, with or without attracting parts

In summary, various characteristics of FEDs with respect to the structure, design and installation were observed during the survey along the coastal areas of Thailand. These enhancing devices could be categorized into five (5) based on their patterns (**Figure 4** and **Box 1**).

From the survey, it was also observed that anchored FEDs were mainly found in 14 provinces (29 fisher groups) in the Gulf of Thailand and the Andaman Sea. The use of traditional FADs (No. 1) spreads over ten (10) provinces (19 fisher groups). Concrete pipe FEDs functioning as AR-FEDs (No. 2) were found only in 4 provinces (5 fisher groups) in the Andaman Sea, while the anchored FEDs submerged type (No. 3) were found in 3 provinces (4 fisher groups), and the pillar FEDs (No. 4) were deployed only in Trat Province (3 fisher groups). Moreover, in Trat Province, the fishers modified the design of FEDs to make these more suitable in the area considering the depth of the sea water. Furthermore, wrecked spirit houses and used motorcycle tires were also deployed as FADs and FEDs in Chumphon and Ranong Provinces, respectively.

From the results of the interviews with fishers, FEDs have been effective as tool to enhance the fishery resources and to protect the resources from the encroachment of destructive fishing gear into the coastal areas used by artisanal fishers for their fishing activities. Most fishers from the survey sites were satisfied with the presence of FEDs in their respective areas because the FEDs had remarkably enhanced and restored the coastal resources. The fishers also found aggregations of various aquatic species after the FEDs installation, *e.g.* barracuda, Spanish mackerel, black pomfret, longfin trevally, shortbody mackerel, yellowstripe scad, talang queenfish, fourfinger threadfin, groupers, snappers, catfish, including the blue swimming crab and splendid squid. Thus, the fishers are able to catch more fish to increase their income, while some fishers also earn additional income from carrying out eco-tourism activities like sports fishing and diving near the installed FEDs. Similar to the conclusion of Ali *et al*. (2004) that after a few years of the deployment of new design of FADs called "Artificial Reef Fish Aggregating Devices (ARFADs)," the FADs had turned into new habitats for many demersal fish species and sanctuaries of fish and other marine organisms. Furthermore, the fisher communities also observed that during the construction of FEDs, the cooperation among members of the fishers' groups had been strengthened. Therefore, FADs or FEDs would not only address resource deterioration but also ensure the sustainable livelihoods of coastal fishers.

Conclusion and Recommendations

Considering that the local fishers would be tasked to manage and maintain the FEDs, they should organize themselves into groups to take the leading role of regulating and controlling the use of fishing gear near the FEDs. Regulations should then be enforced that prohibit the irresponsible use of fishing gear and over-exploitation of the resources near the FEDs. This would also eliminate the same problems that were encountered during the FADs installation without any regulation. The fisher's groups are also expected to establish financial systems following the fisheries cooperative concept. The income earned from the fisheries cooperatives could then be used for the construction and installation of new units of FEDs.

Fish aggregating devices (FADs) and fish enhancing devices (FEDs) are well recognized as devices that help gather the living aquatic resources. The design and shape of FADs could differ from country to country, considering the behavior of target species and the conditions of the coastal waters. As alternative devices of FADs, FEDs could also be made of used fishing gear materials, such as ropes, nets and buoys that are still reusable to reduce the cost of FEDs construction and increase the reuse of waste materials that contribute to the accumulation of marine debris in the oceans. Reusing waste fishing gear materials could also help in addressing the concerns on micro-plastics in the oceans, as the FEDs synthetic materials could turn into micro-plastics, although this aspect should be a subject of further research studies.

Way Forward

Capacity building programs should be strengthened and promoted to enhance the knowledge and skills of stakeholders on co-management which is crucial for the management and maintenance of the FEDs to last longer. Accordingly, local users of the FEDs and stakeholders would be able to efficiently increase their fishing activities to support their families and improve community economic development.

Information on the use and management of FEDs in other Southeast Asian countries should also be compiled to be able to come up with a regional synthesis on FEDs including the issues and concerns. Guidelines for the proper installation and management of FEDs should also be developed similar to the guidelines for the installation of ARs.

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Upgrading the Purse Seine Fishing Vessels to Promote Responsible Fishing Operations:

a pilot study in Pattani Province, Thailand

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

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

Figure 1. Map of Thailand showing Pattani Province

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

Pilot-testing of the improved technology in purse seines

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

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

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

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

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

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

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

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

Trend of fisheries production of Thailand

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

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

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

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

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

Source: SEAFDEC, 2018

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

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

Source: SEAFDEC, 2018

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

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

Source: FAO, 2018

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

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

( ) World's ranking
Source: FAO, 2018

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

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

Source: DOF, 2019

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

Effects of the improved technology on purse seiners

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

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

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

Conclusion and Recommendations

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

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

Way Forward

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

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

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

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Boosting the Traceability of ASEAN Fish and Fishery Products through the eACDS

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Considering that illegal, unreported and unregulated (IUU) fishing had been threatening the sustainability of fisheries in the world and since IUU fishing had also been occurring in Southeast Asia, discussions had been conducted in several regional fora during the mid 2000s that came up with regional consensus in addressing the issues on IUU fishing. As a result, the ASEAN-SEAFDEC Resolution (RES) and Plan of Action (POA) on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 was adopted to serve as framework for the ASEAN Member States (AMSs) and SEAFDEC in planning for the necessary actions that would address among other concerns, the issues on IUU fishing in the region. Guided therefore by RES#8 encouraging SEAFDEC and AMSs to: "*Foster cooperation among ASEAN Member Countries and with international and regional organizations in combating IUU fishing*," RES#19 to: "*Support the competitiveness of the ASEAN fish trade through the development of procedures and programs that would certify, validate or otherwise indicate the origin of fish to reflect the need for traceability, sustainable fishing practices and food safety, in accordance with international and national requirements*," POA# 21 on the need to "*Strengthen regional and national policy and legislation to implement measures and activities to combat IUU fishing, including the development and implementation of national plans of action to combat IUU fishing, and promote the awareness and understanding of international and regional instruments and agreements through information dissemination campaigns*," and POA# 60 to "*Develop traceability systems, with mechanisms as needed to certify or validate the information, for the whole supply chain, and establish regulations and enforcement schemes in line with international standards. Align Member Countries' inspection systems and incorporate strengthened port inspections in the process as a means to improve inspection systems*," SEAFDEC in collaboration with the AMSs developed in 2015 the "ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain." In support of the implementation of ASEAN Guidelines in the AMSs, the "ASEAN Catch Documentation Scheme" or ACDS for marine capture fisheries was established by SEAFDEC as a management tool for combating IUU fishing and enhancing the competitiveness of the ASEAN fish and fishery products in the region. Undertaken by SEAFDEC Marine Fishery Resources Development and Management Department (SEAFDEC/MFRDMD) in cooperation with SEAFDEC Training Department (SEAFDEC/TD) and with support from the AMSs, the ACDS concept was designed to enhance the traceability of marine capture fisheries in the AMSs, covering not only the domestic trade but also international trade.

Many of the Southeast Asian countries are major producers of fish and fishery products from marine capture fisheries. In fact, the Southeast Asian total production from marine capture fisheries had been annually contributing about 20.7% to the world's total production from marine capture fisheries during the period from 2012 to 2016 (**Table 1**).

Moreover, FAO (2018) also reported that the top 20 major producing countries from marine capture fisheries in 2016 included five Southeast Asian countries, namely: Indonesia, Viet Nam, Philippines, Thailand, and Myanmar (**Table 2**). The increasing global demand for marine fish and fishery products had therefore been fulfilled by the production from the Southeast Asian region that had been exported to the global market, as most of the Southeast Asian countries are also major exporters of fish and fishery products.

In 2016, FAO (2018) indicated that Viet Nam and Thailand were among the top ten exporters of fish and fishery products to the world market (**Table 3**). Meanwhile, the European Union (EU) issued EC Regulation No. 1008/2008 establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing. With the main objective of controlling IUU fishing activities, the EC Regulation which was made effective in January 2010, requires that countries exporting fish and fishery products to the EU should

Table 1. Contribution of Southeast Asian fisheries production to the world's total fisheries production (in million metric tons (mt))

	2012	2013	2014	2015	2016
Southeast Asia[1]					
From Marine Capture Fisheries	15.5	16.2	16.6	16.8	17.2
Total Fisheries Production	39.5	40.2	42.1	44.0	45.3
World's Total[2]					
From Marine Capture Fisheries	78.4	79.4	79.9	81.2	79.3
Total Fisheries Production	156.2	160.7	164.9	168.7	170.9

[1] *Source: SEAFDEC (2018)*
[2] *Source: FAO (2018)*

Table 2. Marine capture fisheries production (2016): Major producing Southeast Asian countries

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

( ) World's ranking
Source: FAO, 2018

Table 3. Top ten exporters of fish and fishery products: Southeast Asian countries

Top exporting countries	2006		2016	
	Value (US$ million)	Share (%) of world total	Value (US$ million)	Share (%) of world total
(3) Viet Nam	3,372	3.9	7,320	5.1
(4) Thailand	5,267	6.1	5,893	4.1
World total export of fish and fishery products	**86,293**		**142,530**	

( ) World's ranking
Source: FAO, 2018

implement such EC Regulation. In responding to the request of the AMSs, SEAFDEC initiated capacity building activities to enable the AMSs to comply with the requirements of the EC Regulation (Siriraksophon *et al*., 2016), while the AMSs also amended their laws and administrative regulations to meet the requirements stipulated in the EC Regulation.

The ASEAN Catch Documentation Scheme

While considering the importance of developing measures that could guide the countries in improving the traceability system of their respective capture fisheries and combating IUU fishing in the Southeast Asian region, the AMSs suggested that a regional catch documentation system could be developed as a management tool to improve the management of fisheries in the region. Moreover, the AMSs also proposed that such system could be developed taking into consideration the format, standard and information requirements of the existing schemes of importing countries, but should be simple enough for easy application by the region's small-scale fisheries, and should be aligned with the existing market-driven measures (Kawamura and Siriraksophon, 2014). Thus, with funding support from the Japanese Trust Fund (JTF), SEAFDEC with the collaboration of the AMSs developed various countermeasures for combating IUU fishing in Southeast Asia, which include among others, the establishment of a regional catch documentation system that takes into consideration the EC Regulation, as well as the national regulations and those of the concerned Regional Fisheries Management Organizations (RFMOs). Such a system which would initially focus on inter- and intra-regional trade of fish and fishery products from marine capture fisheries, should enable the AMSs to export fish and fishery products to the EU. Upon the endorsement of the SEAFDEC Council of Directors and the higher authorities of the ASEAN in April 2013, the development of the so-called ASEAN Catch Documentation Scheme or ACDS had subsequently commenced.

At the onset, the development of the ACDS was intended to provide a unified framework for enhancing not only the traceability and credibility of fish and fishery products for intra-regional and international trade, but also the sustainable management of marine fisheries in the Southeast Asian region. Eventually, it had been envisioned that the ACDS would lead to the prevention of the entry of fish and fishery products from IUU fishing activities into the supply chain of the AMSs (Siriraksophon *et al*., 2016). During the initial stage, adoption of the ACDS could be voluntary but should be made voluntary later, considering that the ACDS would also be used to improve national traceability of fish and fishery products.

In the implementation of the ACDS, completion and issuance of five main documents should be accomplished. These are: Catch Declaration (CD), Movement Document (MD), Catch Certification for Export (CC), Processing Statement (PS), and Re-export Certification (RE). In 2017, the ACDS Concept for marine capture fisheries including the structure and processes was endorsed by the SEAFDEC Council and the higher authorities of the ASEAN for pilot testing in the AMSs.

As part and parcel of the ACDS, the AMSs also recommended that an electronic catch documentation system be developed to reduce the burden of the countries in the implementation of the ACDS. After the initial pilot-testing of the ACDS in Brunei Darussalam, analysis of the results was then used for the initiation of the electronic ACDS or eACDS with the cooperation of the Fish Market Organization (FMO) of Thailand. Subsequently, training was organized in Brunei Darussalam for the hands-on use of web-based and mobile applications of the eACDS, especially in the issuance of the CD and MD for verifying the route of the fish catch in the supply chain.

Structure and Processes Involved in the eACDS

As a simplified format of the ACDS, the eACDS generates the certificates for all the important points in the supply chain, such as: Catch Declaration (CD) for fishing masters/operators to ensure that they are not involved in IUU fishing activities; Movement Document (MD) for fish buyers who are authorized by the government to report the fish purchased and transported to other destinations such as processing plants or local markets; and Catch Certification (CC) for processors to be able to export their fish and fishery products. Based on these documents, an importer would be able to make clearance based on the CC and trace the origin of the fish and fishery products along the supply chain (Siriraksophon *et al.*, 2017). An example of the eACDS software on web-based application is shown in **Figure 1**, and that of the eACDS software on mobile application in **Figure 2**.

For the development of the software framework of the web-based and mobile application of eACDS, two major phases had been determined. The first phase had been designed for domestic marine capture fisheries, and the second phase is meant for the traceability system of imported fish and fishery products, including products that have been moved through transhipment vessels. The key data elements (KDEs) required for the eACDS include: point of catch, buyers/receivers and sellers (broker/wholesale), processors, exporters and international shipping, importers, and end consumers (**Figure 3**).

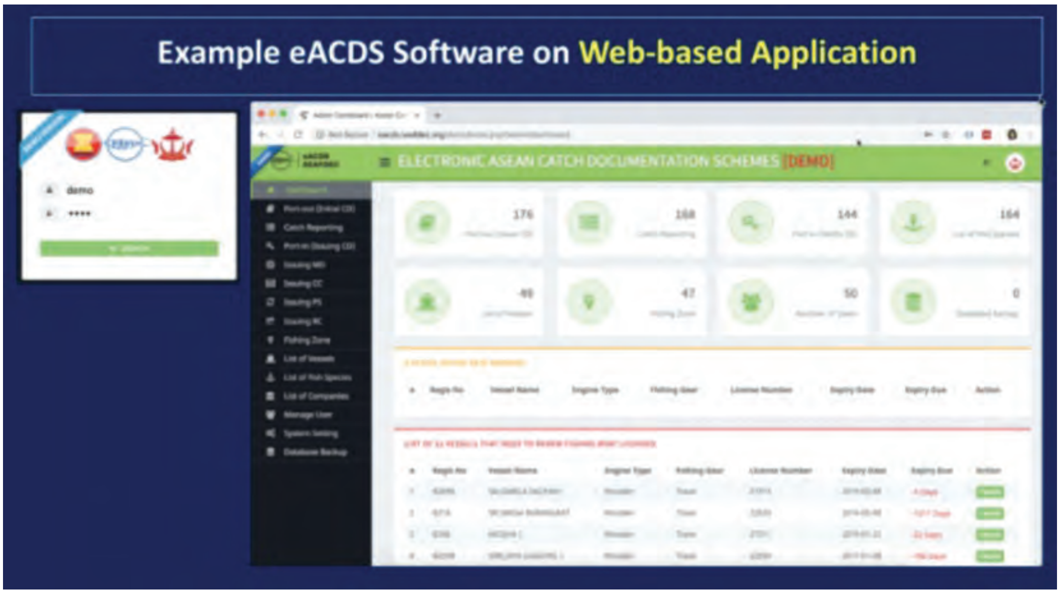

Figure 1. The eACDS software on web-based application

Figure 2. The eACDS software on mobile application

Figure 3. Key data elements required for the eACDS software

Promotion and Implementation of the eACDS in the AMSs

The steps involved in the implementation of the web-based and mobile applications of the eACDS, are shown in **Box 1**, and the flowchart of the web-based and mobile applications of the eACDS is shown in **Figure 4**. The eACDS which was developed through a series of consultations among the AMSs, was pilot-tested in Brunei Darusslam in 2017. The prototype eACDS software is also being promoted in Malaysia, Myanmar (**Figure 5**), and Viet Nam (**Figure 6**).

The process in the promotion and implementation of the eACDS in the AMS would involve five phases (**Box 2**), while the status of the promotion of the eACDS is summarized in **Box 3** (Imsamrarn *et al*., 2019).

Way forward

The eACDS which has been pilot-tested in Brunei Darussalam is already operational in the country. As experienced during the pilot-testing, the effective use of eACDS should also take into account various good practices, such as catch reporting at

Box 2. Process in the promotion and implementation of eACDS in the AMSs
Introduction - the eACDS system including its structure and functions is demonstrated to relevant authorities and stakeholders in participating countries
Baseline survey and situation analysis - baseline survey is carried out and analysis of the situation in issuing CD, MD, and CC as well as identification of KDEs is conducted involving relevant authorities and stakeholders in the respective AMSs
Prototype development - the eACDS is modified and appropriate prototype developed taking into consideration the context of the respective AMSs
Testing and improving the system - the eACDS is pilot tested with relevant users (*e.g.*, relevant authorities, fishing master, fishing vessel owners, buyers, and processers) who are trained on the use of the application, and problems addressed in order that the system is tailored to the context of the respective AMSs
IT transfer - During the testing phase, all data are stored in the SEAFDEC cloud server, and afterwards, the database would be transferred to and maintained by the respective AMSs

Box 1. Steps involved in the implementation of the eACDS
Step 1: Port-out control - for permission and issuance of initial Catch Declaration (CD) to Fishing Master who informs the Fishing Port Authority before going out for fishing operation. The Fishing Port Authority issues the initial CD with password for accessing the mobile application for catch reporting at sea.
Step 2: Catch reporting at sea - after each fishing operation at sea, Fishing Master reports their estimated catch via mobile eACDS application using the access accounts and password that appear on the initial CD form (features for offline reporting is also available if fishing vessel does not have communication signal)
Step 3: Port-in control and catch-weight verification – reporting by the Fishing Master to the Port-in Control, of catch-weight and species, and issuance of the CD by the Fishing Port Authority to the Fishing Master, to guarantee that the catch is regulated and does not come from IUU fishing activities.
Step 4: Catch movement to local market - purchasing of fish by buyers and processors for local markets and/or for processing, registered buyers to report the necessary information to the center/port using mobile application, while the MD will be issued by the Fishing Port Authority. At the markets, consumers would be able to trace the origin of the fish catch and other information from the QR-Code attached to the MD.
Step 5: Catch movement to processing plants - issuance of Movement Document (MD) by authorized fishery officer at port, for transferring of fish to either local markets or fish processing plants.
Step 6: Issuance of CC to processors - fish sent to processing plants, and in case the processed products are meant for export, the processor should request for Catch Certificate (CC) from competent authority using web-based application.
Step 7: Issuance of the CC by Competent Authority (CA) - when CA receives request from processors, CA will validate all information and if found okay, CA will issue the CC to the processor for exportation of the products.
Step 8: Issuance of CC and QR-Code - for exportation of fish and fishery products for tracing of the origin of the fish and fishery products
Step 9: Use of mobile QR-Code application - for consumers/importers to trace the origin pf the fish and fishery product

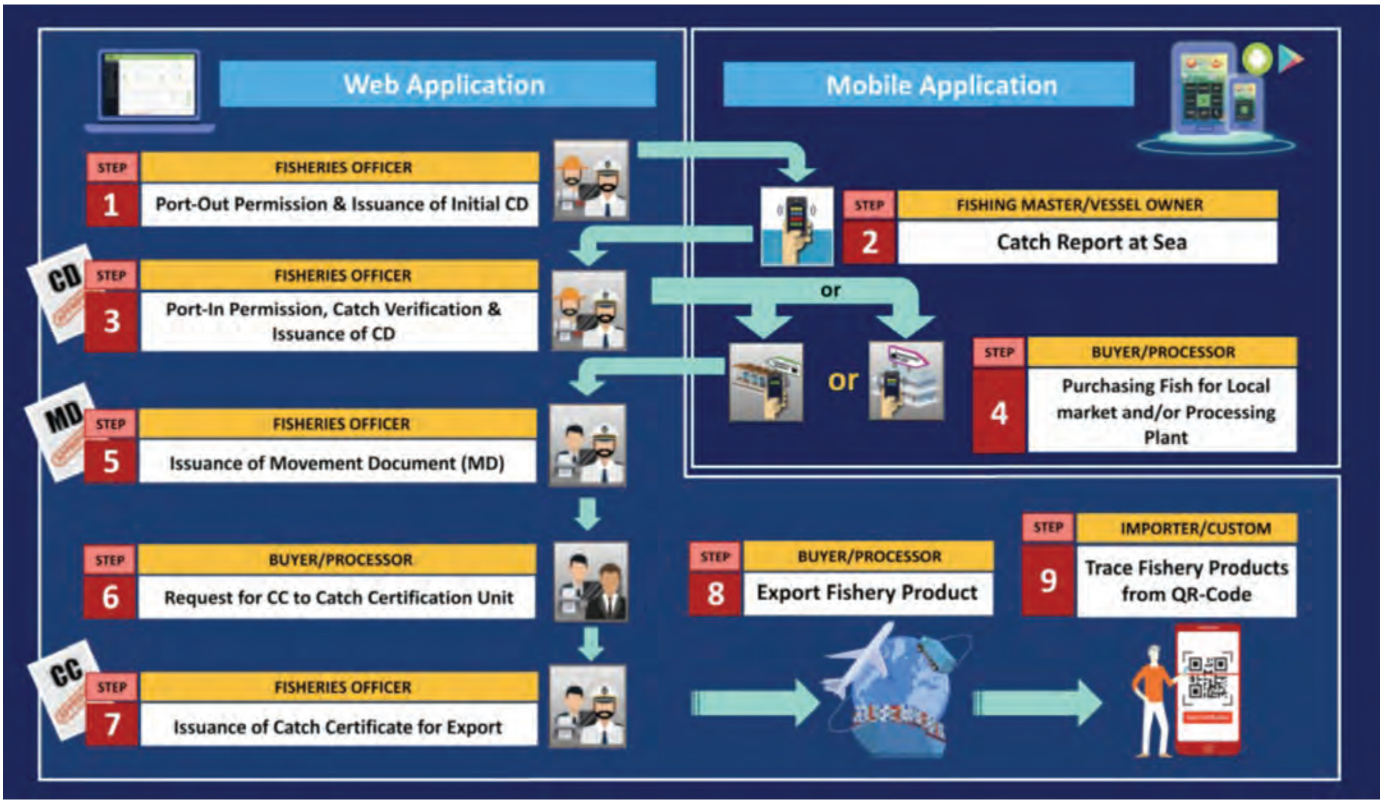

Figure 4. Flowchart of the web-based and mobile applications of the eACDS

Box 3. Status of promotion and implementation of the eACDS (as of December 2019)
Brunei Darussalam With the collaboration of the Department of Fisheries (DOF) of Brunei Darussalam, series of consultations and on-site training on the use of eACDS with relevant stakeholders had been carried out. Presently, the eACDS is in the process of testing and improvement. In 2019, the pilot testing was monitored and the application was adjusted to make it user-friendly. The DOF staff had been trained on the use of the offline web-based and mobile applications.
Malaysia The eACDS was introduced to the staff of the Department of Fisheries (DOF) Malaysia and relevant stakeholders. With the cooperation of DOF Malaysia, the initial planning and discussion were facilitated through the conduct of baseline survey and analysis including collection of KDEs for eACDS database development. Kelanton and Kuantan were selected as the project sites. The verification of development of the eACDS application in Port In-Port Out was conducted in November 2019 and the process is now going into prototype development.
Myanmar SEAFDEC introduced the eACDS system to the Department of Fisheries (DOF) of Myanmar and relevant stakeholders. Discussion on initial planning and cooperation with DOF of Myanmar for eACDS implementation was facilitated through the preparation of KDEs for eACDS database development and selection of pilot area. Presently, the eACDS system is in the process of prototype development and the KDEs were collected to develop the eACDS database and application. Verification on the development of eACDS application in the part of Port In-Port Out was conducted in December 2019 in collaboration with the DOF of Myanmar.
Viet Nam In 2017, The eACDS system was introduced to the Directorate of Fisheries (D-Fish) of Viet Nam and relevant stakeholders. Subsequently, the initial planning including the preparation of KDEs and selection of pilot areas were carried out in 2018. Presently, the process of eACDS prototype development and several activities are being implemented in Binh Thuan Province as the project site. The development and verification of eACDS and on-site training on the use of eACDS web-based and mobile applications were conducted for fishery officers and stakeholders in the part of Point In-Port Out, catch report at sea through offline technology, movement procedure, purchasing, request of Catch Certification which came upon issuance of Catch Declaration (CD), Movement Document (CD), Statement of Catch (SC), and Catch Certification (CC).

sea which requires good communication system through the use of mobile telephone and satellite communications. In case there is no communication system or mobile signal especially for medium and small-scale fishing vessels, the offline system for mobile application of the eACDS has been developed to support such good practices for implementing the eACDS. It is expected that the testing phase in Brunei Darussalam would be completed very soon, while its promotion and implementation in the other AMSs would be continued. This has been made possible through the continued support of the JTF for the implementation of activities related to coordination, facilitation, development, and expansion of the eACDS under the five-year plan (2020-2024) of the project "Strengthening Regional Cooperation and Enhancing National Capacities to Eliminate IUU Fishing in Southeast Asia."

Figure 5. Demonstration of eACDS applications in Myanmar

Figure 6. Demonstration of eACDS applications in Viet Nam

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Towards Reviving the Production of Philippine Native Aquatic Species

Frolan A. Aya

The overexploitation of native aquatic species mainly for household consumption, not to mention the habitat loss and introduction of invasive alien species in major inland water bodies of the Philippines, has resulted in the significant decline of their natural populations. Philippine Republic Act 9147 otherwise known as the Wildlife Resources Conservation and Protection Act of 2001 and the Fisheries Administrative Order 233-1 in 2010 issued by the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) served as two legal frameworks for protecting and conserving aquatic wildlife including indigenous species of the Philippines. With the current declining state of the country's native aquatic species, relevant studies such as breeding and development of seed production techniques are necessary to revive the production of native aquatic species. These studies would also support the Philippine Government's *Balik Sigla sa Ilog at Lawa (BASIL)* program of restocking inland water bodies with native aquatic species.

The Philippines has about 361 freshwater fish species found in inland water bodies, with 181 considered as native aquatic species (Froese & Pauly, 2019). Also, the country has more than 80 lakes (Palma, 2016) and the largest of which is the Laguna de Bay (**Figure 1**) located in Luzon Island. With a total area of 90,000 ha, Laguna de Bay is also the third largest freshwater lake in Southeast Asia having an average depth of about 2.8 m, and elevation of about 1.0 m above sea level.

Figure 1. Location of Laguna de Bay in Luzon Island, Philippines *(Source: Google maps)*

Laguna de Bay is home to a number of native freshwater fish species that have great potentials for aquaculture. **Figure 2** shows some of the species, such as the silver therapon (*Leiopotherapon plumbeus*), climbing perch (*Anabas testudineus*), Manila sea catfish (*Arius manilensis*), freshwater

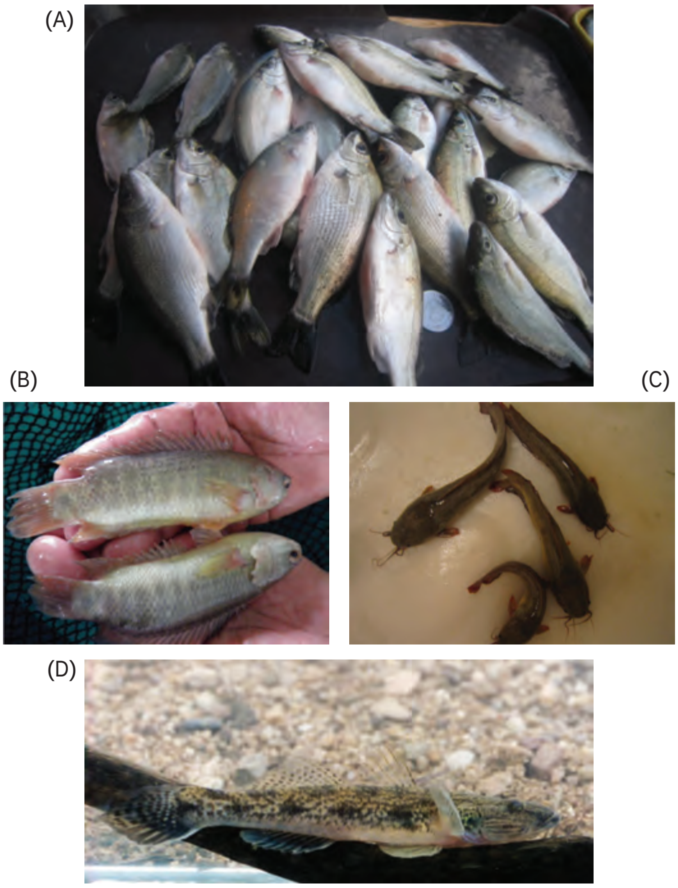
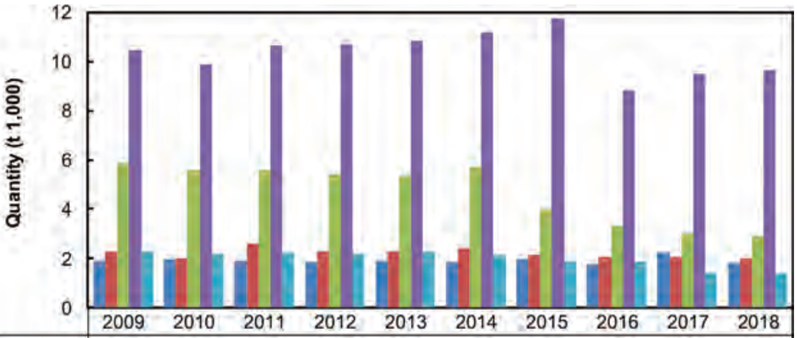


Figure 2. Selected Philippine native freshwater fish species found in Laguna de Bay, Luzon Island, Philippines. (**A**) silver therapon, (**B**) climbing perch, (**C**) Asian sea catfish, and (**D**) freshwater Celebes goby *(Source: fishbase.se)*

Celebes goby (*Glossogobius celebius*), as well as the Asian catfish (*Clarias macrocephalus*), and striped snakehead (*Channa striata*).

Declining catch of native fishes in major lakes of the Philippines

Some native freshwater fish species of economic importance in the Philippines include mudfish (*Channa striata*), Manila sea catfish (*Arius manilensis*), and Asian catfish (*Clarias macrocephalus*). The latter species, however, is fast disappearing in their natural environment and considered near threatened, thus it is included in the IUCN Red List of Threatened Species (Vidthayanon & Allen, 2011). Production of the climbing perch, although was stable for some time, started to decline in 2015 (**Figure 3**) as it is being subjected to increasing anthropogenic exploitation.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Catfish	1.90	1.97	1.90	1.87	1.91	1.85	1.95	1.77	2.24	1.83
Climbing perch	2.32	2.02	2.57	2.31	2.31	2.39	2.17	2.07	2.07	2.00
Freshwater goby	5.91	5.62	5.61	5.41	5.33	5.68	3.99	3.28	3.03	2.89
Mudfish	10.47	9.91	10.68	10.70	10.86	11.20	11.75	8.83	9.51	9.67
Silver therapon	2.29	2.19	2.26	2.20	2.32	2.17	1.92	1.89	1.44	1.41

Figure 3. Production quantity (t 1,000) of selected native freshwater fish species of the Philippines from 2009 to 2018
(Source: PSA, 2019)

For freshwater goby and silver therapon, there has been a continuous decline in the volume of production in recent years. This could have been brought about by the rampant and non-responsible fishing activities, contributing to the overexploitation of indigenous fish species, considering that rural communities near the lakes are dependent on subsistence capture fisheries for household consumption (**Figure 4**). Another threat to the production of native fish species is the introduction of invasive alien species such as the predatory fish *Chitala ornata* or knife fish (**Figure 5**). Naturally distributed in Cambodia, Lao PDR, Thailand, and Viet Nam, this ornamental fish is believed to be accidentally introduced in Laguna de Bay during the Typhoon Ondoy in 2009 (Guerrero III, 2014). Particular attention is paid on the containment of this invasive species for they heavily feed on small native fish species in lakes and other freshwater bodies.

Recently, a report on the feeding ecology of knife fish in Laguna de Bay found silver therapon as the most important component of its diet (Corpuz, 2018), resulting in the significant decline of wild silver therapon population in the lake. Consequently, it was also reported that the livelihood of

Figure 5. Knife fish, *Chitala ornata*, is a predatory fish that have caused the significant decline of native aquatic species in Laguna de Bay, Luzon Island, Philippines

(A) (B) (C)

Figure 4. Fresh (**A**) and dried (**B**) silver therapon sold in lakeside fishing communities, locals consume ayungin sinigang, a delicious Filipino sour soup dish (**C**)

many fisherfolk around Laguna de Bay was severely affected because about 40 percent of their daily catch was composed of knife fish (BFAR and PCAARRD, 2012).

This problem caused the fishermen to earn less income as compared before when most of their catch were the farmed bighead carp (*Aristichthys nobilis*), milkfish (*Chanos chanos*), and tilapia (*Oreochromis niloticus*) which command higher market prices and are more preferred commodities than the knife fish.

Government initiatives on habitat conservation and restoration of native aquatic species

There are two legal frameworks which safeguard the aquatic wildlife and their habitats in the Philippines. First is the Republic Act 9147 otherwise known as the Wildlife Resources Conservation and Protection Act of 2001 which mandates the State to conserve the country's wildlife resources and their habitats for sustainability. Second, the Fisheries Administrative Order 233-1 in 2010 was issued by BFAR to protect and conserve the aquatic wildlife including the indigenous species. In addition, the five-year National Inland Fisheries Enhancement Program (NIFEP) was conceptualized and implemented by BFAR to restore the conditions of 16 lakes around the country and increase fish biodiversity by restocking of indigenous fish species in these lakes (Palma & Bartolome, 2016). Situated in San Antonio, Quezon Province in Luzon Island, Dagatan Lake is home to some indigenous freshwater fishes such as the Asian catfish, and has been restored successfully through the efforts of the NIFEP. The Program envisioned to: 1) establish a national center and gene bank for indigenous fishes; 2) develop breeding protocols for low trophic species; 3) repopulate, manage, and conserve indigenous fishes; and 3) develop a network of satellite regional government and private hatcheries to supply the fingerlings requirement (Palma & Bartolome, 2016).

To control and manage the proliferation of invasive species such as knife fish, an inter-agency technical working group was formed in 2013 involving various government agencies including BFAR, Laguna Lake Development Authority (LLDA), Technical Skills and Development Authority (TESDA), Department of Environment and Natural and Resources (DENR), Philippine Council for Agriculture and Aquatic Resources Research and Development (PCAARRD), Department of Trade and Industry (DTI), Department of Social Welfare and Development (DSWD), and the Department of Interior and Local Government (DILG) as well as the academe (*e.g.* University of the Philippines in Los Baños or UPLB) to develop effective strategies to contain or eradicate this unwanted species in Laguna de Bay.

A website on invasive fishes was developed by BFAR and is already in place to serve as a repository of information on the reported invasive species in the Philippines as well as to provide updates on the strategies and interventions of the technical working group. In addition, UPLB has issued a technical bulletin on the biology of knife fish for the fisherfolk to understand the biology, behavior, and movement of this invasive species (PCAARRD, 2017).

Intensifying research programs on native freshwater fishes

Research on native fish species is very important to address their declining populations in the wild. Currently, there have been interests in studying the native aquatic species for conservation and aquaculture. The Binangonan Freshwater Station of Southeast Asian Fisheries Development Center/ Aquaculture Department (SEAFDEC/AQD), in collaboration with the University of the Philippines in Diliman has conducted research on several indigenous freshwater species such as silver therapon (Aya *et al.*, 2015a, b, c; 2016; 2017; 2019) and climbing perch aimed at domesticating these native aquatic species. At SEAFDEC/AQD, the life cycle of captive silver therapon has been successfully closed and the rearing protocols during the most critical phase of its culture, the larval stages, have been established (**Figure 6**). Other universities such as UPLB and Bataan Peninsula State University as well

(A)

(B)

Figure 6. Early stage larvae (**A**) and advanced juveniles (**B**) of silver therapon produced at the hatchery facilities of SEAFDEC/ AQD Binangonan Freshwater Station in Binangonan, Rizal, Philippines

as the National Fisheries Research and Development Institute (NFRDI) of BFAR are also doing complementary efforts to conserve and manage the natural populations of native freshwater fishes such as silver therapon, goby, and mudfish.

Most of the studies conducted to date are on the aspects of larval and reproductive biology of freshwater fish species. Information on the larval biology of silver therapon have been reported, particularly in the feeding traits (Aya *et al*., 2015a, b), early life history (Aya & Garcia, 2016), larval and early juvenile development (Aya *et al*., 2017), and the effect of physical substrate, including prey selection and diel feeding cycle of this species (Aya *et al*., 2019). In addition, a preliminary study has been conducted on weaning and larval diets suitable for rearing silver therapon larvae (Aya *et al*., 2015c). The findings on feeding biology and larval development studies of silver therapon are the key source of valid information to develop a viable hatchery seed production technology for this valuable food fish commodity. These are also important in understanding the biology of the species for the development of effective larval feeding schemes for aquaculture, and means to conserve and manage their natural populations. In addition, hatchery production of this species would support the national government's BASIL program of restocking natural waters with native fish species.

However, studies on the reproductive biology of silver therapon are outdated and limited. Reproductive studies have been focused on the effect of hormones and handling stress on spermiation of male silver therapon as well as on the gonad development and size-at-maturity of wild silver therapon in two Philippine volcanic lakes (Denusta *et al*., 2014; 2019). Studies comparing wild-sourced and hatchery-bred silver therapon in terms of their breeding performance, reproductive development, nutritional composition, growth, and survival have also been completed. The development of broodstock diets to enhance the reproductive performance and eggs and larval quality of silver therapon is still in progress. Recently, a report of the reproductive biology of the climbing perch in a tropical wetland (Bernal *et al*., 2015) could be useful in the efforts to successfully breed this fish species under captive conditions.

Preliminary work on climbing perch at SEAFDEC/AQD has also focused on developing artificial spawning and larval rearing protocols in the hatchery. Nonetheless, the existing hatchery seed production trials have remained tentative due to low survivorship of climbing perch during the early larval rearing stages. Therefore, further studies are needed to develop and improve seed production techniques for climbing perch.

Way Forward

Studies are extremely important for reviving the production of Philippine native aquatic species, many of which are facing threats of overfishing and possible extinction. The alarming decline of the freshwater fisheries catch emphasizes the need to manage the wild stocks, which requires an understanding of their reproductive and larval biology. There is a need also to conduct stock assessment or inventory of indigenous freshwater species in the Philippines to understand the status of their production in the wild. Studies that are geared towards the development of breeding and seed production techniques for native freshwater species are urgent and necessary before they become extinct in their natural habitat. SEAFDEC/AQD, government agencies, the academe, and other research institutions have initiated research interventions to immediately address the problem and save these Philippine native freshwater species from extinction. Reviving the production of these native freshwater species could help increase the local fish biodiversity and secure food fish supply in rural areas.

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Development of Albacore Tuna Fishery and Estimation of Allowable Biological Catch for Resource Management in the Indian Ocean

Watcharapong Chumchuen and *Shiela Villamor Chumchuen*

Albacore tuna, or ALB for short, is a highly migratory fish distributed in all oceans and is economically important in the white meat tuna supply chain. Reports have indicated that the global annual ALB catch has increased since 1950s. For ALB resource management, a six-stock model is considered in six regions, *i.e.*, two in the Pacific Ocean, two in the Atlantic Ocean, one in the Mediterranean Sea, and one in the Indian Ocean. The Indian Ocean Tuna Commission (IOTC) is the tuna regional fisheries management organization (tRFMO) in the Indian Ocean, of which four Southeast Asian countries, namely: Indonesia, Malaysia, Philippines, and Thailand are among the Contracting Parties. Although several methods of stock assessment were adopted to estimate the maximum sustainable yield (MSY), there was still high uncertainty in the results due to the limited biological information on ALB stock in the Indian Ocean. Besides MSY, the allowable biological catch (ABC) could also be considered as an effective method for ALB resource management in the Indian Ocean. This article, therefore, describes the ALB fishery in the Indian Ocean, as well as compares the values of the calculated ABC and the MSY estimated by the IOTC. The data on ALB fishery in the Indian Ocean had been accessed from the IOTC website, and the ABC calculation rule 2-2 was performed using a series of ALB catch statistics.

Albacore tuna or ALB (*Thunnus alalunga* (Bonnaterre, 1788)) is one of the most economically important species (**Figure 1**), particularly in Thailand, and is utilized mainly as raw materials for the white meat tuna products (Chumchuen and Songphatkaew, 2019). From 2011 to 2015, Thailand imported more than 30,000 t/year of ALB, mostly captured from the Indian Ocean and used for the country's tuna processing industry. The country has been considered as one of world's largest exporters of tuna products with exports valued at more than US$ 20 billion annually, contributing more than 40 percent to the global export volume (NFI, 2016).

ALB is an oceanic scombrid species distributed in tropical and temperate waters of all oceans as well as in the Mediterranean Sea, extending between 50° N and 40° S, but not at the surface between 10° N and 10° S (**Figure 2**). Their depth distribution is from the surface down to at least 380 m in the Pacific Ocean and believed to occur as deep as 600 m in the Atlantic Ocean. ALB migrates over great distances in schools of single species and appears to form separate groups at different stages of its life cycle. Their schools may be associated with floating objects, including sargassum seaweeds (Collette and Nauen, 1983), but association with floating objects is not common (ISSF, 2019).

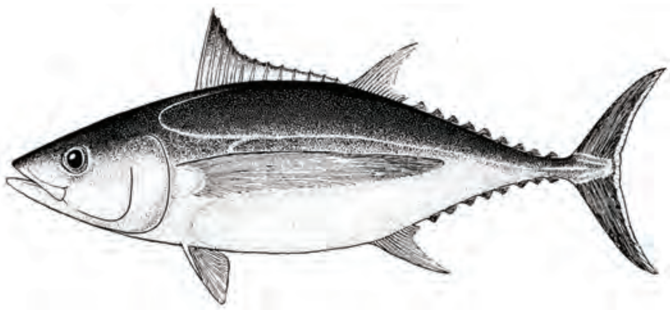

Figure 1. Albacore tuna *Thunnus alalunga* (Bonnaterre, 1788)
Source: Collette and Nauen (1983)

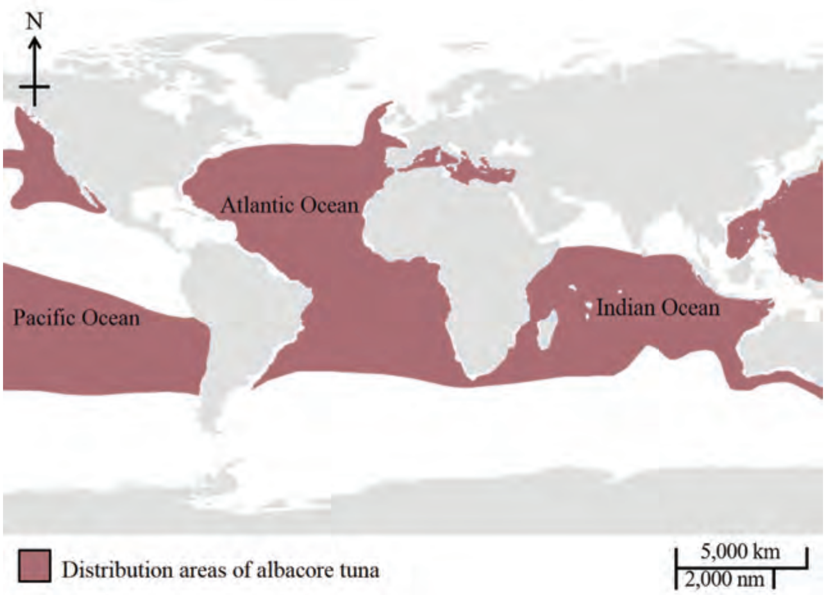

Figure 2. Geographical distribution of albacore tuna
(Modified from FAO, 2019a)

ALB is a pelagic predator feeding on fishes, crustaceans, and squids (Consoli *et al*., 2008). Mature ALB spawn in spring and summer in the tropical and sub-tropical waters. In one spawning season, a 20-kg female may produce between two and three million eggs, released at least in two batches. The sex ratio in catches is about 1:1 for immature specimens, but males predominate among mature fishes possibly due to differential mortality of sexes and differential growth rate after maturity (Collette and Nauen, 1983).

Production from Albacore Tuna Fishery

The main fishing grounds of ALB fishery are in temperate waters, and the basic types of fishing gears include longline, trolling line, pole and line, and purse seine. Small-sized individuals of ALB are mainly caught by trolling line, pole and line, and purse seine, while large-sized individuals mainly caught by longline (Collette and Nauen, 1983). Based on the available information on the global annual ALB catch between 1950 and 2017, the annual catch was about 100,000 t in early 1950s and reached 200,000 t in late 1960s. Between 1970s and 2000s, the annual catch fluctuated and ranged about 170,000 - 260,000 t (**Figure 3**). Recently, the annual catch was more than 200,000 t during 2013-2017 (FAO, 2019a; ISSF, 2019).

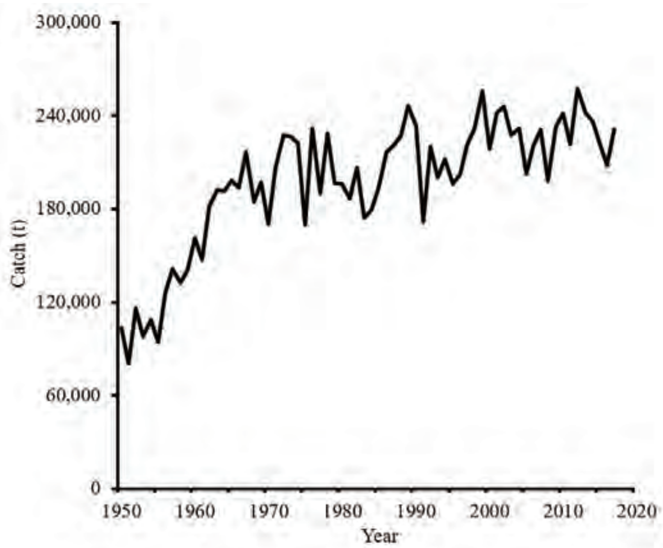

Figure 3. Global albacore tuna catch (t) between 1950 and 2017 (1950-2016 data from FAO (2019a) and 2017 data from ISSF (2019))

Due to the continued global exploitation of ALB resource, this species was listed as near threatened by the IUCN because of the decreasing population trend and continuing decline of mature individuals (Collette *et al*., 2011). As of 2004, the stock has been considered overexploited in the North Atlantic, fully exploited in the Indian Ocean and North Pacific, moderately exploited in the South Atlantic and South Pacific, and the stock status is unknown in the Mediterranean (Majkowski, 2007). At present, six stocks of ALB are being assessed and managed by several tuna regional fisheries management organizations (tRFMOs) in six regions including the North Pacific Ocean, South Pacific Ocean, North Atlantic Ocean, South Atlantic Ocean, Mediterranean Sea, and Indian Ocean (Nikolic and Bourjea, 2014). Effective management measures are now in place in many regions; however, up-to-date and standardized information on the fishery is necessary to accurately report the abundance and determine if overfishing would indeed happen (Collette *et al*., 2011).

In the Indian Ocean, the Indian Ocean Tuna Commission (IOTC) is the tRFMO that assesses and manages the stocks of tuna and tuna-like species. The IOTC aims to promote cooperation among its Contracting Parties and Cooperating Non-Contracting Parties in ensuring the conservation and optimum utilization of stocks, and encouraging sustainable development of the fisheries based on such stocks through appropriate management. Four Southeast Asian countries, namely: Indonesia, Malaysia, Philippines, and Thailand are among the Contracting Parties of the IOTC. ALB fishery management in the Indian Ocean has been substantial since the First Meeting of Working Parties on Temperate Tunas (WPTmT) organized by the IOTC in 2004. The Meeting considered the information on stock assessment of ALB and provided scientific advice on maximum sustainable yield (MSY) for the ALB fishery management (IOTC, 2004). Subsequently, WPTmT meetings were organized every 1-4 years to improve and develop the stock assessment of ALB fishery in the Indian Ocean.

In order to estimate the MSY of ALB, several methods of stock assessment (*e.g.*, non-equilibrium production model, age-structured production model, Bayesian biomass dynamic model and Stock Synthesis) were used in the past (Langley, 2019). However, the results were still highly uncertain because of limited biological information on ALB stock in the Indian Ocean (IOTC, 2016; 2019a). In addition to the MSY, allowable (or acceptable) biological catch (ABC) could also be considered as an effective method for fisheries resource management. ABC was developed and used in Japan from 1996 to the present (Watanabe, 2018). Various procedures (ABC calculation rules) were utilized to generate the values of ABC (FRA, 2018). Depending on available information of the concerned resource, the ABC calculation rule 2-2 is one of the ABC procedures that would require catch statistics data only. This procedure is a harvest control rule using an operating model based on a production model (Ohshimo and Naya, 2014), which aims to stabilize stock size and ensure the sustainable utilization of the resource (Harlyan *et al*., 2019). Therefore, for data-limited ALB fishery involving multi-fishing fleets and gears, ABC could be an alternative method to manage the ALB resource in the Indian Ocean.

The objectives of this article were to describe the ALB fishery in the Indian Ocean, and to compare the values of calculated ABC and MSY estimated by the IOTC.

Figure 4. The Indian Ocean Tuna Commission area of competence
(modified from FAO, 2019b)

Fishing data

The data on ALB fishery in the IOTC area of competence (**Figure 4**) was accessed from the IOTC website (IOTC, 2019b). The data collected includes ALB catch, fishing fleets, and fishing gears.

ABC calculation rule 2-2

The ABC calculation rule 2-2 was performed to express the maximum level of resource utilization (ABClimit) and target level of resource utilization (ABCtarget) based on historical catch data. The procedure assumed that the catch in year t (C_t) reflects the stock abundance index in year t.

The calculation of ABClimit requires the catch statistics over the past 20 years, and uses the Equation (Eq.) 1 below (Hiramatsu, 2004):

$$\text{ABClimit}_{t+1} = \delta_t \times C_t \times [1+k(b/I)] \qquad \text{Eq. 1}$$

where ABClimit_{t+1} is ABClimit for the year $t + 1$; δ_t is the coefficient depending on the stock status level in year t; k is the weighted coefficient; b is the slope (trend) of catch calculated from the last three years or $[(C_t - C_{t-2})/2]$; and I is the average catch for the last three years or $[(C_{t-2} + C_{t-1} + C_t)/3]$.

For obtaining the δ_t value, C_t and thresholds (Clth: catch at lower threshold and Cuth: catch at upper threshold) are considered. The thresholds are determined by Eq. 2 and Eq. 3 using the maximum catch (Cmax) and the minimum catch (Cmin) over the past 20 years.

$$\text{Clth} = (2\text{Cmin} + \text{Cmax})/3 \qquad \text{Eq. 2}$$

$$\text{Cuth} = (\text{Cmin} + 2\text{Cmax})/3 \qquad \text{Eq. 3}$$

Regarding the stock status level in year t, three scenarios are considered for calculating the δ_t values based on Eq. 4 (FRA, 2018):

$$\delta_t = \begin{cases} 0.8 & \text{if } C_t < \text{Clth} \\ 1.0 & \text{if Clth} \leq C_t < \text{Cuth} \\ 1.0 & \text{if } C_t \geq \text{Cuth} \end{cases} \qquad \text{Eq. 4}$$

For the three scenarios: (1) stock status is at low level (δ_t = 0.8) if C_t is less than Clth; (2) stock status is at medium level (δ_t = 1.0) if C_t is equal to or higher than Clth, but less than Cuth; and (3) stock status is at high level (δ_t = 1.0) if C_t is equal to or higher than Cuth.

In fisheries management, total allowable catch (TAC) is set as an output control strategy. TAC should correspond to the ABCtarget (Hamada, 2007) calculated using ABClimit in Eq. 5 (FRA, 2018):

$$\text{ABCtarget} = \text{ABClimit} \times \alpha \qquad \text{Eq. 5}$$

where α is the coefficient for precautionary measure for the resource, which varies between 0 and 1.

In order to calculate the ABClimit and ABCtarget, k and α values should be set using their standard values (FRA, 2018) which are 0.5 and 0.8, respectively.

Data analyses

The historical ALB catch by fishing fleets and gears was analyzed using descriptive statistics in order to describe the development of ALB fishery in the Indian Ocean, trend of annual ALB catch, and proportion of ALB catch by fishing gear. The comparison between the values of the ABC calculations and the MSY estimated by the IOTC was carried out by paired samples t-test at significant level of 0.05. The values of MSY assessed by IOTC were acquired from the WPTmT meeting reports from 2004 to 2019 at *https://www.iotc.org/meetings*.

Results and Discussion

Albacore tuna fishery in the Indian Ocean

The accessed data contained 2,118 datasets for ALB fishery in the Indian Ocean recorded by the IOTC from 1950 to 2017. The ALB fishery in the Indian Ocean involved at least 37 countries, of which 26 are Contracting Parties and one Cooperating Non-Contracting Party of the IOTC (**Table 1**). ALB fishery in the Indian Ocean had developed between 1950 and 2017 through the introduction of different types of fishing gears (*i.e.*, handline, trolling line, gillnet, longline, purse seine, Danish seine, pole and line, and lift net) (**Figure 5**). The

Table 1. The Indian Ocean Tuna Commission (IOTC) Contracting Parties and Cooperating Non-Contracting Parties that are present (+) or absent (-) in the data compiled on albacore tuna fishery in the IOTC area of competence between 1950 and 2017

Contracting Parties			
Australia	+	Mauritius	+
Bangladesh	+	Mozambique	+
China	+	Oman	+
Comoros	+	Pakistan	-
Eritrea	-	Philippines	+
European Union	+	Seychelles	+
France	+	Sierra Leone	-
India	+	Somalia	-
Indonesia	+	South Africa	+
Iran	+	Sri Lanka	+
Japan	+	Sudan	-
Kenya	+	Tanzania	+
Korea, Republic of	+	Thailand	+
Madagascar	+	United Kingdom	+
Malaysia	+	Yemen	+
Maldives	+		
Cooperating Non-Contracting Parties			
Liberia	-	Senegal	+

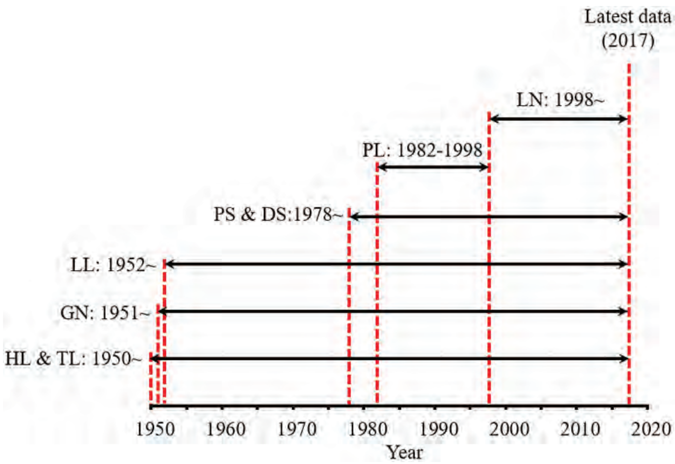

Figure 5. Development of albacore tuna fishery in the Indian Ocean through the introduction of fishing gears between 1950 and 2017. Each vertical red broken line indicates the year of earliest or latest data of particular fishing gear that captured albacore tuna. Each horizontal black arrow indicates the period of particular fishing gear that captured albacore tuna. TL: trolling line, HL: handline, GN: gillnet, LL: longline, PS: purse seine, DS: Danish seine, PL: pole and line, LN: lift net

fishing gears are categorized into four main types, namely: longlines, purse seines, gillnets, and other gears.

Comparing with the report of WCPFC (2018), where ALB fishery in the WCPFC area of competence involved about 30 countries, of which some countries' fishing fleets operated in the Indian Ocean to capture ALB (*e.g.* fishing fleets from Australia, China (including Taiwan), Indonesia, Japan, Korea, and the Philippines). For the main fishing gears in the WCPFC area of competence, ALB is mostly captured by longline, pole and line, purse seine, trolling line, and other gears. This revealed that fishing fleets and gears that exist in ALB fishery are common to both Indian Ocean and Pacific Ocean.

Albacore tuna catch in the Indian Ocean

From the historical catch between 1950 and 2017, the ALB catch during 1950-1951 was 8-18 t captured by handline, trolling line, and gillnet. When longline was introduced in 1952, the ALB catch increased during 1953-1958 from 1,100 t to about 7,300 t. Since 1959, the ALB catch fluctuated with lowest in 1975 (11,485 t) and highest in 2001 (46,103 t), as shown in **Figure 6**.

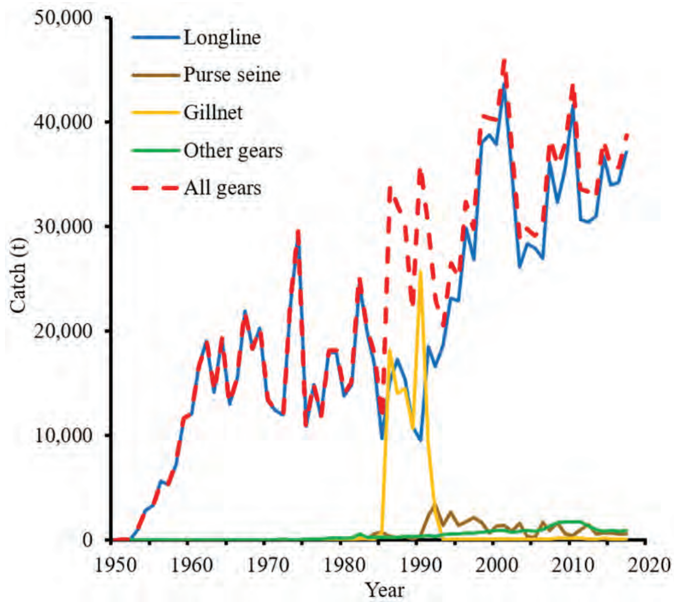

Figure 6. Annual albacore tuna catch (t) from the Indian Ocean between 1950 and 2017 by fishing gears. Other gears include handline, trolling line, pole and line, Danish seine, and lift net

For the last five years (2013-2017), the average ALB catch from all fishing gears was 36,235±2,453 t/year (**Figure 7**), and most ALB was captured by longline (34,641±2,465 t/year or 95.6±0.4 %). The catch data also revealed that the main fishing fleet for ALB fishery in the Indian Ocean was Chinese (including Taiwanese) fleet which accounted for more than 60 % of ALB catch, followed by Indonesian (20 %) and Japanese (7 %) fleets.

With regards to the main fishing fleets and gears in ALB fishery, the results were similar to the study of Brouwer *et al.* (2018) in the South Pacific Ocean, who reported that Chinese (including Taiwanese) fleet was the key fishing fleet which accounted for 59 % of ALB catch, and the main fishing gear

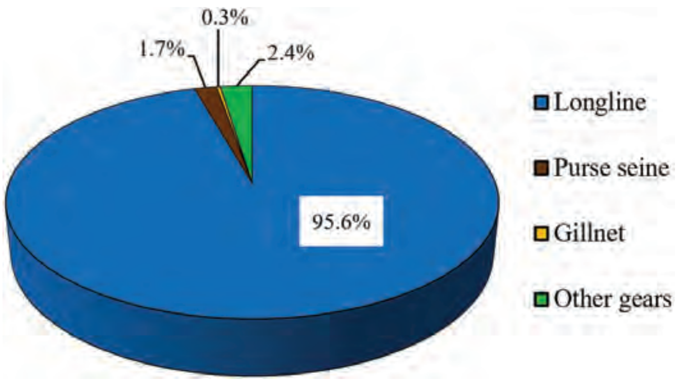

Figure 7. Proportion of average annual albacore tuna catch in the Indian Ocean between 2013 and 2017 by fishing gears. Other gears include handline, trolling line, Danish seine, and lift net

that captured ALB was longline which represented 98 % of the total ALB catch from all fishing gears. This emphasized that Chinese (including Taiwanese) fleet focused on ALB resource and had the highest fishing capability on ALB fishery among the various fishing fleets. Besides, ALB was mainly targeted by longline rather than other fishing gears.

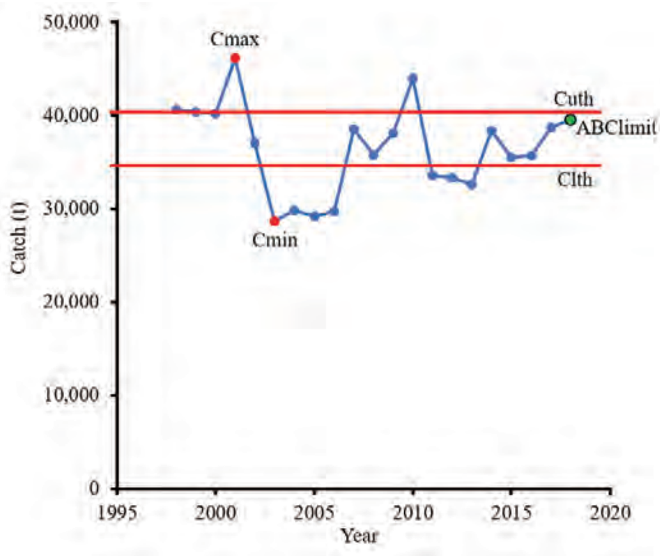

Figure 8. Total albacore tuna catch (t) in the Indian Ocean over the past 20 years (1998-2017) and predicted allowable biological catch (t) for 2018 (Cmin: minimum catch, Cmax: maximum catch, Clth: catch at lower threshold, Cuth: catch at upper threshold, ABClimit: allowable biological catch at limited level for 2018)

On the other hand, other fishing fleets and gears in the Indian Ocean also targeted other species. For example, the Indonesian longline fleet targeted yellowfin and bigeye tunas with ALB ranking third and accounting for about 6 % of tuna catch (Rochman *et al*., 2019), and Mauritian longline fleet targeted swordfish where ALB also accounted for 6 % of total catch (Shung and Sheikmamode, 2019). For other fishing gears, purse seine fisheries mainly targeted tropical tunas, *i.e.* skipjack, yellowfin, and bigeye tunas (Justel-Rubio *et al*., 2017). The volume of ALB captured by trolling line as well as pole and line was not significant in the Indian Ocean unlike in other oceans (Langley, 2019).

ABClimit and ABCtarget from historical catch

From historical catch of ALB between 1950 and 2017, the catch statistics over the past 20 years (1998-2017) was used for ABClimit calculation (**Figure 8**). Cmin and Cmax were found in 2003 (28,687 t) and 2001 (46,103 t), respectively. Clth and Cuth were 34,492 t and 40,298 t, respectively, whereas the latest catch (C_{2017}) was 38,713 t. Consequently, δ_{2017} is equal to 1.0. The average catch for the last three years (2015-2017) or I was 36,690 t/year and the trend of catch (b) was +1,543 t/year. Therefore, ABClimit_{2018} was 39,527 t and ABCtarget_{2018} was 31,622 t.

The results showed that ABClimit_{2018} and ABCtarget_{2018} cover the MSY (35,700 t) for 2018 which was estimated by the IOTC (2019a). In the ABC calculations, k was fixed at 0.5 as a standard value (FRA, 2018), although it could be flexible to reflect the ABCtarget. However, the function of k is likely an accelerator of the harvest control rule, where small values of k lead to slight fluctuation in the changing level of resource utilization, while large values of k result in great fluctuation in the changing level of resource utilization. Harlyan *et al.* (2019) simulated ABC using values of k from 0.5 to 2.5 and emphasized that if k is too large, catch quota would greatly increase even when the biomass is slightly increasing and *vice versa*, leading to high variability in catches due to random fluctuation in the biomass index. Regarding the ABCtarget calculation, the standard value of α as 0.8 (FRA, 2018) which means that the ABCtarget is equal to 80 % of the ABClimit. However, the value of α can be adjusted from 0 to 1 (utilization level from 0 % to 100 %) depending on the resource status and management capability.

Comparison between the ABC calculations and MSY estimated by IOTC

In order to compare the values between the ABC calculations and the MSY estimated by the IOTC, the ABClimit and ABCtarget were generated corresponding to the MSY for the assessed years from 2003 to 2018. For the corresponding years, most values of ABClimit were higher than the values of MSY while values of ABCtarget were not much different from the values of MSY (**Table 2**). The statistical comparison revealed that there was no significant difference between ABClimit and MSY (t = 2.1479; df = 5; p = 0.08) as well as between ABCtarget and MSY (t = 0.4342; df = 5; p = 0.68).

Results of the calculations supported that ABC calculation rule 2-2 is an effective alternative method for the stock management of data-limited situation (*i.e.*, insufficient biological information) of multi-fishing fleets and gears in

Table 2. Albacore tuna catch (t) assessed by allowable biological catch (ABC) calculation rule 2-2 and maximum sustainable yield (MSY) estimated by the Indian Ocean Tuna Commission (IOTC)

Assessed years	ABC calculation rule 2-2		MSY estimated by the IOTC	
	ABClimit (t)	ABCtarget (t)	MSY (t)	Reference
2003	36,301	29,041	26,380	IOTC (2004)
2008	41,345	33,076	n.a.	IOTC (2008)
2011	46,444	37,155	29,900*	IOTC (2011)
2011	46,444	37,155	33,300**	IOTC (2012)
2013	30,935	24,748	34,700	IOTC (2014)
2015	39,810	31,848	38,800	IOTC (2016)
2018	39,527	31,622	35,700	IOTC (2019a)

n.a.: not available
** MSY was estimated in 2011*
*** MSY was estimated in 2012*

ALB fishery in the Indian Ocean. The method has provided a simple calculation procedure despite the requirement for a series of 20-year catch statistics. Although this study was a case for a single species (ALB) applying the ABC procedure, Harlyan *et al*. (2019) validated and considered this procedure as an appropriate tool for multi-species fisheries management.

Conclusion and Recommendations

Many countries had been involved in the development of ALB fishery in the Indian Ocean throughout the period of 1950-2017. Recently, the Chinese (including Taiwanese) fleet was identified as the main fishing fleet followed by Indonesian and Japanese fleets. The ALB catch started to increase after the introduction of longline which was found to be the main fishing gear that captures this species. The comparison between the values of ABC calculations and the MSY estimated by the IOTC suggested that ABC calculation rule 2-2 could be applied for the resource management of data-limited situation of multi-fishing fleets and gears ALB fishery in the Indian Ocean. This demonstrated that the ABC procedure could be considered as a useful tool for stock management of concerned fishery resources. Besides, the ABC procedure could be adopted by the ASEAN Member States (AMSs) for effective resource management of their respective data-limited, multi-fishing gears, and/or multi-species fisheries.

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Utilization of the tropical almond tree leaves in aquaculture

Rex Delsar B. Dianala

Tropical almond tree (*Terminalia catappa*), also known in the Philippines as "*talisay*" is a large tropical tree in the Combretaceae (leadwood tree) family that grows mainly in tropical areas of Asia. The tree grows from 10 m to 25 m high and has horizontal whorls of branches with shiny and ovate leaves, 10-25 cm long, and tapering below to a narrow and heart-shaped base with expanded rounded apex. "*Talisay*" fruit is smooth and ellipsoid, 3-6 cm long, and prominently bi-ridged or keeled down to the sides, with fibrous and fleshy pericarp and hard endocarp. Studies have indicated that the leaves of "*talisay*" are rich in tannins and a host of organic compounds that help in conditioning the culture water resulting in improved survival, growth, and health of cultured aquatic species.

"*Talisay*" at SEAFDEC Aquaculture Department

This is a daily early morning scene at the SEAFDEC Aquaculture Department (SEAFDEC/AQD) in Tigbauan, Iloilo, Philippines. Broad red leaves litter the driveway of the SEAFDEC/AQD premises, especially during the dry season. In previous months, the leaves were a brilliant green before turning into shades of yellow, orange and red (**Figure 1**), and falling away from the tall "*talisay*" trees lined up along the roads leading to the SEAFDEC/AQD buildings and research facilities. Groundsmen armed with leaf blowers and broomsticks promptly clean the driveway early each morning, gathering the leaves before dumping them far from sight.

Figure 1. Green "talisay" leaves with young fruits *(above)*, and various shades of "*talisay*" leaves *(left)*

Not too many people know that these dried tropical almond tree leaves scattered around SEAFDEC/AQD's premises hold almost magical properties that can solve fundamental problems in the aquaculture industry. Being rich in organic compounds, these leaves could be used to condition the culture water resulting in improved survival, growth, and health of cultured species.

Utilization of "*talisay*" leaves in aquaculture

Recently, SEAFDEC/AQD Scientist *Dr. Frolan Aya* demonstrated that simply littering hatchery tanks with "*talisay*" leaves significantly improves the survival of the larvae of "*ayungin*" or silver therapon (*Leiopotherapon plumbeus*). In his experiment, *Dr. Aya* observed that the "*talisay*" leaves, which were simply laid and allowed to decompose in the culture tanks, resulted in a 48% survival of *ayungin* larvae (**Figure 2**). Meanwhile, those without the leaf substrate only achieved 27% survival rate.

Figure 2. Silver therapon or "ayungin" (*Leiopotherapon plumbeus*) larvae
Source: Aya (2019)

In their recent study, Aya *et al*. (2019) supposed that the presence of the "*talisay*" leaf litter allowed small organisms, such as zooplankton and insect larvae, to colonize the leaf surfaces. These organisms soon became food for the *ayungin* larvae. It might have also been possible that the accumulation of leaves at the tank bottom reduces water motion and allows the larvae to conserve their energy instead of going against the flow of current. The darkening of the rearing water caused by the decomposing leaves could have also provided a good background or contrast for the larvae to efficiently capture its prey, thus contributing to better feeding success and consequently improve the larval survival significantly. Previous studies have also shown that the mere presence of the "*talisay*" leaf litter in culture tanks presents some advantages to improve fish survival from fingerlings to commercial sizes (**Figure 3**).

Figure 3. Marketable size of silver therapon or "ayungin" (*Leiopotherapon plumbeus*)
Source: Aya (2019)

Figure 4. Post-larvae of *Penaeus monodon*

Furthermore, other studies using only extracts of the "*talisay*" leaf have also shown significant improvements in the survival of fish as well as of tiger shrimp (*Penaeus mondon*). Mhd Ikhwanuddin *et al*. (2014) determined the effectiveness of different concentrations of *Terminalia catappa* leaves extract on the survival and growth of the post-larvae of black tiger shrimp *Penaeus monodon* (**Figure 4**). While establishing the concentration of *T. catappa* leaves extracts that has positive effect on the survival and growth performance of *P. monodon* post-larvae, Mhd Ikhwanuddin *et al*. (2014) also suggested that higher concentrations could be toxic to the shrimp larvae that possibly result in high mortality.

Tannin present in the aqueous extract of the leaves of the tropical almond tree could also enhance water quality in culture tanks by reducing the pH and total ammonia nitrogen (TAN) levels, as well as removing the turbidity in water (Bryan, 2017), proving that this plant-based coagulant could be used as water treatment agents in culture tanks. Some studies have also shown that the beneficial organic compounds in *T. catappa* leaves extracts have antimicrobial and antifungal properties. Nevertheless, in the study of Bryan (2017), he observed that *T. catappa* leaf extract had no observable anti-bacterial effect on the water. Babayi *et al*. (2004) however have shown that the methanolic extracts of the *T. catappa* leaf inhabited the growth of Bacillus subtilis and Staphylococcus aureus but had no inhibitory effects on Pseudomonas aeruginosa, Salmonella typhi and Escherichia coli. In another study, Ko *et al*. (2002) found that the extracts of *T. catappa* leaves possessed potent antioxidative and scavenging activities that increase as the leaf matures.

In Thailand, the leaves of *T. catappa* have been used as alternative to chemicals and antibiotics in the culture of tilapia (Chitmanat *et al*., 2005), where the results showed that the ectoparasite *Trichodina* was eradicated from tilapia (**Figure 5**) at 800 ppm concentration of ground leaves while the growth of *Aeromonas hydrophila* was also inhibited at a concentration of 0.5 mg/ml leaves. The extracts were also observed to reduce the fungal infection in tilapia eggs. However, research on the toxicity of leaf extracts on tilapia and the isolation of the active ingredients of the leaves for fish pathogen treatment is still underway. Meanwhile, unpublished data at SEAFDEC/AQD show that the effect of *T. catappa* crude ethanolic extracts on the survival of mangrove crabs mirrored that of antibiotics at the zoea 5 and crab instar 1 stages. This further supports the possible replacement of antibiotics with this natural product.

The effects of *T. catappa* leaf extract on breeding activity of Siamese gourami (Trichogaster pectoralis) also known as snakeskin gourami (**Figure 6**), were determined by Lee *et al*. (2016) by controlling the water pH using the extracts from *T. catappa* leaves. The results indicated that after exposing the fish to various pH using the extracts, the best environment to breed the Siamese gourami was at pH 6.5. Such findings could help the fish farmers in breeding the fish instead of harvesting the seeds of the fish from the wild for their culture activities.

Figure 5. Tilapia, *Oreochromis niloticus*
Source: SEAFDEC/AQD Archive

Figure 6. Siamese gourami, *Trichogaster pectoralis*
Source: FAO

In the breeding of ornamental fishes, the extracts of *T. catappa* leaves have also proven to be useful, especially in eliminating the external parasites such as *Gyrodactylus* sp. and *Dactylogyrus* sp. from goldfish (*Carassius auratus*). This would help the aquarium industry considering that goldfish (**Figure 7**), which is a very popular ornamental fish is often affected by these ectoparasites. In the *Aeromonas hydrophila* infection in ornamental fishes, Jacob *et al*. (2018) had established that plant extracts that are known for their anti-microbial properties could serve as potential alternative therapeutics to treat bacterial septicemia associated with *A. hydrophila* in fish, instead of using antibiotics. Among the plant extracts used was from the leaves of *T. catappa*.

For the culturists of betta fish or the Siamese fighting fish (*Betta splendens*) which is a very popular ornamental fish in the aquarium trade, *T. catappa* is a miracle tree. This is because of its role in healing fungal infections as well as lowering the pH and treating hardness of the culture water for this ornamental fish. In the aquarium industry in Thailand, the use of extracts from *T. catappa* is very popular among

Figure 7. Goldfish, *Carassius auratus*
Source: Public Domain

Figure 8. Betta fish bred in Thailand
Source: Sermwatanakul, 2019

the betta breeders as it also helps them in creating vibrant colors in betta fish (**Figure 8**) as well as in increasing their spawning capacity.

In 2008, a study was conducted by researchers from the Faculty of Veterinary Medicine of Khon Khaen University in Thailand to verify the claims of betta breeders in Thailand on the antibacterial properties of *T. catappa*. In their study, Chansue *et al*. (2008) exposed three species of the most popular ornamental fishes: guppy fish (*Poecilia reticulate*), fancy carp (*Cyprinus carpio*), and Siamese fighting fish (*Betta splendens*) to the water extracts from dried leaves of *T. catappa* for more than 14 days. The results confirmed the findings of Chansue and Assawawongkasem (2008) that the extracts have antibacterial properties addressing the concerns on chemical residues and antibiotic resistance in ornamental fish culture.

Way Forward

Based on the abovementioned findings, placing dried leaves of *Terminalia catappa* in culture tanks could provide the physical benefit of a leaf litter substrate as well as the leaching of desirable organic chemicals to the rearing water. While the method seems simple, more studies are still needed, especially on new applications of the *T. catappa*. Meanwhile, extracts from the dried leaves of *T. catappa* have also provided antibacterial and antifungal benefits. Nonetheless, more studies on this aspect would be necessary, especially in determining the levels of toxicity of the extracts on the cultured organisms.

As the use of natural products are preferable to chemical and antibiotic interventions to improve the health of cultured species, perhaps, soon, the broad red leaves littering the SEAFDEC/AQD driveway will be no more. They will all be stashed away in the hatcheries and laboratories, no longer neglected, because of their almost magical properties.

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CALENDAR OF EVENTS

Date	Venue	Event	Organizer(s)
2019			
2-4 October	Bangkok, Thailand	Capacity Development Workshop on Stock Status Assessment and Estimation of SDG Indicator 14.4.1 for the Asia Pacific Region	SEAFDEC/TD
3-4 October	Samut Prakan, Thailand	Regional Core Experts Meeting on Tropical Anguillid Eel Information Sharing	SEAFDEC Secretariat
7-8 October	Bangkok, Thailand	Regional Workshop on Lesson Learned in Application of EAFM in Learning Sites	SEAFDEC/TD
8-9 October	Bangkok, Thailand	1-Year Shark Data Collection Validation Workshop (under the SEAFDEC-EU/Shark Project Phase 2)	SEAFDEC Secretariat
8-10 October	Jakarta, Indonesia	Workshop on 5-Year of IFRDMD's Achievement	SEAFDEC/IFRDMD
22-24 October	Sakon Nakhon Province, Thailand	Regional Workshop on Facilitating Fisheries Activities Information Gathering through Introduction of CBRM/Co Management in Southeast Asian Region	SEAFDEC/TD
30-31 October	Bangkok, Thailand	End-of-Project Meeting of the SEAFDEC-Sweden Project: Fisheries and Habitat Management, Climate Change and Social Well-being in Southeast Asia (2013-2019)	SEAFDEC Secretariat
31 October	Bangkok, Thailand	Workshop on Thailand Fisheries Traceability Supply Chain Analysis	USAID/Oceans
4-8 November	Samut Prakan, Thailand	Regional Training Course on Fish Handling Technique Applicable to Various Fishing Operations in Southeast Asia	SEAFDEC/TD
5-6 November	Sarawak Malaysia	2nd Project Steering Committee Meeting for the SEAFDEC/UNEP/GEF Project on Fisheries *Refugia*	SEAFDEC & UNEP/GEF
11-13 November	Chiang Mai, Thailand	42nd Meeting of SEAFDEC Program Committee (PCM)	SEAFDEC Secretariat & TD
14-15 November	Chiang Mai, Thailand	22nd Meeting of the Fisheries Consultative Group of the ASEAN-SEAFDEC Strategic Partnership (FCG/ASSP)	SEAFDEC Secretariat
25-29 November	Vigo, Spain	17th Session of the FAO/COFI Sub-Committee on Fish Trade	FAO
26-28 November	Cambodia	12th RPOA-IUU Coordinating Committee Meeting	RPOA-IUU
27-28 November	Lao PDR	Meeting on Analysis for Strengthening the Effective Management of Inland Fisheries and Aquaculture in AMSs with GIS and RS Technology	SEAFDEC Secretariat
9-12 December	Kep, Cambodia	Regional Workshop on Fisheries Resource Enhancement and Habitat Conservation Measures in Southeast Asian in Kep Province, Cambodia	SEAFDEC/TD
13-14 December	Bangkok, Thailand	2nd ASEAN Meeting on Combating IUU Fishing in Partnership with the EU	Thailand
16-19 December	Maldives	34th INFOFISH Governing Council Meeting	INFOFISH
16-20 December	Hai Phong, Viet Nam	Practical Workshop on Stock and Risk Assessments of Yellowfin Tuna and Skipjack Tuna in the South China Sea using Software on CPUE Standardization, A Stock-Production Model Incorporating Covariates (ASPIC), Kobe Plots, and Risk Assessments	SEAFDEC/TD
2020			
10-14 February	Bali, Indonesia	28th Session of the Asia and Pacific Commission on Agricultural Statistics	FAO/RAP
10-15 February	Samut Prakan, Thailand	Practical Workshop on Stock and Risk Assessments of Longtail Tuna and Kawakawa in the Southeast Asian Waters	SEAFDEC Secretariat
17-20 February	Thimphu, Bhutan	35th Session of the FAO Regional Conference for Asia and the Pacific	FAO/RAP
12-14 March	Krabi, Thailand	36th Session of the Asia-Pacific Fishery Commission	APFIC
6-9 April	Fukuoka, Japan	52nd Meeting of the SEAFDEC Council	SEAFDEC
13-17 July	Rome, Italy	34th Session of FAO Committee on Fisheries (COFI)	FAO

Southeast Asian Fisheries Development Center (SEAFDEC)

What is SEAFDEC?

SEAFDEC is an autonomous intergovernmental body established as a regional treaty organization in 1967 to promote sustainable fisheries development in Southeast Asia. SEAFDEC currently comprises 11 Member Countries: Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.

Vision

Sustainable management and development of fisheries and aquaculture to contribute to food security, poverty alleviation and livelihood of people in the Southeast Asian region

Mission

To promote and facilitate concerted actions among the Member Countries to ensure the sustainability of fisheries and aquaculture in Southeast Asia through:

i. Research and development in fisheries, aquaculture, post-harvest, processing, and marketing of fish and fisheries products, socio-economy and ecosystem to provide reliable scientific data and information.
ii. Formulation and provision of policy guidelines based on the available scientific data and information, local knowledge, regional consultations and prevailing international measures.
iii. Technology transfer and capacity building to enhance the capacity of Member Countries in the application of technologies, and implementation of fisheries policies and management tools for the sustainable utilization of fishery resources and aquaculture.
iv. Monitoring and evaluation of the implementation of the regional fisheries policies and management frameworks adopted under the ASEAN-SEAFDEC collaborative mechanism, and the emerging international fisheries-related issues including their impacts on fisheries, food security and socio-economics of the region.


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The third prize winner, *Nadya Wahyudi Kusmono*, from the national drawing contest in Indonesia

National Drawing Contests were organized in all ASEAN-SEAFDEC Member Countries as part of the preparatory process for the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment" held by ASEAN and SEAFDEC in June 2011 in Bangkok, Thailand, in order to create awareness on the importance of fisheries for food security and well-being of people in the region.