FISH for the PEOPLE

A Special Publication for the Promotion of Sustainable Fisheries for Food Security in the ASEAN Region

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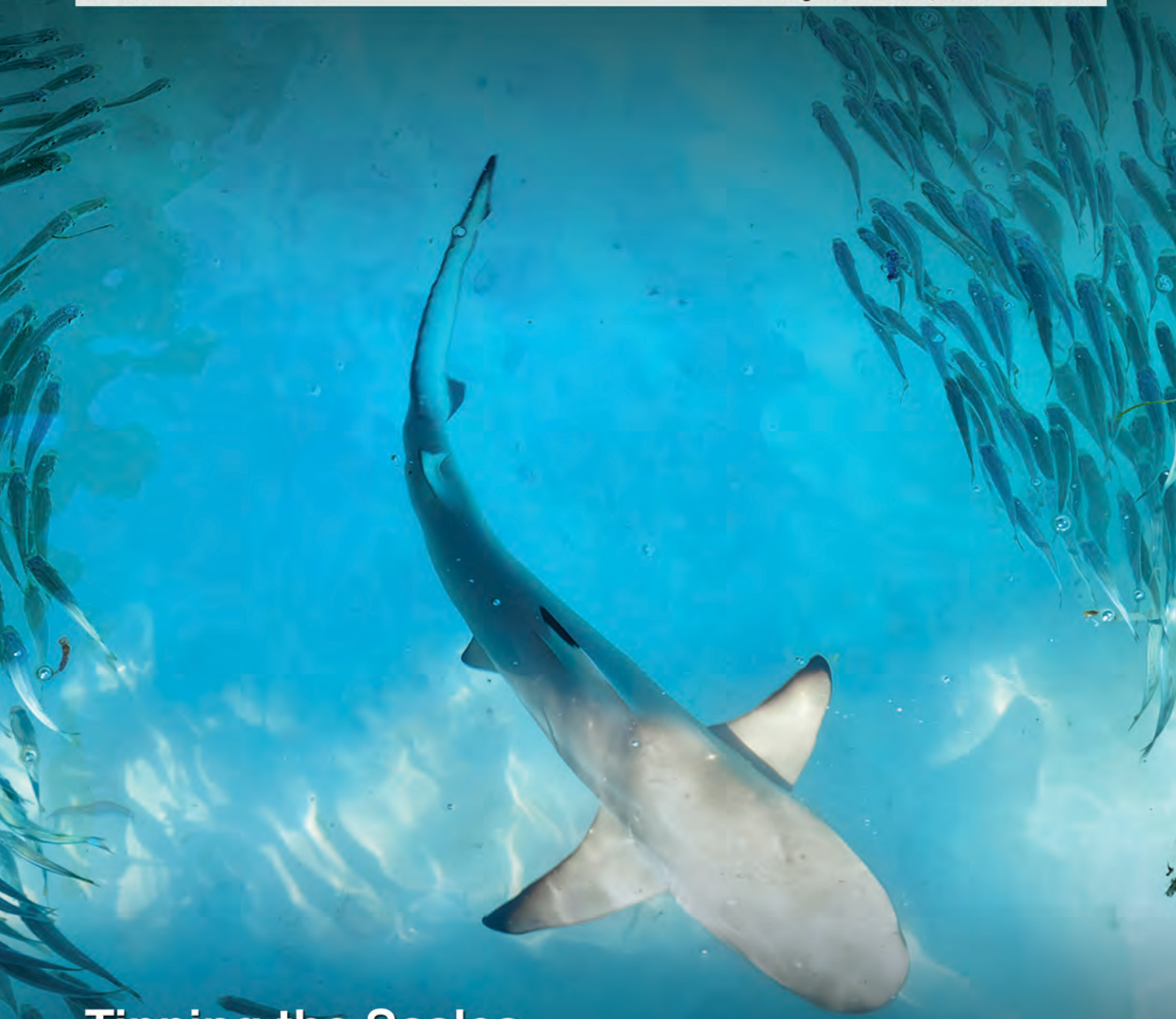

Tipping the Scales for Sustainable Fisheries in Southeast Asia

Southeast Asian Fisheries Development Center

Editor in Chief (Fish for the People)

SEAFDEC Secretariat
Kasetsart University Campus
P.O. Box 1046, Kasetsart Post Office,
Bangkok 10903, THAILAND
E-mail: fish@seafdec.org

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Editorial

While targeting the sustainability of fisheries development in the Southeast Asian region, SEAFDEC ensures that the balance scale is tipped towards responsible utilization and conservation of the fishery resources through the implementation of programs and activities that are aimed at attaining environmental integrity and socio-economic stability. Since 1998, SEAFDEC has been promoting the adoption in Southeast Asia, of the Regional Guidelines for Responsible Fisheries in Southeast Asia that were developed based on the Global Code of Conduct for Responsible Fisheries, and recently, the measures and tools towards combating illegal, unreported and unregulated (IUU) fishing to make sure that the region's fisheries operations are conducted in responsible ways that aim for the sustainability of the fishery resources. The traceability of fish and fishery products from the region has also been strengthened for the safety of consumers. SEAFDEC also ensures that utilizing the region's fishery resources should be responsive to the Sustainable Development Goal (SDG) 14 "*Conserve and sustainably use the oceans, seas and marine resources for sustainable development*," and also to SDG 15.5 "*Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity, and protect and prevent the extinction of threatened species*," believing that by balancing the utilization of the fishery resources with conservation, the socio-economic stability of the countries in the region would be assured.

Working towards attaining such goals, SEAFDEC also promotes the sustainable utilization and conservation of aquatic species that are of international concern. With funding support from the Government of Japan through the Japanese Trust Fund (JTF), SEAFDEC has been addressing the international trade-related issues concerning various commercially-exploited aquatic species by providing fora for the ASEAN-SEAFDEC Member Countries to respond to international initiatives and other evolving fisheries situations that have serious implications to the region's trade of fish and fishery products including the sustainability of the region's fishery resources. The series of consultations convened by the SEAFDEC Secretariat therefore facilitated the development of the common positions and policy options reflecting the region's fisheries, especially with respect to the issues related to the requirements of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) corresponding to the proposals for listing of economically-important aquatic species in the CITES Appendices, to ensure that any subsequent actions would not threaten the sustainability of the region's fisheries. With the parallel objective of conserving the threatened aquatic species, the ASEAN-SEAFDEC Member Countries also undertake their roles of ensuring the sustainability of their respective fisheries and carry out initiatives in terms of promoting the conservation and sustainable utilization of aquatic species that are considered commercially-important and of international concern.

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.

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CONTENTS

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.

Developing the Regional Position on Proposed Inclusion of Commercially-exploited Aquatic Species into CITES Appendices: the Southeast Asian Region under the Spotlight

Suwanee Sayan, Worawit Wanchana, Lawrence Kissol, Jr., and *Virgilia T. Sulit*

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) which was entered into force on 1 July 1975, is an international agreement among governments (also known as Parties) with the objective of ensuring that international trade in specimens of animals and plants does not threaten their survival in the wild. Specifically for the commercially-exploited aquatic species (CEAS), CITES sets the criteria and guidelines for making decisions as to whether or not a certain CEAS should be listed into the CITES Appendices. The listing of some species of CEAS in the CITES Appendices on the one hand, could have certain impacts not only on the management of the fisheries of the species but also on the economies of many countries of the Southeast Asian region that have been catching and trading some of the species and their "look-alikes" as well as trading in parts of their processed forms. On the other hand, the inclusion of any CEAS in the CITES Appendices would serve as means of addressing the concerns with regards to the conservation and management of such species. The Parties to CITES, referred to as the Conference of the Parties (CoP), meet every two to three years mainly to review the progress in the conservation of the species included in the CITES Appendices, and consider the proposals to amend the lists of species in Appendices I and II or to list new species in the Appendices. To equip the Southeast Asian countries with the necessary justifications with respect to the proposals for listing certain CEAS in the Appendices, which the countries could also use as reference during the voting at the meetings of the CITES CoP, the Southeast Asian Fisheries Development Center (SEAFDEC) regularly organizes regional technical consultations (RTCs) to discuss the possible impacts of the proposals on the fisheries of such species, and develop the common or coordinated position of the SEAFDEC Member Countries on such proposals. Implemented as part of the SEAFDEC collaborative project "Assistance for Capacity Building in the Region to Address International Fish Trade-related Issues," which receives generous financial support from the Government of Japan Trust Fund (JTF), the RTCs also aspire to come up with recommendations on the issues related to the conservation and sustainable utilization of such CEAS which the countries could also raise during the CITES CoP.

Box 1. Listing of species of animals and plants in the CITES Appendices

Appendix I: Species that are the most endangered among CITES-listed animals and plants, and are threatened with extinction are listed in this CITES Appendix. International trade in specimens of these species is prohibited except when the purpose of the import is not commercial, *e.g.* for scientific research. Thus, trade could still take place provided it is authorized by the granting of an import permit and an export permit (or re-export certificate).

Appendix II: Species that are not necessarily threatened now with extinction but could become so unless trade is closely controlled are included in this CITES Appendix. In addition, the so-called "look-alike species," *i.e.* species whose specimens in trade look like those of the species listed for conservation reasons are also placed in this Appendix. International trade in specimens of the species in this Appendix may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES, although a permit may be required by some countries that have taken much stricter measures than those required by CITES. Permits or certificates would only be granted if the relevant authorities are satisfied with the certain conditions that are met, and that such trade will not be detrimental to the survival of the species in the wild.

Appendix III: Under this CITES Appendix are species which a Party requests to be included, as the trade of such species is already regulated by this concerned Party but needs the cooperation of other countries (other Parties) to prevent the unsustainable or illegal exploitation of such species. International trade in specimens of species listed in this Appendix is allowed only upon presentation of the appropriate permits or certificates.

In order to protect some endangered species of wild animals and plants from over-exploitation and intensify the conservation efforts for such species, CITES lists such species in any of the three CITES Appendices (**Box 1**) taking into consideration their exploitation status and the types of protection afforded them corresponding to their international trade (CITES, 1995). The listing of certain species of wild animals and plants in the CITES Appendices therefore implies that the import, export, or re-export of specimens, as well as introduction from the sea of such species are subjected to certain international trade controls.

Moreover, CITES also specifies that certain species could be added to or removed from Appendix I and Appendix II, or moved between them, only by the CITES CoP, either during its regular meetings or by postal procedures (FAO, 2010). However, certain species may be added to or removed from Appendix III at any time and by any Party unilaterally, although such changes could be timed to coincide with amendments to Appendices I and II during the meetings of the CITES CoP.

Listing in CITES Appendices of CEAS that are Economically Important for the Southeast Asian Region

CITES (2018) reported that as of January 2017, about 5,800 species of animals and 30,000 species of plants are protected by CITES against over-exploitation through international trade, and are listed in the CITES Appendices. Currently, the CITES Appendices include approximately 100 commercially-exploited aquatic species of fish, mollusks and echinoderms, some of which are shown in **Table 1**.

The listing of commercially-exploited aquatic species (CEAS) into the CITES Appendices is one crucial issue faced by the fisheries sector of Southeast Asia as it could impact not only on the management of fisheries but also on the economies of the countries in the region. Such impacts are anticipated not only as a result of regulation in trade of the species being listed in the CITES Appendices, but also in the trade of look-alike species, as well as trade in parts or processed forms of the species. Moreover, the listing could also result in the termination of data collection on the catch and landing of these species, leading to the unavailability of data and information on the status of the species. Furthermore, difficulties could also be anticipated in delisting or down-listing of the species once these are listed in the CITES Appendices.

Given such a scenario, SEAFDEC has always heeded to requests by its Member Countries to carefully give consideration on the proposed listing of CEAS into the CITES Appendices, by organizing series of fora to facilitate regional discussion and development of common/coordinated positions among countries in Southeast Asian region on the aquatic species that have been proposed for listing into the CITES Appendices. An example of such fora is the recently organized Regional Consultation for Development of the ASEAN-SEAFDEC Common Position on the Proposed Listing of Commercially-exploited Aquatic Species into the CITES Appendices on 30-31 January 2019 in Bangkok, Thailand

Furthermore, SEAFDEC has also been undertaking technical activities on the conservation and management as well as sustainable utilization of aquatic species (Latun *et al*., 2011; Chamchai and Siriraksophon, 2011), *e.g.* sharks and rays (Chamchai *et al*., 2013; Wanchana *et al*., 2016; Arnupapboon *et al*., 2019), seahorses (Ursua, 2017), sea cucumbers (Bumrasarinpai, 2007), marine turtles (Talib *et al*., 2003; Isa *et al*., 2008; Chokesanguan, 2008; Chanrachkij *et al*., 2009;

Table 1. Major commercially-exploited aquatic species listed in CITES Appendices

English Name	Scientific Name	CITES Appendix	Year Listed
Silky shark	*Carcharhinus falciformis*	Appendix II	2016
Thresher sharks	*Alopias* spp.	Appendix II	2016
Devil rays	*Mobula* spp.	Appendix II	2016
Clarion angelfish	*Holacanthus clarionensis*	Appendix II	2016
Nautilus	*Nautilidae* spp.	Appendix II	2016
Scalloped hammerhead shark	*Sphyrna lewini*	Appendix II	2014
Great hammerhead shark	*Sphyrna mokarran*	Appendix II	2014
Smooth hammerhead shark	*Sphyrna zygaena*	Appendix II	2014
Oceanic whitetip shark	*Carcharhinus longimanus*	Appendix II	2014
Porbeagle shark	*Lamna nasus*	Appendix II	2014
Manta rays	*Manta* spp.	Appendix II	2014
European eel	*Anguilla anguilla*	Appendix II	2007
Sawfishes	Pristidae	Appendix I apart from 1 species on Appendix II	2007
Humphead (Napoleon) wrasse	*Cheilinus undulatus*	Appendix II	2004
Mediterranean date mussel	*Lithophaga lithophaga*	Appendix II	2004
White shark	*Carcharodon carcharias*	Appendix II	2004
Sea cucumber	*Isostichopus fuscus*	Appendix III	2003
Basking shark	*Cetorhinus maximus*	Appendix II	2002
Pipefishes and seahorses	*Hippocampus* spp.	Appendix II	2002
Whale shark	*Rhincodon typus*	Appendix II	2002
Sturgeons and paddlefish	Acipenseriformes	Appendix II apart from 2 species on Appendix I	1997
Caribbean queen conch	*Strombus gigas*	Appendix II	1994
Stony corals	Scleratinia	Appendix II	1990
Giant clams	Tridacnidae	Appendix II	1983
Arapaima	*Arapaima gigas*	Appendix II	1975

Source: SEAFDEC (2019, unpublished)

Siriraksophon, 2009), catadromous eels (Siriraksophon *et al*., 2014; Muthmainnah *et al*., 2016; Suryati *et al*., 2019). These efforts are meant to come up with data and information on the status and trends of these species, as well as improved compilation of the existing conservation and management measures undertaken by the countries that could serve as basis for discussion during the meetings of the CITES CoP. Specifically for sharks and rays, SEAFDEC has been supporting the Southeast Asian countries in the improvement of their data collection activities, by recording sharks and rays at species level, and also in capacity building for the development of Non-Detriment Findings (NDFs) to provide scientific views with regards to the trade of such species (Arnupapboon *et al*., 2019).

Recent Updates on the Proposals to List More CEAS in CITES Appendices

In January 2019, SEAFDEC organized a Regional Consultation for the Development of Common Position on the Newly Proposed Listing of CEAS into the CITES Appendices (SEAFDEC, 2019 unpublished), which include several species found in the waters of Southeast Asia (**Box 2**; **Figures 1-5**).

Box 2. New proposals for listing of CEAS into the CITES Appendices
a) Inclusion of the blackchin guitarfish (*Glaucostegus cemiculus*) and the sharpnose guitarfish (*Glaucostegus granulatus*), and all of other giant guitarfish, *Glaucostegus* spp. in Appendix II
b) Inclusion of the following three species belonging to the subgenus Holothuria (Microthele): *Holothuria (Microthele) fuscogilva, Holothuria (Microthele) nobilis* and *Holothuria (Microthele) whitmaei*, in Appendix II
c) Inclusion of the short-fin Mako shark, *Isurus oxyrinchus* and long-fin Mako shark *Isurus paucus* in Appendix II
d) Inclusion of the two species commonly referred to as the white-spotted wedgefish, *Rhynchobatus australiae* and *Rhynchobatus djiddensis* in Appendix II, and inclusion of all other species in the Family Rhinidae (wedgefish): *Rhynchobatus cooki*, *Rhynchobatus immaculatus*, *Rhynchobatus laevis, Rhynchobatus luebberti, Rhynchobatus palpebratus, Rhynchobatus springeri, Rhynchorhina mauritaniensis, Rhina ancylostoma*, and any other putative species of Family Rhinidae in Appendix II

Upon analyzing the proposed listings, the 2019 Regional Consultation came up with a synthesis of the aforesaid proposals including the status of fisheries of the species in Southeast Asia and technical recommendations with respect to the conservation and utilization of such species (**Table 2**).

Moreover, the possible impacts of the listing of the CEAS into CITES Appendix II identified during the 2019 Regional Consultation (SEAFDEC, 2019 unpublished), are shown in **Table 3**.

Figure 1. blackchin guitarfish *Glaucostegus cemiculus (above)* and sharpnose guitarfish *Glaucostegus granulatus (below)*

Source: Presentations made during the 2019 Regional Consultation for the Development of Common Position on the Newly Proposed Listing of CEAS into the CITES Appendices (SEAFDEC, 2019 unpublished)

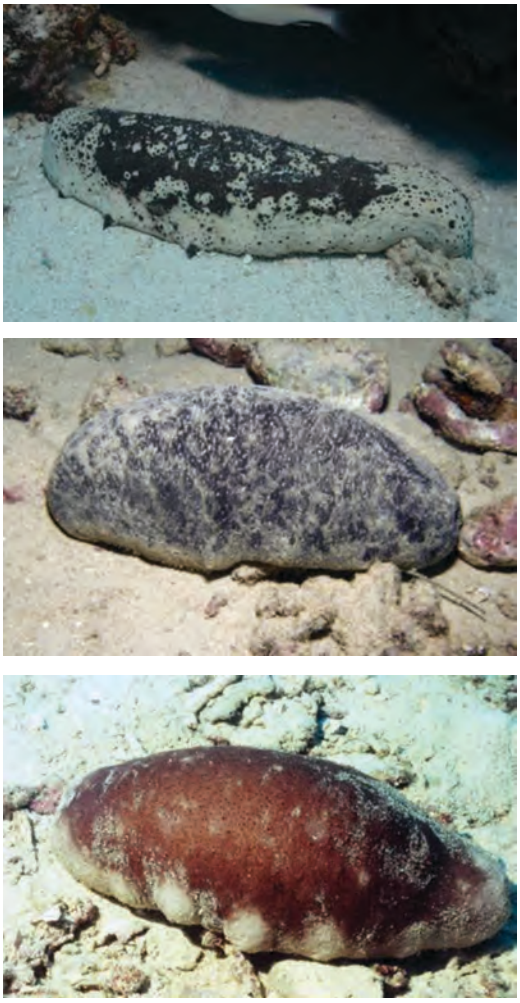

Figure 2. *Holothuria (Microthele) fuscogilva (above), Holothuria (Microthele) nobilis (center) and Holothuria (Microthele) whitmaei (below)*

Source: Presentations made during the 2019 Regional Consultation for the Development of Common Position on the Newly Proposed Listing of CEAS into the CITES Appendices (SEAFDEC, 2019 unpublished)

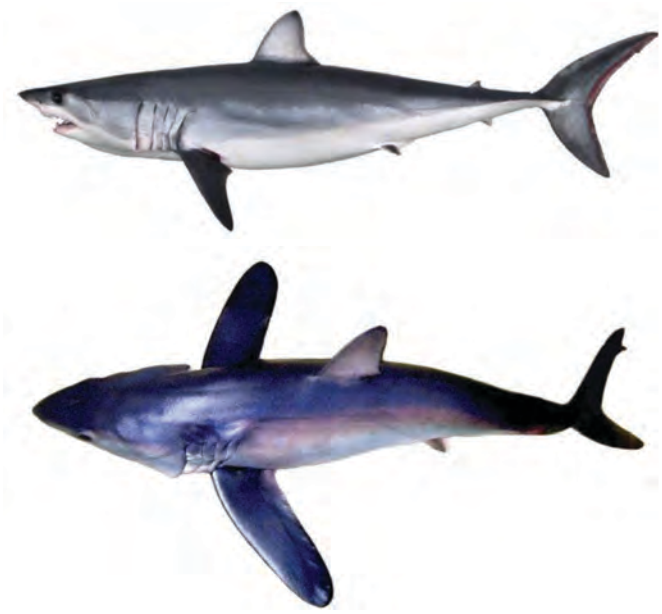

Figure 3. short-fin Mako shark, *Isurus oxyrinchus (above)* and long-fin Mako shark *Isurus paucus (below)*

Source: Presentations made during the 2019 Regional Consultation for the Development of Common Position on the Newly Proposed Listing of CEAS into the CITES Appendices (SEAFDEC, 2019 unpublished)

Figure 4. white-spotted wedgefish, *Rhynchobatus australiae (above)* and *Rhynchobatus djiddensis (below)*

Source: Presentations made during the 2019 Regional Consultation for the Development of Common Position on the Newly Proposed Listing of CEAS into the CITES Appendices (SEAFDEC, 2019 unpublished)

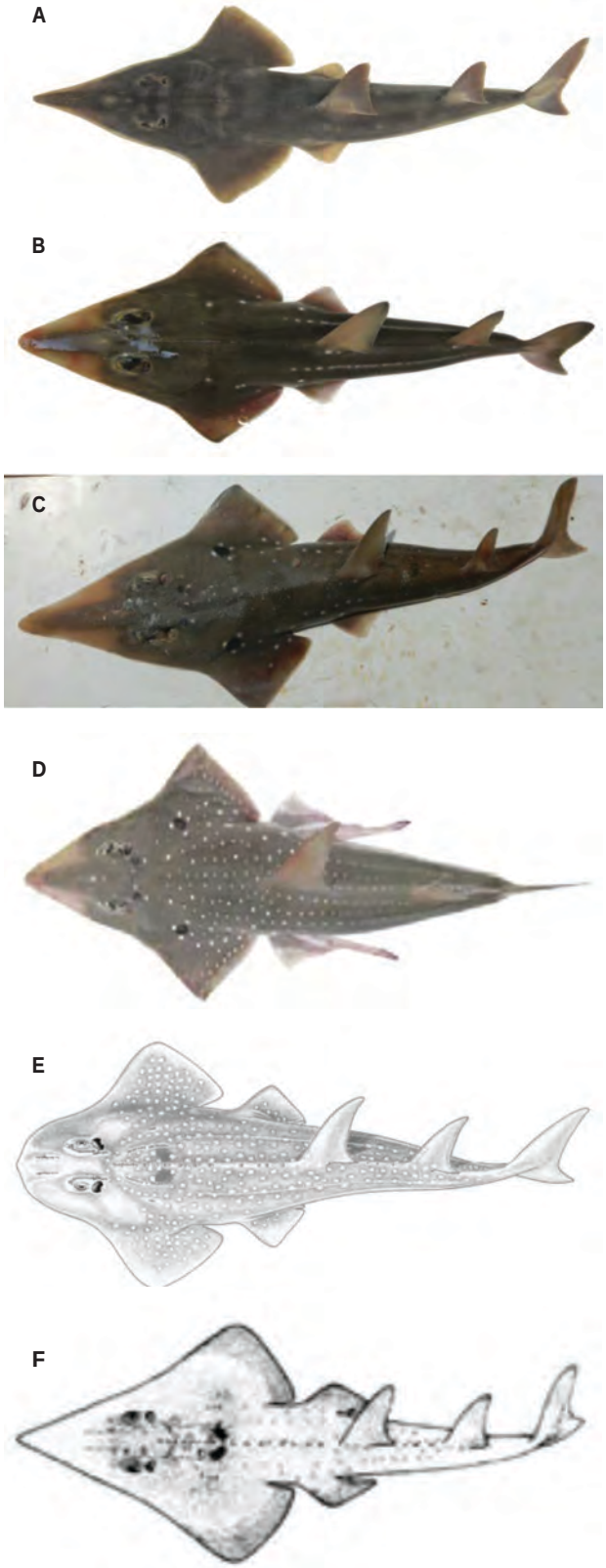

Figure 5. A - *Rhynchobatus cooki*; B - *Rhynchobatus immaculatus*; C - *Rhynchobatus laevis*; D - *Rhynchobatus springeri*; E - *Rhynchorhina mauritaniensis*; F - *Rhynchobatus luebberti*

Source: Presentations made during the 2019 Regional Consultation for the Development of Common Position on the Newly Proposed Listing of CEAS into the CITES Appendices (SEAFDEC, 2019 unpublished)

Way Forward

SEAFDEC has continued to provide the platform for the AMSs to discuss and develop common positions on the proposed listings of CEAS into the CITES Appendices during the CITES CoP. For example, in preparation for the CITES CoP18 which was originally scheduled in May 2019 in Sri Lanka, SEAFDEC convened the Regional Consultation for Development of the ASEAN-SEAFDEC Common Position on the Proposed Listing of Commercially-exploited Aquatic Species into the CITES Appendices on 30-31 January 2019 in Bangkok, Thailand. Results of the said Regional Consultation indicated that the AMSs have no common position to support most of the proposals except for the proposed listing of the Mako sharks, wherein the common position of the AMSs is not to support the said proposed listing (**Table 2**).

Table 2. Synthesis of the Newly Proposed Listing of CEAS in CITES Appendices

Proposals	Status of fisheries of species in Southeast Asia	Recommendations for conservation and utilization	Remarks
Inclusion of the blackchin guitarfish (*Glaucostegus cemiculus*) and the sharpnose guitarfish (*Glaucostegus granulatus*), and all of other giant guitarfish, *Glaucostegus* spp. in Appendix II	• Catch of these species has been recorded in Southeast Asia except for *Glaucostegus cemiculus* • Only few *G. granulatus* had been caught in Thailand, while reports indicate that this species had been observed to be distributed in Viet Nam • There is no record of catch of *Glaucostegus* spp. in Cambodia, Japan, Myanmar • Although *Glaucostegus* spp. had been reported to be caught in the waters of Indonesia, Malaysia and Viet Nam, there is no species specific information (*e.g.* oftentimes these are recorded together with sharks) • There is no record of catch of *Glaucostegus* spp. in the Philippines	• *Glaucostegus cemiculus* and *G. granulatus* are not reported in the Southeast Asian region, while other species under the Genus Glaucostegus are caught as "by-catch," so listing of the species into the Appendix II of CITES would not reduce the catch of these species • Promotion of better management schemes, *e.g.* by-catch reduction, use of selective fishing gears, would therefore be the more appropriate approaches for the conservation of the species	• No common position to SUPPORT the Proposal
Inclusion of the following three species belonging to the subgenus Holothuria (Microthele): *Holothuria (Microthele) fuscogilva, Holothuria (Microthele) nobilis* and *Holothuria (Microthele) whitmaei*, in Appendix II	• The three species proposed for listing are distributed in the Southeast Asian waters, but the catch data has not been classified at species level (*i.e.* catch is generally grouped as sea cucumbers) • Based on scientific evidence, the three species proposed are found to be over-exploited in most range States, while the major threats are not only from fishing activities but also due to habitat destruction and pollution • Besides the three species proposed, there are nearly 40 species of sea cucumbers distributed in the region which could be considered as look-alike species, making it difficult to distinguish the species from their products, *e.g.* in dried and powdered forms • The species of sea cucumber widely cultured in the region is *Holothuria scabra*, in Thailand, Philippines, Malaysia, and Viet Nam, hatchery technologies have been developed for some *Holothuria* species (but not on the three species proposed), mainly for stock enhancement purposes as well for commercial aquaculture, and in Indonesia, sea cucumber culture relies mainly on wild seeds, and the country is still in the process of developing the hatchery techniques for sea cucumbers • There are existing management measures for sea cucumbers adopted by the countries in the region, *e.g.* one island in Malaysia has been declared as sea cucumber sanctuary; the Philippines allows the commercial export of only the dried whole sea cucumber meat with the minimum size limit of 5-cm in length regardless of the species; while Cambodia has established a working group to identify and protect the aquatic species listed as endangered and under CITES	• While fisheries management measures for sea cucumbers are being promoted in some countries in the region, *e.g.* in the Philippines, such effort should be strengthened • The potentials for hatchery production of teatfish should be explored to support prospects for aquaculture and stock enhancement	• No common position to SUPPORT the Proposal

Table 2. Synthesis of the Newly Proposed Listing of CEAS in CITES Appendices *(Cont'd)*

Proposals	Status of fisheries of species in Southeast Asia	Recommendations for conservation and utilization	Remarks
Inclusion of the short-fin Mako shark, *Isurus oxyrinchus* and long-fin Mako shark *Isurus paucus* in Appendix II	• Short-fin Mako shark is under the management of several RFMOs, and stock assessments have been undertaken, coming up with the following information on its stock status: o In North Atlantic, stock evaluation (undertaken by ICCAT in 2017) indicated that the stock was overfished and since overfishing was continuing, conservation and management measures had been adopted in 2017 o In the North Pacific, stock evaluation (undertaken by the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC) in 2018) showed that the stock was not overfished and that overfishing was not occurring o In both North Atlantic and North Pacific, the stock status does not meet the criteria for listing of the species into the CITES Appendices o In the Indian Ocean, the Indian Ocean Tuna Commission (IOTC) plans to undertake stock assessment in 2020, nevertheless, the CPUE data does not show a marked increasing or decreasing trend	• As the proposed species are not targeted in the Southeast Asian region but is caught as "by-catch," listing of the species into the CITES Appendix II would not reduce the catch of these species. • Promotion of better management schemes should therefore be the more appropriate measures for the conservation of the species • Listing of the species should be considered taking into account the situation that the stock status does not meet CITES listing criteria and that implementation challenges are expected	• Common position is NOT TO SUPPORT the Proposal
Inclusion of the two species commonly referred to as the white-spotted wedgefish, *Rhynchobatus australiae* and *Rhynchobatus djiddensis* in Appendix II, and inclusion of all other species in the Family Rhinidae (wedgefish): *Rhynchobatus cooki, Rhynchobatus immaculatus, Rhynchobatus laevis, Rhynchobatus luebberti, Rhynchobatus palpebratus, Rhynchobatus springeri, Rhynchorhina mauritaniensis, Rhina ancylostoma*, and any other putative species of Family Rhinidae in Appendix II	• Out of the ten proposed species, six species are distributed in the Southeast Asian waters • From the stock assessment based on available data, the species population had been observed to have declined in most regions including the Southeast Asian region, nonetheless, the available data is still insufficient to determine whether the species meet the criteria for listing in CITES Appendix II • From the 1-year data collection undertaken by SEAFDEC in selected Member Countries, wedgefishes were caught as by-catch, but with very low composition in the total catch, and despite the limited data that may not be able to represent the status of the species, it could be observed that most species are still easily found in the region and not over-exploited	• As the proposed species are not targeted in the Southeast Asian region but caught as "by-catch," listing of the species into the CITES Appendix II might not reduce the catch of these species. • Promotion of better management schemes for reduction of by-catch should therefore be the more appropriate measures for the conservation of the species	• No common position to SUPPORT the Proposal

As the CITES CoP 18 had been rescheduled for August 2019 in Geneva, Switzerland, the positions of the AMSs with respect to the newly proposed listing of CEAS into the CITES Appendices would be raised by the representatives from the AMSs during the said CoP. It should be noted that such common positions of the AMSs have been submitted for endorsement by the SEAFDEC Council and subsequently by the ASEAN Working Group on Fisheries (ASWGFi), and finally endorsed by the Senior Officials Meeting of the ASEAN Ministers on Agriculture and Forestry (SOM-AMAF).

Furthermore, in order to strengthen the views of the AMSs with regards to the conservation efforts carried out by the AMSs on the CEAS that merit the development of the common positions for the proposed listing of some CEAS into the CITES Appendices, SEAFDEC with financial assistance

Table 3. Possible impacts of the listing of new CEAS into CITES Appendix II

Proposals	Possible Impacts of Proposed Listings into CITES Appendix II
• Inclusion of the blackchin guitarfish (*Glaucostegus cemiculus*) and the sharpnose guitarfish (*Glaucostegus granulatus*), and all of other giant guitarfish, *Glaucostegus* spp. in Appendix II	• Although *Glaucostegus cemiculus* and *G. granulatus* are not reported in the Southeast Asian region, if these species are listed in the Appendix II, this might have an impact on the trade of other species under this Genus and their products • More trained officers would be needed in the field (landing ports) to identify the catch up to the species level, and also identify the products from these other species • If these species are listed in the Appendix II, it is likely that the other species under the Genus Glaucostegus found in the region would also be proposed for listing in Appendix II in the future • There is need to conduct an assessment to support the development of non-detriment finding (NDF) documents to sustain the trade of the listed as well as the look-like species
• Inclusion of the following three species belonging to the subgenus Holothuria (Microthele): *Holothuria (Microthele) fuscogilva, Holothuria (Microthele) nobilis* and *Holothuria (Microthele) whitmaei*, in Appendix II	• The listing might create impacts to the trade of products from other species of the same Genus that could not be identified from the product forms (particularly powdered form, as dried teatfish could be easily distinguished) at the entry or exit point of the countries • Other species could also be proposed for listing in the Appendix II in the future. • Data on catch and status of the proposed species from all Southeast Asian countries are still insufficient, so the listing of the species might lead to difficulties in data collection in the future • Although CITES would support the data collection once the species are listed in the CITES Appendices, such data collection would require considerable amount of investments from donors. • Listing of the proposed species into the CITES Appendix II could result in increased illegal trade of the species in the future
• Inclusion of the short-fin Mako shark, *Isurus oxyrinchus* and long-fin Mako shark *Isurus paucus* in Appendix II	• If the proposed species are listed under the CITES Appendix II, trade of the species might require NDF documents • Implementation issues might emerge, such as introduction from the sea
• Inclusion of the two species commonly referred to as the white-spotted wedgefish, *Rhynchobatus australiae* and *Rhynchobatus djiddensis* in Appendix II, and inclusion of all other species in the Family Rhinidae (wedgefish): *Rhynchobatus cooki, Rhynchobatus immaculatus, Rhynchobatus laevis, Rhynchobatus luebberti, Rhynchobatus palpebratus, Rhynchobatus springeri, Rhynchorhina mauritaniensis, Rhina ancylostoma*, and any other putative species of Family Rhinidae in Appendix II	• If the species are listed in the Appendix II, the trade of other species and their products (*e.g.* guitarfishes) would create some impacts, *e.g.* more officers in the field (landing ports) would be necessary to classify the catch up to the species level, and also identify the products from other species (*e.g.* dried fins) • Implementation issues might emerge, such as introduction from the sea

from the Japanese Trust Fund would support the participation in the upcoming CITES CoP, of additional representatives from some AMSs, namely: Cambodia, Lao PDR, Myanmar, and Viet Nam, as well as the representative from Malaysia who served as Chairperson during the Regional Consultation for Development of the ASEAN-SEAFDEC Common Position on the Proposed Listing of Commercially-exploited Aquatic Species into the CITES Appendices on 30-31 January 2019 in Bangkok, Thailand.

Meanwhile, SEAFDEC continues to monitor the developments in the international arena related to the conservation of CEAS and the movements that eventually lead to the proposals for the listing of CEAS in the CITES Appendices. In the Southeast Asian scenario, SEAFDEC sustains its efforts in promoting the sustainable development of fisheries for food security in the region.

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About the Authors

Ms. Suwanee Sayan is the Policy and Program Officer of SEAFDEC based at SEAFDEC Secretariat in Bangkok, Thailand, and currently, the Assistant Coordinator of the Project "Assistance for Capacity Building in the Region to Address International Fish Trade-related Issues."

Dr. Worawit Wanchana is the Policy and Program Coordinator of SEAFDEC based at SEAFDEC Secretariat in Bangkok, Thailand, and currently, the Coordinator of the Project "Assistance for Capacity Building in the Region to Address International Fish Trade-related Issues."

Mr. Lawrence Kissol, Jr. is a Senior Fisheries Officer of the Marine Resource Management Office, CITES and Conservation of Endangered Species Unit, Department of Fisheries Sabah, Malaysia. He was elected Chairperson for the **Regional Consultation for Development of the ASEAN-SEAFDEC Common Position on the Proposed Listing of Commercially-exploited Aquatic Species into the CITES Appendices** convened by SEAFDEC on 30-31 January 2019 in Bangkok, Thailand.

Ms. Virgilia T. Sulit is the Managing Editor of *Fish for the People* based at the SEAFDEC Secretariat in Bangkok, Thailand, and Member of the Secretariat of the 2019 Regional Consultation.

Paving the Way for the Development of Non-detriment Findings: Towards precise species identification of sharks and rays in Southeast Asia

Sukchai Arnupapboon, Ahmad Ali, Worawit Wanchana, and *Virgilia T. Sulit*

CITES defines non-detriment finding as "*a conclusion by a Scientific Authority that the export of specimens of a particular species will not impact negatively on the survival of that species in the wild. The non-detriment finding by a Scientific Authority is required before an export or import permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-I species, and before an export permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix-II species*." Many species of sharks and rays have been listed in the CITES Appendices in view of the increasing exploitation of such species that has become an international concern resulting in the promotion of their conservation and management through the enforcement of trade management measures and control. Considering that listing of commercially-exploited aquatic species in the CITES Appendices, *e.g.* sharks and rays, would have certain impacts not only on the management of the fisheries of these species but also on the economies of many countries of the region that have been trading some of the species and their "look-alikes" as well as trading in parts of their processed forms, SEAFDEC has been implementing projects that would help the Southeast Asian countries in addressing the issues concerning such species that had been listed in the CITES Appendices. In the case of sharks and rays, SEAFDEC has been supporting the countries in their efforts to improve data collection, especially in recording the landings of sharks and rays at species level, by enhancing the capacities of the countries in species identification. With sufficient knowledge and skills in the precise identification of the species found in the waters of Southeast Asia, the countries could continue trading the commercially-exploited aquatic species that are listed in the CITES Appendices provided these are accompanied with non-detriment findings. Thus, SEAFDEC has also been advocating the establishment of non-detriment findings that provide the scientific evidence to prove that trading of such commercially-exploited aquatic species would not endanger the survival of the wild populations of such species.

Among the approximately 100 commercially-exploited aquatic species (CEAS) listed in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as of 2016, 12 species of sharks and 18 species of rays had been listed under the CITES Appendices. Specifically, the basking shark (*Cetorhinus maximus*), whale shark (*Rhincodon typus*), oceanic whitetip shark (*Carcharhinus longimanus*), porbeagle shark (*Lamna nasus*), scalloped hammerhead shark (*Sphyrna lewini*), smooth hammerhead shark (*Sphyrna zygaena*), great hammerhead shark (*Sphyrna mokarran*), great white shark (*Carcharodon carcharias*), silky shark (*Carcharhinus falciformis*), pelagic thresher shark (*Alopias pelagicus*), bigeye thresher shark (*A. superciliosus*), and thresher shark (*A. vulpinus*) had been listed in Appendix II of CITES. For rays, all six species of sawfishes (family Pristidae) had been listed in Appendix I, while all 12 species of devil rays (three species of manta and nine species of mobula) are listed in Appendix II of CITES (**Table 1**).

CITES which was entered into force on 1 July 1975, is an international agreement among governments that works towards ensuring that the international trade in specimens of wild animals and plants does not threaten their survival in the wild. Sets of criteria and guidelines have therefore been developed by CITES for the evaluation of CEAS, whether or not a certain species should be listed under the CITES Appendices. Once listed in the CITES Appendices, the specimens of such species would be subjected to certain international trade controls, which implies that all import, export, re-export, and introduction from the sea of such species must be authorized through a licensing system indicating the relevant information on the effects of trade on the status of the species, which could be proven through the development of non-detriment findings (NDFs). Nonetheless, the inclusion of any CEAS in the CITES Appendices would serve as means of addressing the problem on the conservation and management of such species.

Improvement of Data Collection for Development of NDFs

Although the waters of Southeast Asia is believed to host the richest elasmobranch diversity in the world, the actual status of such resources, *e.g.* sharks and rays, could not be established due to various reasons that include the inadequacy of data on catch landings and utilization at species level (Wanchana *et al.*, 2016a). It is also the same situation that contributes to the difficulties of the ASEAN Member States (AMSs) in their efforts of pursuing the sustainable management of sharks and rays fisheries and in complying with relevant international requirements to avoid the listing of certain species of sharks and rays in the CITES Appendices.

CITES enforces some controls for the trade in specimens of species listed in the CITES Appendices to ensure that trading of such species or parts and products derived thereof would not be detrimental to the survival of the species in the wild. One of the control measures is through the NDFs which provide the assurance that the harvest and trade of such species do not harm the wild populations. The development of NDFs

is required even before any of the listed species intended for the export market or introduced from the sea are fished and landed, where introduction from the sea refers to the landing of CITES-listed species taken from the high seas and not under the jurisdiction of any State (Mundy-Taylor *et al*., 2014). The first step in developing NDFs is information gathering (**Table 2**), which also implies that the available information should focus on the species being considered for the development of the NDFs. At the Southeast Asian scene, this would require the need to improve the data collection systems, especially for the species of international concern, *e.g.* CEAS that include sharks and rays.

Table 1. Species of sharks and rays listed in the CITES Appendices (as of 2016).

English Name	Scientific Name	CITES Appendix	Year listed
Basking shark	*Cetorhinus maximus*	Appendix II	2002
Whale shark	*Rhincodon typus*	Appendix II	2002
Great white shark	*Carcharodon carcharias*	Appendix II	2004
Porbeagle shark	*Lamna nasus*	Appendix II	2014
Oceanic whitetip shark	*Carcharhinus longimanus*	Appendix II	2014
Scalloped hammerhead shark	*Sphyrna lewini*	Appendix II	2014
Great hammerhead shark	*Sphyrna mokarran*	Appendix II	2014
Smooth hammerhead shark	*Sphyrna zygaena*	Appendix II	2014
Silky shark	*Carcharhinus falciformis*	Appendix II	2016
Thresher sharks (all three species)	*Alopias* spp.	Appendix II	2016
Sawfishes (all 6 species)	*Pristis* spp. and *Anoxypristis cuspidata*	Appendix I	2007
Manta rays (all three species)	*Manta* spp.	Appendix II	2014
Mobula rays (all nine species)	*Mobula* spp.	Appendix II	2016

Table 2. Structure of the NDF process for sharks and rays (adapted from Mundy-Taylor *et al*., 2014)

Steps	Sections	Concerns to be addressed
Information gathering		
1. Preliminary considerations and information gathering	1.1 Review origin and identification of specimen	1.1a Is the specimen subject to CITES controls?
		1.1b Where or from which stock of the species, was (will) the specimen (be) taken?
	1.2 Review legality of acquisition and export	1.2 Was (will) the specimen (be) legally obtained and is export allowed?
	1.3 Compile information on management context	1.3 What does the available management information tell us?
NDF development		
2. Intrinsic biological vulnerability and conservation concern	2.1 Evaluate intrinsic biological vulnerability	2.1 What is the level of intrinsic biological vulnerability of the species?
	2.2 Evaluate conservation concern	2.2 What is the severity and geographic extent of the conservation concern?
3. Pressures on species	3.1 Evaluate trade pressures	3.1 What is the severity of trade pressure on the stock of the species concerned?
	3.2 Evaluate fishing pressures	3.2 What is the severity of fishing pressure on the stock of the species concerned?
4. Existing management measures	4.0 Evaluate whether management is adequate to mitigate the concerns, pressures, and impacts identified	4.1a Are existing management measures appropriately designed and implemented to mitigate the pressures affecting the stock or population of the species concerned?
		4.1b Are existing management measures effective (or likely to be effective) in mitigating the pressures affecting the stock or population of the species concerned?
5. Non-detriment Finding and related advice	5.0 Based on the above evaluations, use judgment to make a Non-detriment Finding by setting mandatory NDF conditions, if required, and provide related advice	5.1 What is the final outcome of the previous steps? Based on the outcomes of the previous steps, the Scientific Authority should use its judgment to decide whether: Is it possible to make a positive NDF (with or without associated conditions? OR Is a negative NDF required?
NDF is completed		
6. Further measures		6.1 Identify actions necessary to implement or improve monitoring, management, and other measures

Capacity Building for Improved Collection of Information on Sharks and Rays

The Southeast Asian Fisheries Development Center (SEAFDEC) through its Training Department (SEAFDEC/TD) and Marine Fishery Resources Development and Management Department (SEAFDEC/MFRDMD) has been promoting the improvement of data collection of sharks and rays found in the Southeast Asian waters, by carrying out several activities generally aimed at enhancing the capability of the region's fisheries sector in compiling and utilizing sharks and rays statistics and information to support the sustainable management of the fisheries of such commodities, as well as boosting the understanding of concerned stakeholders about the resource situation of sharks and rays in Southeast Asia.

In one of the Technical Meetings organized by SEAFDEC in 2013, a major finding confirmed that the national statistics on sharks and rays compiled by the Southeast Asian countries have been reported by groups (*i.e.* sharks or rays) and not by species. Moreover, recording of essential information such as biological data has been insufficient due to inadequate number of enumerators capable of identifying sharks and rays at species level. Thus, it was agreed that the regional activities on sharks and rays should start with building the national capacities of the concerned ASEAN Member States (AMSs) in identifying the species of sharks and rays, while robust national shark landing data collection systems should also be established.

National taxonomic activity for proper identification of shark and ray species based on SOP developed by SEAFDEC

While efforts had been sustained to address the concerns on sharks and rays data collection in the Southeast Asian region, regional training-cum-workshops were organized by SEAFDEC to improve the capacities of relevant stakeholders in the AMSs on elasmobranch identification at species level, with initial focus given to trainers capable of conveying the knowledge gained to the local shark landing enumerators in their respective areas of assignments. In 2015, the participating countries from the AMSs agreed on the format and template for data collection on sharks and rays, leading to the development by SEAFDEC of the Standard Operating Procedures (SOPs) for sharks and rays data collection (Wanchana *et al*., 2016b; SEAFDEC, 2017).

Regional Activities on Sharks and Rays Data Collection and Species Identification

In support of the region's efforts towards sustainable management of sharks and rays fisheries in the waters of Southeast Asia, SEAFDEC with financial support from the Government of Japan through the Japanese Trust Fund and the European Union (EU) through the CITES Secretariat, implemented the "Regional Project on Sharks and Rays Data Collection" starting in 2015. To date, the major outputs of the Regional Project included: 1) initial compilation of regional sharks and rays data at species level in the Southeast Asian region; 2) improved human resources capacity of concerned AMSs on sharks and rays identification and data collection; 3) updated information on sharks and rays in the Southeast Asian region; and 4) national reports on landings of sharks and rays.

In order to step up the region's efforts to promote the sustainable management of sharks and rays resources, a stock assessment model was established which is appropriate for converting landing data on sharks and rays stocks into scientific information. The "Yield Per Recruit Model" or YPR Model" (Pattarapongpan, 2018) was therefore adapted considering the short-term data situation in the Southeast Asian region. Consequently, training-workshops were organized by SEAFDEC in 2018 to strengthen the capacity of researchers from the SEAFDEC Member Countries on stock assessment of sharks and rays using YPR Model. The important aspect of using the YPR model is the quantification of the effect of size selection and fishing mortality on the yield from a fixed number of individuals that enters the fisheries, *i.e.* recruitment, by incorporating the growth parameters as inputs for the model. However, during the 2018 training, it was found that the growth parameters estimated from the length frequency data, appeared biased due to insufficient landing data. In obtaining the accurate growth parameters, the ideal number of fish samples should be at least 500 tails for each species and the length measurements of the samples must comprise the lengths of all samples from small to large size. This situation led to some difficulties in estimating the YPR of the targeted shark species based on the data available in the Southeast Asian region. Nevertheless, in determining the reliable growth parameters, the use of length-at-actual age analysis could be pursued. This led to an agreement during the 2018 training that the age-length analysis should be adopted to be able to determine the accurate growth rate. As a result, the training workshop on age determination was organized by SEAFDEC in April 2019 for the main purpose of building the human resource capacity of the AMSs in this aspect.

Building on the progress of the regional activities carried out by SEAFDEC from 2013 to 2018, the CITES Secretariat collaborated with SEAFDEC through a Small-Scale Funding Agreement (SSFA) and provided assistance to the four (4) information-poor AMSs Parties, *i.e.* Cambodia, Myanmar, Philippines, Viet Nam, on the improvement of their systems of collecting catch data on sharks and rays at species level. Moreover, the SSFA is also meant to support the other

three (3) AMSs Parties, *i.e.* Indonesia, Malaysia, Thailand, where data is already available for the development of their respective national NDFs. More specifically, the SSFA is aimed at improving the capacity of the AMSs in developing robust NDFs for CITES-listed species of sharks and rays by supporting the compilation of primary data to make sure that all Parties in the AMSs, especially those that have no or limited or little available data due to inadequate data collection systems, would be able to develop their respective national NDFs.

National Capacity Building in Data Compilation of Sharks and Rays at Species Level

Under the SSFA, national workshops have therefore been organized by SEAFDEC to continue the process of compiling catch data on sharks and rays, especially in countries where data had been insufficient for developing the national NDFs, *e.g.* Cambodia, Myanmar, Philippines, and Viet Nam. Considering the results of data collection activities during 2013-2018, SEAFDEC has continued to promote the compilation of landing data on sharks and rays at species level in selected landing sites of the aforementioned four countries.

Promoting the guidelines on photography techniques for taxonomic and stock assessment purposes

National capacity building activities had therefore been carried out with the main objective of enhancing the capacity of enumerators in the proper identification of sharks, rays and skates at species level as well as in the management of their respective landing data compilations (SEAFDEC, 2019 unpublished). Hands-on practice on species identification, length measurement and weight recording of the samples of selected specimens was carried out. Some samples of sharks and rays were taken back to the laboratories for the photography training sessions using the SOP on Sharks, Rays, and Skates Data Collection in the Southeast Asian Waters (SEAFDEC, 2017) as reference during the training on the techniques for taking photographs of sharks and rays for taxonomic purposes. Practical sessions on the use of the standard template for data compilation and management were also organized to enhance the knowledge and skills of the enumerators in this aspect of their works.

National Workshop and Training on Sharks Data Collection for Enumerators in Myanmar

Organized in Yangon, Myanmar (**Figure 1**), the National Workshop on 22-24 July 2018 was mainly aimed at enhancing the capacity of enumerators from the Department of Fisheries of Myanmar in identifying sharks, rays and skates at species level, as well as in promoting landing data management for sharks and rays.

Thus, the process for systematically recording and reporting the landings of sharks and rays at species level had been initiated; results from the 2017 shark data collection in Myanmar as well as the summary of the regional data had been disseminated; shark data collection plan in Myanmar established; and four collection sites had been identified (**Figure 1**), *i.e.* Haingyi Island in Ayeyarwady Division, Tabotseik at Launglone Township in Tanintharyi Division, Ye in Mon State, and Yangon. The Training in Myanmar paved the way for the country to fulfill the CITES provisions for trade of certain species of sharks and rays listed in Appendix II of the CITES Appendices.

Figure 1. Map of Myanmar showing the collection sites for data on sharks and rays

National Workshop and Training on Sharks Data Collection for Enumerators in Cambodia

Phreah Sihanouk Province in Cambodia was the venue of the National Workshop on 20-22 August 2018, which came up with a tentative plan and an agreement on the landing sites to be considered. These are in Kampot and Preah Sihanouk (**Figure 2**). The Training supported the efforts of the country to collect primary data on sharks landed and to record the information at species level. More specifically, the Training enhanced the knowledge of the enumerators on the need to compile the country's landing information on sharks and rays, as well as on the appropriate management and utilization of the data collected in 2016. The enumerators also improved their

Figure 2. Map of Cambodia showing Kampot and Phreah Sihanouk Provinces

skills in the taxonomic analysis of elasmobranch species and mustered their capacity in data collection based on the SOP on Sharks, Rays, and Skates Data Collection in the Southeast Asian Waters (SEAFDEC, 2017).

National Workshop and Training on Sharks Data Collection for Enumerators in Viet Nam

The National Workshop in Vung Tau, Viet Nam on 27-28 September 2018 followed the same framework of the Project as well as the experience from the one-year sharks/rays data collection activities in 2017. Two landing sites were identified for the data collection activities, *i.e.* Ben-Da in An Giang Province and Phuoc Tinh in Vung Tau Province (**Figure 3**). Development of the text and contents for posters and books on sharks, skates and rays of Viet Nam had been initiated.

Thus, Viet Nam would continue to collect landing data and other relevant information on sharks and rays after the country's enumerators shall have already been capacitated to implement the SOP on Sharks, Rays, and Skates Data Collection in the Southeast Asian Waters (SEAFDEC, 2017)

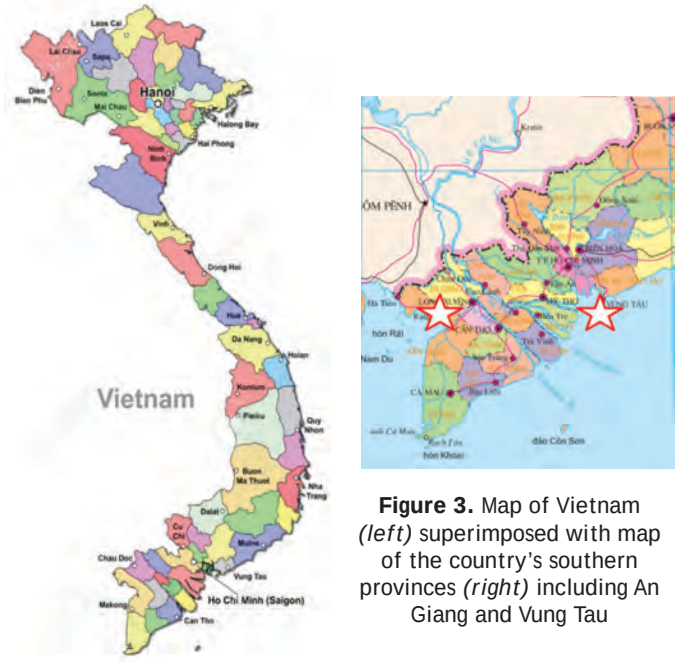

Figure 3. Map of Vietnam *(left)* superimposed with map of the country's southern provinces *(right)* including An Giang and Vung Tau

National Workshop and Training on Sharks Data Collection for Enumerators in the Philippines

The Training on Taxonomic Identification based on the Data Collection Protocol for Sharks and Rays was organized in Iloilo City, Philippines on 15-17 January 2019 in close collaboration with the Philippine Bureau of Fisheries and Aquatic Resources (BFAR).

The venue was crucial for the Training because Region VI (Western Visayas) of the Philippines comprising the Provinces of Iloilo, Antique, Aklan, Capiz, Guimaras, and Negros Occidental (**Figure 4**), is surrounded by productive fishing grounds, of which the Visayan Sea and Guimaras Strait are known fishing grounds for sharks and rays species. Moreover,

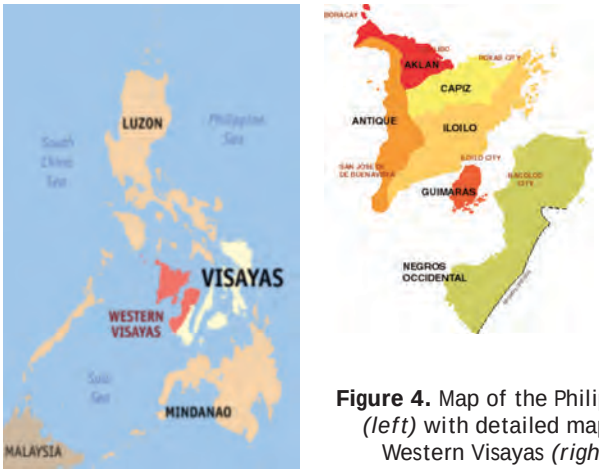

Figure 4. Map of the Philippines *(left)* with detailed map of Western Visayas *(right)*

BFAR records also show a long-term series of catch landings for sharks and rays in Western Visayas, but the veracity of the taxonomic identification in terms of species classification of such landings is still not certain due to the inadequacy of the needed expertise.

The Training was therefore considered crucial for the field enumerators of the Philippines, especially those coming from the Western Visayas, for henceforth they would be able to report the data on sharks and rays not only in terms of volume of catch but also classified in terms of species. Compilation of biological information as well as establishment of the catch and effort of the sharks and rays landings, were also notable for the enumerators as the stock status of certain targeted sharks and rays species could be determined. These information are necessary for the establishment of the country's NDFs for sharks and rays species, considering that catch, trade and utilization data have not been properly documented and/or reported before.

Identification of shark and ray specimens at species level based on the Key to Order of Sharks, Rays and Skates; and Key to Family of Sharks and Rays

Examination of the internal organs of shark specimens, especially its reproductive organs

Morphological study and species identification *(left)* using the Guides provided during the Training, leading to the identification of the shark sampled *(right)* as *Carcharhinus sorrah*

Nonetheless, various issues and concerns that confronted the enumerators during the course of their sampling activities were raised including: refusal of some boat operators and owners to divulge information on their landings of sharks and rays; difficulties in identifying the species as most of the sharks and rays have already been cut into pieces prior to landing; absence of gills, fins, and other parts when sharks and rays are landed; difficulties in collecting information, especially for those species that have been regulated under the Philippine Fisheries Administrative Order or FAO 193 or the "Ban on the Taking or Catching, Selling, Purchasing and Possessing, Transporting and Exporting of Whale Sharks and Manta Rays." Moreover, an apprehension was raised by fishers about the collection of data and information on sharks and rays as the information could be used by BFAR to develop regulations to ban the catching of other species of sharks and rays. Small-scale fishing boats in the Philippines with no registration numbers also made it difficult for enumerators to properly record the relevant and required information.

Way Forward

The proposed listing of commercially exploited aquatic species (CEAS) into the Convention on the CITES Appendices is one of the crucial issues that could impact not only on the management of fisheries but also on the economies of the countries in the region. Such impacts are anticipated not only as a result of regulation in trade of the species being listed into the CITES Appendices, but also trade of look-alike species, as well as trade in parts or processed forms of the species. Furthermore, the listing of species into the CITES Appendices could lead to the termination of data collection on landings of such species, resulting in the unavailability of data and information on the status of the species.

With the aforesaid concerns as the backdrop, SEAFDEC would continue to follow-up with the abovementioned four countries on the progress of their efforts to improve the compilation of data and information on sharks and rays at species level. Moreover, SEAFDEC would also organize national workshops in the three countries where data is available for the development of NDFs, *i.e.* Indonesia, Malaysia, and Thailand. The NDFs developed by these countries would be shared with the other Southeast Asian countries as well as with the other Parties to CITES through the CITES mechanism.

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About the Authors

Mr. Sukchai Arnupapboon is the Head of Fishing Ground and Fishery Oceanography Section of SEAFDEC Training Department (TD) based in Samut Prakan, Thailand, and has been involved in the capacity building activities of the SEAFDEC Regional Project on Sharks and Rays.

Dr. Ahmad Ali is Senior Researcher from SEAFDEC Marine Fishery Resources Development and Management Department (MFRDMD) stationed at Terengganu, Malaysia, and is the Regional Shark Expert and Regional Vice Chair of the IUCN Sharks Specialist Group for the Southeast Asian Region since 2013.

Dr. Worawit Wanchana is the Policy and Program Coordinator of SEAFDEC based at SEAFDEC Secretariat in Bangkok, Thailand, and Coordinator of the SEAFDEC Regional Project on Sharks and Rays Data Collection in Southeast Asia.

Ms. Virgilia T. Sulit is the Managing Editor of *Fish for the People* based at the SEAFDEC Secretariat in Bangkok, Thailand, and has been involved in the capacity building activities of the SEAFDEC Regional Project on Sharks and Rays.

Sustained Utilization of SEAFDEC Vessels through Collaborative Research Surveys: Marine Resources Survey of the Gulf of Thailand using the M.V. SEAFDEC 2

Sukchai Arnupapboon, Suy Serywuth, Pavarot Noranarttragoon, Nguyen Van Minh, Taweekiet Amornpiyakrit, and *Isara Chanrachkij*

Cognizant of the state of depletion and to some extent, collapse of the fishery resources particularly in coastal areas, concerned ASEAN Member States (AMSs) have increasingly placed focus on the under-utilized marine fishery resources in the offshore areas of their respective Exclusive Economic Zones (EEZs). Many AMSs are therefore making considerations to exploit these offshore fishery resources to reduce fishing pressure on their respective coastal resources and give the coastal fishery resources respite for recovery and rebuilding (Garcia *et al*., 2018). The same concern was addressed by the AMSs during the June 2011 **ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2929 *"Fish for the People 2020: Adaptation to a Changing Environment"*** that led to the adoption of the "Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020," which include among others, the advocacy to: "*Investigate the potential of under-utilized fisheries resources and promote their exploitation in a precautionary manner based upon analysis of the best available scientific information*." Responding to such needs and requirements, the Southeast Asian Fisheries Development Center (SEAFDEC) through its Training Department (SEAFDEC/TD) has been working closely with the AMSs for the conduct of marine fishery resources surveys and studies on the marine environment of specific offshore areas, such as the Gulf of Thailand, Andaman Sea, and South China Sea, utilizing the SEAFDEC research vessels, the M.V. SEAFDEC and the M.V. SEAFDEC 2, that aim to collect information on the status of marine fishery resources and oceanographic conditions, as well as build the capacity of human resources in the aspects of fisheries and oceanographic surveys, onboard navigation practices, and marine engineering. The most recent of such surveys facilitated by SEAFDEC/TD, was the two-month "Collaborative Research Survey on Marine Fishery Resources and Marine Environment in the Gulf of Thailand" from 17 August to 18 October 2018 which made use of the M.V. SEAFDEC 2.

From 1993 to the present, SEAFDEC has helped the AMSs in the assessment of their respective fishery resources through collaborative research surveys in their respective EEZs utilizing the SEAFDEC research vessels (**Figure 1**). Specifically, the M.V. SEAFDEC (1178-GT purse seine research vessel) has been utilized for the conduct of regional collaborative surveys in the waters of the Southeast Asian countries, while the M.V. SEAFDEC 2 (211-GT research vessel) which started its operations in 2004, has been focusing on the assessment of the fishery resources through research surveys of the coastal and offshore areas of the AMSs (Sayan and Chanrachkij, 2019).

Figure 1. SEAFDEC research vessels: the M.V. SEAFDEC *(above)*, and the M.V. SEAFDEC 2 *(right)*

The information compiled from the collaborative research surveys had been analyzed, the results of which had been disseminated to the region in the forms of proceedings and technical reports (**Figure 2**) that served as basis for the development of guidelines and standard operating procedures for scientific surveys and responsible fishing operations. Moreover, the collaborative surveys have also enhanced the research and training capabilities of the participating countries while the technical cooperation among the AMSs has been strengthened towards the effective management of fisheries and the environment.

Collaborative Research Surveys on Marine Fishery Resources and Marine Environment: Gulf of Thailand

From 1995 to 2013, SEAFDEC/TD had carried out major collaborative marine fishery resources research surveys in the Gulf of Thailand using the M.V. SEAFDEC and the M.V. SEAFDEC 2. These included the surveys in 2005-2006 to monitor the fishery resources in Central Gulf of Thailand with

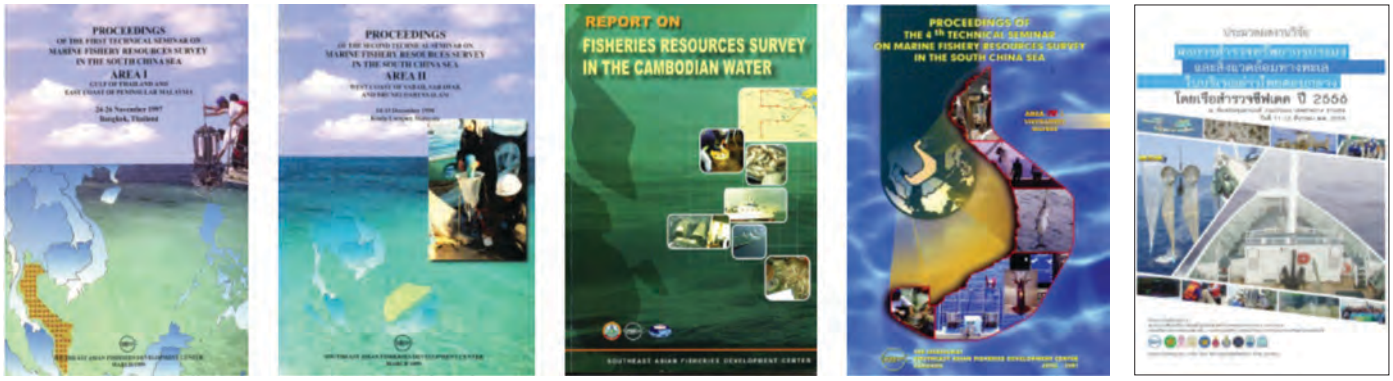


Figure 2. Some of the publications on the results of the collaborative research surveys conducted by SEAFDEC/TD since 1996

SEAFDEC/TD providing technical support to the Department of Fisheries (DOF) of Thailand including the use of the M.V. SEAFDEC 2. The survey results were reported in the DOF publication "National Report on Fishery Resources in the Middle Gulf of Thailand Surveyed by Otter Board Trawl during 2004-2005" (in *Thai*).

Although SEAFDEC/TD had undertaken a number of fishery resources and environmental surveys in the Gulf of Thailand during the past several years, these were mostly focused in the EEZ of Thailand. One of these surveys was the fisheries and environmental research survey within the EEZ of Thailand using the M.V. SEAFDEC from 14 March to 12 April 2013. Conducted by SEAFDEC/TD with support from the Petroleum Authority of Thailand (PTT) Exploration and Production Public Company Limited, the survey was a collaborative effort among relevant agencies and academic institutions in Thailand, *i.e.* Department of Fisheries, Department of Coastal and Marine Resources, Pollution Control Department, Burapa University, Chulalongkorn University, Kasetsart University, Ramkamhaeng University, and Walailuk University.

When the results of the aforesaid survey were presented during the Seminar "Results of Fisheries and Environmental Research Survey in the Gulf of Thailand" organized in early 2018, it was recommended that the oceanographic study in the Gulf of Thailand (**Figure 3**) should be continued, specifically focusing on the water stratification and influence from the South China Sea into the Gulf of Thailand, both spatial and temporal conditions. In addition, the Standard Operational Procedures for Data Collection for the M.V. SEAFDEC 2 (SEAFDEC, 2004) should be updated and used as reference for future surveys. Another very important recommendation during the 2018 Seminar was the expansion of the survey area to include the waters of Cambodia and Viet Nam, to take into consideration the transboundary nature of the marine aquatic species in the Gulf of Thailand, and the importance of studying the hydrography and oceanography of the habitats of particular straddling marine aquatic species, *e.g.* Indo-Pacific mackerel which spawns in the eastern part of the Gulf of Thailand but the broodstock is believed to straddle within the waters of Cambodia, Thailand, and Viet Nam.

Thus, with support from the Government of Japan through the Japanese Trust Fund (JTF), the Collaborative Survey on Marine Fisheries Resources and Marine Environment in the Gulf of Thailand was carried out under the JTF Project

Figure 3. Map of Gulf of Thailand bounded by Thailand, Cambodia, Viet Nam, and Malaysia

Source: Google map

Figure 4. One hundred and ten (110) stations proposed for the 2018 collaborative survey, covering the EEZs of Cambodia, Thailand, and Viet Nam

"Offshore Fisheries Resources Exploration in Southeast Asia." With SEAFDEC/TD at the helm, the survey was planned to be carried out in the Gulf of Thailand (**Figure 4**) with the collaboration of the Fisheries Administration of Cambodia, Department of Fisheries of Thailand, and the Directorate of Fisheries of Viet Nam through its Research Institute for Marine Fisheries Research, from 17 August to 18 October 2018. Baseline data on marine fishery resources and marine environmental situation as well as the status of the marine fishery resources in the Gulf of Thailand, were then compiled to be used as scientific reference during the said collaborative survey.

2018 Collaborative Survey: the Processes

A collaborative survey, especially using the SEAFDEC vessels, starts with a survey plan developed through a series of Technical Consultation Meetings with the concerned national agencies of participating countries and SEAFDEC/TD. In the case of the 2018 Collaborative Survey, series meetings were organized with representatives from the three (3) participating countries in attendance, *i.e.* from the Research Institute for Marine Fisheries Research (RIMF) of the Directorate of Fisheries (D-FISH) of Viet Nam, Fisheries Administration (FiA) of Cambodia, and from the Department of Fisheries (DOF) of Thailand together with representatives from relevant national academic institutions and agencies in Thailand.

In order to finalize the survey plan for the 2018 Collaborative Survey, the Regional Technical Meeting on the Collaborative Research Survey on Marine Fisheries Resources and Marine Environment in the Gulf of Thailand (Cambodia, Thailand, and Viet Nam Waters) was organized by SEAFDEC/TD in July 2018, where the survey and cruise period was confirmed as well as the area to be covered and the number of survey stations, *i.e.* 24 stations in Cambodian waters, 62 in the waters of Thailand, and 24 in the waters of Viet Nam (**Figure 5**).

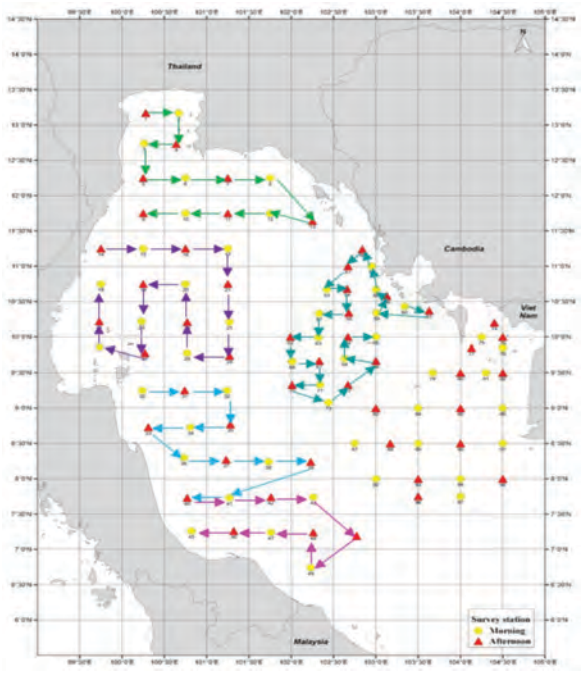


Figure 5. Map of the 2018 Collaborative Survey in the Gulf of Thailand using the M.V. SEAFDEC 2

Prior to the start of the actual survey, SEAFDEC/TD organized the Pre-Survey Meeting to finalize the list of survey device/equipment to be carried onboard (**Figure 6**), the list of researchers and scientists who would go onboard, the sampling operations and data collection activities onboard, and the shipboard research activities to be conducted. The detailed survey plan also includes provisions of hygienic supplies for crew and scientists, and safety measures onboard the research vessel. Moreover, the Cruise Order of the M.V. SEAFDEC 2 No. 51-1/2018 was also finalized as agreed upon by the participating countries.

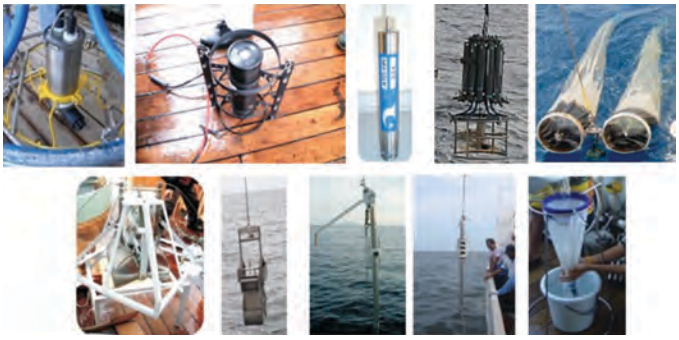


Figure 6. Major equipment carried onboard the M.V. SEAFDEC 2 for the collaborative survey *(clockwise from left)*: *(Top left)* CTD, portable CTD, rosette sampler, bongo net, neuston net, gravity core, Smith-McIntyre grab, box core, and Van Don water sampler

Furthermore, the Pre-Survey Meeting also finalized the operations and activities to be undertaken onboard the M.V. SEAFDEC 2 during the collaborative survey, as shown in **Box 1**.

Box 1. Detailed operations for the 2018 Collaborative Survey
Demersal fishery resources survey – using bottom trawl, to collect updated data on the status of the demersal fishery resources in the Gulf of Thailand, and specifically to determine the catch per unit effort (CPUE) of bottom trawls
Oceanographic survey – using CTD device, to collect relevant oceanographic parameters, *e.g.* conductivity, temperature, depth) in the various areas of the Gulf of Thailand
Microplastic and marine Debris survey – through ocular observation, to determine the microplstic and debris situation in the waters and environment of the Gulf of Thailand
Other surveys – includes activities to determine the radiation dose and assess the radiation risk in marine biota, as well as investigate the source of aerosol in the Gulf of Thailand, to be used as information to improve the weather predictions in the region

The Actual Survey

As planned, the collaborative survey from 17 August to 18 October 2018 using the M.V. SEAFDEC 2 was supposed to be carried out in six (6) legs. However, because of time and other constraints, the planned survey of the waters of

Table 1. Schedule of the survey operations in the Gulf of Thailand

Leg	Station Nos.	Areas surveyed	Date surveyed
Leg 1	No. 1 – No. 13	Upper Gulf of Thailand	17-26 August 2018
Leg 2	No. 14 – No. 29	Eastern Gulf of Thailand	27 August-7 September 2018
Leg 3	No. 30 – No. 41	Central Gulf of Thailand	8-16 September 2018
Leg 4	No. 41 – No. 49	Southern Gulf of Thailand	17-25 September 2018
Leg 5	No. 50 – No. 73	Waters of Cambodia	26 September-16 October 2018
Leg 6		Western waters of Viet Nam	Survey operations in Viet Nam waters were cancelled for some administrative and technical reasons

Figure 7. Survey and research activities carried out onboard the M.V. SEAFDEC 2 Cruise No.56-1/2018 - Collaborative Research Survey on the Marine Fisheries Resources and Marine Environment Survey in the Gulf of Thailand

Viet Nam was cancelled, as a result, only 73 survey stations were considered, *i.e.* 49 stations in the waters of Thailand, and 24 in the waters of Cambodia (**Figure 5**). Nonetheless, the operations in two (2) stations had to be cancelled, *i.e.* Station No. 20 in Thai waters because of rough bottom conditions in the area, and Station No. 50 in Cambodian waters considering the noticeable number of squid traps that were found spread in the area. Thus, only 71 survey operations were carried out, *i.e.* 48 operations in Thai waters and 23 operations in Cambodian waters. The survey schedule of the six legs is detailed in **Table 1**, corresponding to the survey plan laid out in **Figure 5**.

The Survey and Research Activities

The overall survey and research activities carried out during the 2018 Collaborative Survey on Marine Fisheries Resources and Marine Environment in the Gulf of Thailand are exhibited in **Figure 7**.

Demersal Fishery Resources Survey

The demersal fishery resources survey was undertaken using bottom trawl, and was aimed at updating the status of the

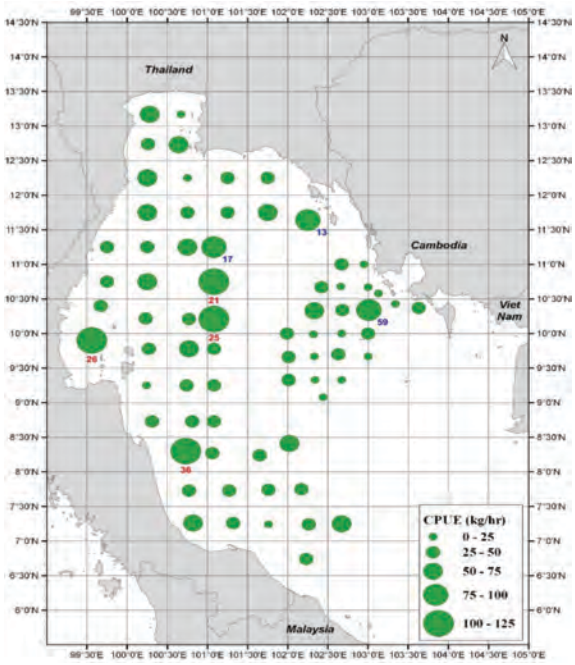


Figure 8. Preliminary results of the demersal fishery resources survey in the Gulf of Thailand by trawling operations, indicating the CPUEs

Figure 9. Shipboard operations of the bottom trawl in the waters of Thailand and Cambodia, using the M.V. SEAFDEC 2

Figure 10. Outputs of the demersal fisheries resources survey from 71 bottom trawl fishing operations

demersal fishery resources in the Gulf of Thailand. While SEAFDEC/TD was responsible for selecting the trawl net design, the other participating agencies and institutions helped in preparing the trawl nets and fishing accessories used for the survey operations. Preliminary results of fishery resources survey revealed that the catch per unit effort (CPUE) of bottom trawl in Thai waters was 37.78 kg/hr, and in Cambodian waters at 26.27 kg/hr (**Figure 8**). The overall CPUE in the survey area was estimated at 43.29 kg/hr. The operation of the bottom trawl is shown in **Figure 9**, while the outputs of the bottom trawl operations are shown in **Figure 10**.

Oceanographic Survey

The oceanographic survey comprised four main activities, namely: oceanographic data collection, water sampling, plankton and larvae sampling, and sediment sampling. Collection of oceanographic data was carried out by operating the conductivity, temperature, and depth (CTD) device and the thermosalinograph (TSG) system, as well as making use of the current indicator and weather information. The plankton and larvae sampling made use of phytoplankton and zooplankton nets, bongo net, and neuston net, while for the sediment and benthos sampling, the gravity and box core, and Smith McIntyre grab were used. Oceanographic winches, CTD winch and capstan winches were also operated during the survey activities. The data collected through the oceanographic survey would be used in the analysis of the shipboard research studies shown in **Box 2**.

Box 2. Shipboard research studies that made use of the data collected from the oceanographic survey

- Amount of mercury and arsenic in seawater
- Carbon dioxide flux and primary productivity in the Gulf of Thailand
- Nutrient and nutrient pool in seawater
- Validation of the hydrographic in-situ data in the Gulf of Thailand compared with multi-satellite model data
- Microbiome composition and function in seawater
- Relationship between chlorophyll-a concentration, primary production and ocean color from remote sensing

Oceanographic Data Collection using CTD Systems

Two CTD systems were used in the survey: (1) CTD system (SeaBird SBE-911+); and (2) Portable CTD model SD 204 (**Figure 11**). The CTD model SeaBird SBE-911+, which was designed for real-time data acquisition and control, includes underwater unit, deck unit, auxiliary sensor, water sampler and software. The portable CTD model SD 204 is a sensor using personal computer to display the data record. For the 2018 collaborative survey, the CTD Model SeaBird SBE-911+ was used in 62 stations (**Figure 12**). The operation of CTD SeaBird SBE-911+ was however canceled in Leg 2 due to

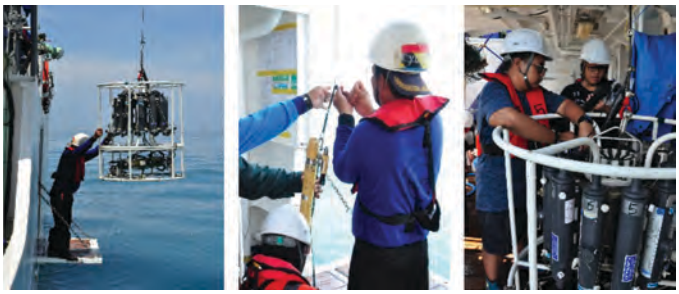


Figure 11. Collection of oceanographic data using CTD SeaBird SBE-911+ and SD-204

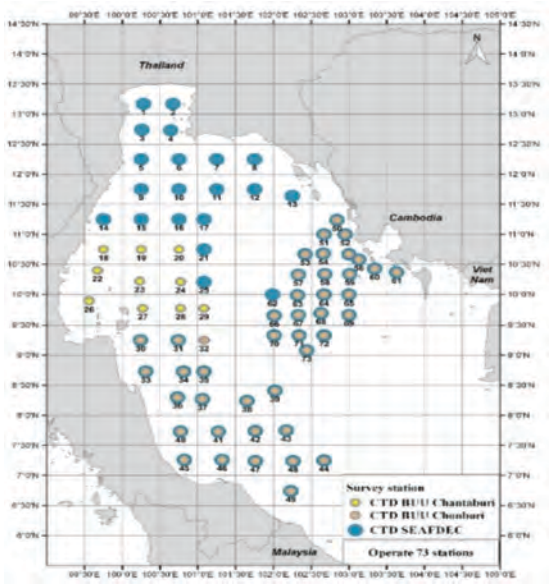


Figure 12. Survey stations for the oceanographic data collection using CTD SeaBird SBE-911+ and SD-204

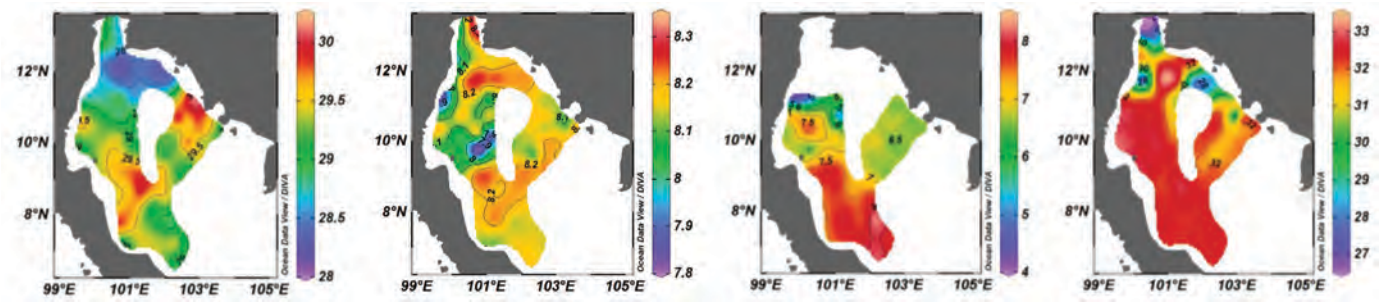


Figure 13. Analysis of the preliminary data on the sea surface oceanographic parameters collected by CTD device during the 2018 Collaborative Survey of the Gulf of Thailand

leaking cable connection, electrical short circuit, damaged and non-functioning unit. Considering that it would take seven 7 days to repair and make the damaged CTD Model SeaBird SBE-911+ ready for use in Leg No.3, the CTD model SD 204 was used instead. Meanwhile, the research activities in Station No.32 were canceled due to strong winds. Thus, temperature and salinity data were also collected from all stations from Leg 3 to Leg 5 using the CTD Model SD 204, which was also used to collect the DO profile. However, no data could be collected from Station No. 62 as the device was no longer functioning. The data collected through the CTD device could provide profiles of the chemical and physical parameters in the entire water column, which could lead to the establishment of the distribution and abundance of marine species in certain areas of the ocean. Results of the analysis of the preliminary oceanographic parameters of the sea surface of the Gulf of Thailand collected through the CTD device shown in **Figure 13**, provide the necessary inputs for the shipboard research studies shown in **Box 2**.

Water Sampling

Four (4) models of water bottle samplers (**Figure 14**) were used during the 2018 Collaborative Survey, *i.e.* Niskin bottles, Vandon bottle, dropped bottle, and bucket sampler. The Rosette multi-bottle array which has 12 Niskin 1.7 L bottles was remotely activated in conjunction with CTD system, and the data collected were used for the different shipboard research studies. A total of 73 operations were conducted: 49 operations in Thai waters and 24 in Cambodian waters. The water samples were analyzed to serve as inputs for the different shipboard research studies (**Box 3**).

Box 3. Shipboard research studies that made use of the data from the water sampling

- Density and diversity of phytoplankton in the Gulf of Thailand
- Relationship between chlorophyll-a concentration d and ocean color from remote sensing of the Gulf of Thailan
- Inherent properties of sea water in Gulf of Thailand
- Total petroleum hydrocarbons in surface seawater
- Radiation dose and radiological risks in marine biota and seafood consumers

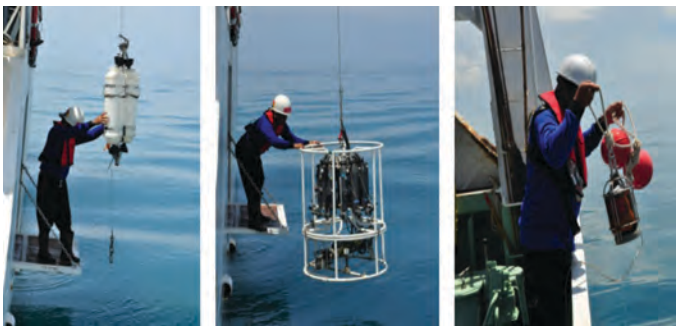


Figure 14. Bottle Samplers *(left to right)*: Vandon Bottle, Niskin bottles, and Dropped bottle

Figure 15. Zooplankton and phytoplankton vertical sampling

Plankton and Larvae Sampling

Phytoplankton net with 20 µm mesh size was used for filtering phytoplankton from the seawater (40 liters) collected by 10 liters Van Dorn samplers at the surface and chlorophyll maximum layer (**Figure 15**). Zooplankton and phytoplankton were collected by vertical sampling tows using a zooplankton net with 300 µm mesh size from 20 meters below the water surface to the surface. If the station depth is less than the specified depth, sampling collection was conducted by towing net from two meters above the bottom.

Larvae samples were collected using neuston net and bongo net (**Figure 16**). Bongo net has stainless frame with 55 cm diameter and mesh size of 330 and 500 µm, and towed from sea surface to 5 m above sea bottom. Neuston net, which is used for surface horizontal towing, is rectangular shaped, 100 x 70 cm with 1,000 µm mesh size, and attached with flow meter.

Figure 16. Nueston net *(left)* and bongo Net *(right)*

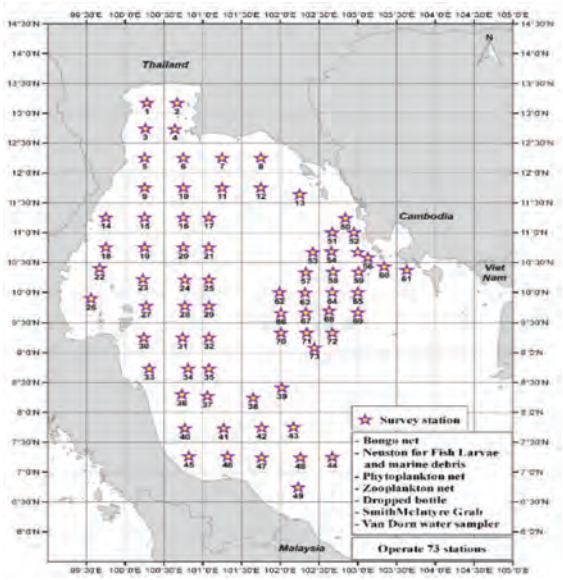


Figure 17. Survey stations for fish larvae sampling, phytoplankton and zooplankton sampling, and sediment sampling

Box 4. Shipboard research studies that made use of the data from the larvae, zooplankton and phytoplankton sampling

- Zooplankton diversity in the Gulf of Thailand
- Density and diversity of phytoplankton in the Gulf of Thailand
- Species and distribution of paralarvae and cephalopods in the Gulf of Thailand
- Composition and distribution of fish larvae in the Gulf of Thailand

The samples collected from 71 operations: 48 in Thai waters and 23 in Cambodian waters (**Figure 17**), comprising larvae, zooplankton and phytoplankton were analyzed, to be used as inputs for the shipboard research studies shown in **Box 4**.

Box 5. Shipboard research studies that made use of the data from the sediment sampling

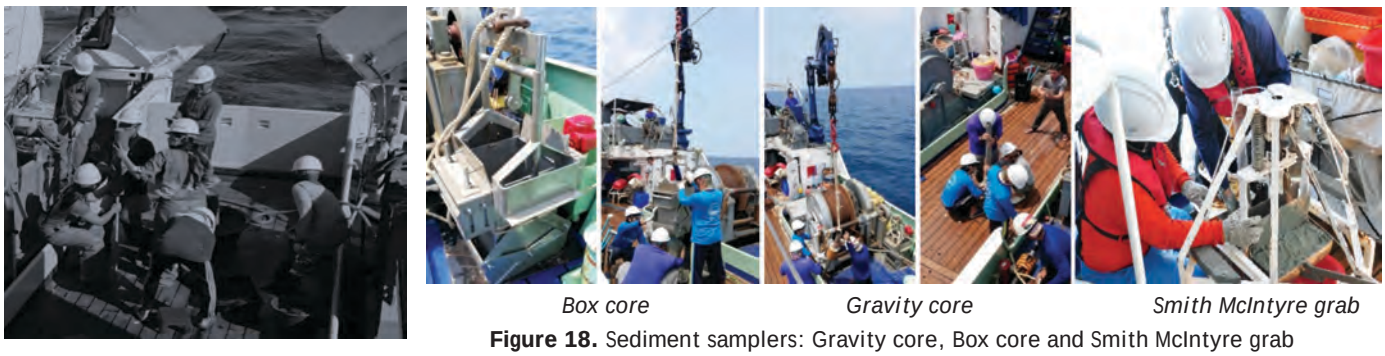
- Sedimentary properties and sedimentation rate of sediment in the Gulf of Thailand
- Temporal distribution of mercury and trace metals in the sediment
- Diversity of benthic microcrustaceans and micromollusks in the Gulf of Thailand
- Stock of marine debris in Gulf of Thailand
- Meiofauna abundance and distribution in the surface of the sediment
- Microbiome composition and function in the sediment
- Spatial sedimentology and source area composition of sediment in the Gulf of Thailand
- Radiation dose and radiological risk in marine biota and seafood consumers
- Petroleum hydrocarbon and polycyclic aromatic hydrocarbon
- Microplastic accumulations in fish and sediment

Sediment Sampling

Three (3) types of sediment samplers, *i.e.* gravity core, box core, and Smith McIntyre grab, were used during the survey (**Figure 18**). Thirty-five (35) box core operations, thirteen (13) gravity core operations, and seventy-three (73) Smith McIntyre grab operations, were conducted. Results of the sediment analysis would be used as inputs for the shipboard research studies shown in **Box 5**.

Microplastic and Marine Debris Study

SEAFDEC/TD has been studying the accumulation of microplastics in sea water, sediments, and marine life to determine the microplastic situation in the environment, especially in the Gulf of Thailand, with the collaboration of Chulalongkorn University in Thailand. During the 2018 Collaborative Survey, microplastics were collected using the



Box core *Gravity core* *Smith McIntyre grab*

Figure 18. Sediment samplers: Gravity core, Box core and Smith McIntyre grab

Figure 19. Study on microplastic accumulation in the Gulf of Thailand *(from left to right)*: collection by nueston net; collection by Smith McIntyre grab; and data on marine biota based on dominant and economically important fishes

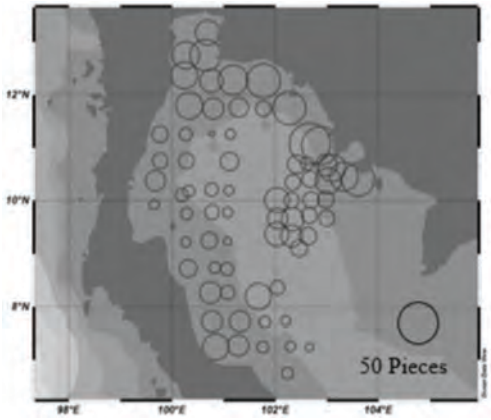


Figure 20. Initial hotspots of marine debris at sea bottom of the Gulf of Thailand

neuston net towed at the surface layer for 10 minutes, while microplastics in sediment were collected using the Smith McIntyre grab, *i.e.* one (1) kg sediment sample from each station (**Figure 19**). The data on marine biota (fish) showed three (3) dominant fish species and three (3) economic fish species that were caught by trawl net (**Figure 19**). All samples have been sorted while the microplastic accumulations in the samples were analyzed using the Bench-top Fourier Transform Infrared Spectroscope (FT-IR).

One of the collaborating partners of the 2018 Collaborative Research Survey, the Burapa University in Chantaburi Campus, Thailand, is the lead institute in Thailand to investigate the distribution of bottom plastic debris in the Gulf of Thailand. Thus, data on marine debris in the Gulf of Thailand was also collected during the 2018 Collaborative Research Survey. The demersal marine plastic debris samples collected during the trawl fishing operations generated 758 pieces of debris. Preliminary analysis showed the hotspot of marine debris at sea bottom around the Gulf of Thailand (**Figure 20**). For the drifting marine debris, especially the density and distribution of drifting marine debris in the waters of Cambodia, the technical support from Tokyo University of Marine Science and Technology (TUMSAT) was availed of (**Figure 21**).

Figure 21. Drifting marine debris observation was conducted in Cambodia waters with *Prof. Dr. Keiichi Uchida* from TUMSAT

Under the supervision of *Prof. Dr. Keiichi Uchida* from TUMSAT, data on marine debris *i.e.* number, size, color, type, and position were recorded through a TUMSAT visual observation mobile and tablet application (**Figure 22**). The estimated accumulation of marine debris in the waters of Cambodia is shown in **Figure 23**.

Figure 22. Data on observed drifting marine debris were recorded in TUMSAT mobile with tablet application

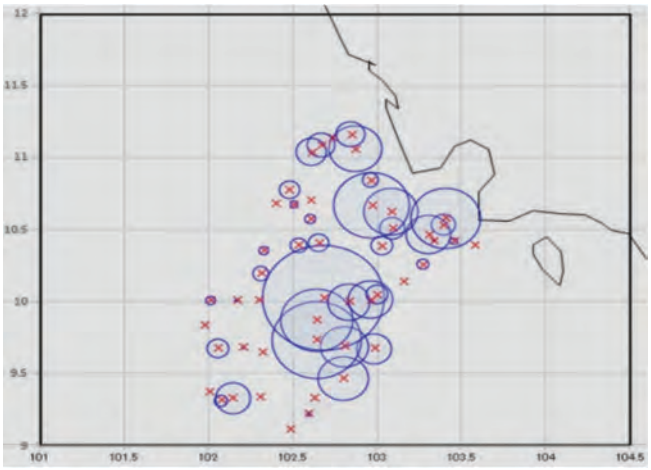


Figure 23. Accumulated drifting marine debris observed in the waters of Cambodia

Figure 24 *(left to right)*: Biota sample, water sample, and sediment sample to study the radiation dose and assess the radiological risks in marine biota from the Gulf of Thailand and in seafood consumers

Figure 25. SEAFDEC researcher collecting information on aerosol in the Gulf of Thailand

Other Survey Activities

Other research activities carried out onboard the M.V. SEAFDEC 2 pertain to human well-being, and deal with the estimation of radiation dose and assessment of radiological risks in marine biota from the Gulf of Thailand and in seafood consumers. Focus of such shipboard study was not only on radio activity from both natural and artificial radio nuclides in seawater and sediments but also on the national safety guideline and values for protecting local marine organisms and seafood consumers from possible radiological hazards. This would also support the establishment of national marine environmental radioactivity database and mapping to be used as reference in nuclear and radiological emergencies. Nonetheless, considering the inadequate facilities onboard the M.V. SEAFDEC 2 for analyzing the samples that comprise marine biota (fishes), water, and sediments (**Figure 24**), the analysis would be done by experts in appropriate laboratories in Bangkok, Thailand.

In addition, study on the composition and potential source of aerosol was also carried out with the main objective of investigating the source of aerosol in the Gulf of Thailand (**Figure 25**). Results of the analysis would be used to support the improvement of weather predictions in the region.

Way Forward

The initial results of the survey were presented during the Regional Technical Meeting (RTM) on the Evaluation of the Collaborative Research Survey on Marine Fisheries and Marine Environment in the Gulf of Thailand, organized at the SEAFDEC/TD from 8 to 9 January 2019, where it was agreed that monitoring and follow up of the data analysis should be continued (SEAFDEC, 2019). Nonetheless, the results had provided an initial cleaner and broader picture of the resources and the environmental conditions of the Gulf of Thailand. Meanwhile, the data and samples collected from the 2018 Collaborative Research Survey would be analyzed by responsible scientists and researchers from the participating countries, national agencies and institutes. The results would be compiled in forms of technical reports. Moreover, results of the monitoring and follow up of the data/sample analysis from the 2018 Collaborative Research Survey in the Gulf of Thailand would be presented during the first follow up meeting tentatively scheduled to be organized in July or August 2019, and during the second meeting in December 2019 or January 2020. The final results, especially from the various shipboard research studies would be presented during the Seventh Marine Science Conference hosted by Ramkhamhaeng University, Bangkok, Thailand in 2020. In this regard, SEAFDEC/TD was tasked to facilitate coordination with Ramkhamhaeng University for the arrangements related to the presentation of the results of 2018 Collaborative Research Survey.

The 2018 Collaborative Research Survey had generated an increased number of experienced researchers on marine fishery resources and marine environment in Southeast Asia, strengthened the network of fisheries and oceanographic scientists and researchers in the region, and maximized the efficiencies and benefits from the use of the SEAFDEC research vessels and equipment to support marine fishery resources and marine environment surveys in the Southeast Asian waters. During the RTM on the Evaluation of the Collaborative Research Survey on Marine Fisheries and Marine Environment in the Gulf of Thailand (SEAFDEC,

2019), the priorities revealed by the three (3) participating countries, *i.e.* Thailand, Cambodia, and Viet Nam pointed towards the conduct of capacity building on the analysis of "zooplankton, phytoplankton and paralarvae of cephalopods diversity and distribution in the Gulf of Thailand." Based on such revelation, SEAFDEC/TD would continue to exert efforts to seek funding support for the conduct of the human resource development programs on the suggested topic for the three (3) participating countries.

For more information on the results of the 2018 Collaborative Research Survey, communication and coordination could be made through the respective Country's National Focal Points of the Survey (**Table 2**) or through SEAFDEC/TD and the concerned institutes and academes shown in **Table 3**.

Table 2. National Focal Points for the Collaborative Research Survey on the Marine Fisheries Resources and Marine Environment Survey in the Gulf of Thailand using the M.V. SEAFDEC 2

Countries	Contact person	National agencies
Cambodia	*Mr. Suy Serywuth*	Fisheries Administration, Cambodia
Thailand	*Dr. Pavarot Noranarttragoon*	Department of Fisheries, Thailand
Viet Nam	*Mr. Nguyen Van Minh*	Directorate of Fisheries, Viet Nam

Table 3. Focal Points from Institutions and Academes in Thailand, for the Collaborative Research Survey on the Marine Fisheries Resources and Marine Environment Survey in the Gulf of Thailand using the M.V. SEAFDEC 2

Contact Person	Institute/Agency/University
Dr. Taweekiet Amornpiyakrit and *Mr. Sukchai Arnupapboon*	Southeast Asian Fisheries Development Center, Training Department
Dr. Supawat Kan-atireklap	Department of Marine and Coastal Resources, Thailand
Dr. Yutthana Tumnoi	Office of Atoms for Peace, Thailand
Dr. Wirote Laongmanee	Burapha University, Thailand
Dr. Supannee Leethochawalit	The Institute of Marine Science, Burapha University, Thailand
Dr. Worrawit Maneepitaksanti	Chiang Mai University, Thailand
Dr. Penjai Sompongchaiyakul	Chulalongkorn University, Thailand
Dr. Jitraporn Phaksopa	KU: Kasetsart University, Thailand
Dr. Sontaya Koolkalya	RBRU: Rambhai Barni Rajabhat University, Thailand
Dr. Tuantong Jutagate	URU: Ubon Ratchathani University, Thailand

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About the Authors

Mr. Sukchai Arnupapboon, is the Head of Fishing Ground and Fishery Oceanography Section, Research and Development Division of SEAFDEC Training Department based in Samut Prakan, Thailand

Mr. Suy Serywath is Director of the Marine Fisheries Research and Development Institute (MaFReDI) of the Fisheries Administration of Cambodia.

Dr. Pavarot Noranarttragoon is Head of the Fisheries Resource Assessment Group of the Department of Fisheries, Thailand.

Mr. Nguyen Van Minh is an Official of the Department of Conservation and Aquatic Resources Development, Directorate of Fisheries, Viet Nam.

Dr. Taweekiet Amornpiyakrit is Head of Fishing Technology Section, Research and Development Division of SEAFDEC Training Department based in Samut Prakan, Thailand.

Mr. Isara Chanrachkij is the Head of Research and Development Division of SEAFDEC Training Department based in Samut Prakan, Thailand.

Crocodile Conservation and Breeding Management – Issues and Constraints: Experience of Myanmar

Myo Min Hlaing

Crocodiles play a vital ecological role as key predators in wetland environments where they thrive, and have always been part of human culture, even co-existing with people, and found in the form of leather as their skin is used to make boots, handbags, jackets, belts, and more. While some regions worship the crocodiles as holy creatures by honoring them to please the god or goddess associated with them (*e.g.* in some Egyptian towns), these reptiles are also being hunted elsewhere for their skin as well as meat for food, and other body parts for medical, religious or decorative purposes. Crocodiles belong to the Order Crocodylia or Crocodilia, comprising three families and nine genera. All 23 species of crocodilians are listed under the Appendix I or II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While crocodilians were reported many years ago to be "slated for rapid extermination at the hands of man" because of overhunting and loss of habitat, currently the populations of many crocodilian species are known to have recovered or restored. Myanmar has been breeding crocodiles since the 70s, but issues and constraints relevant to the conservation and management of crocodile breeding had been encountered, as reported in this article.

Crocodilians are large reptiles with "robust skull, long snout and strongly toothed jaws, short neck, with robust cylindrical trunk extending without constriction into a thick laterally compressed tail, and short but strongly developed limbs" (Vitt and Caldwell, 2013). Crocodilians are known to be distributed in tropical areas but some species found their way in the temperate zones through rivers, but still some inhabit the coastal marshes and even in marine areas. Under the Order Crocodilia are the various species of crocodiles, alligators, caimans, and gharials (Fleming and Fontenot, 2015; Encyclopaedia Britannica, 2019). Alligators (Genus *Alligator*) are large animals with powerful tails used for defense and in swimming, and with eyes, ears, and nostrils found on top of their long head that project slightly above the water when the reptiles float. Gavial also called gharial (*Gavialis gangeticus*), is an exceptionally long and narrow-snouted crocodilian of the family Gavialidae. Inhabiting the rivers of northern India and Nepal, gharials also reproduce by means of hard-shelled eggs laid in nests built by the female, and are characterized by their long, very slender, and sharp-toothed jaws that can sweep sideways to catch fish, their main prey. Caimans also known as caymans, are species of Central and South American reptiles that are related to alligators, that are amphibious and carnivores, living along the edges of rivers and other bodies of water, and reproducing by means of hard-shelled eggs laid in nests built and guarded by the female.

Crocodiles are commonly found in tropical regions of Africa, Asia, the Americas, and Australia. The 13 species of crocodiles include the dwarf crocodile (the smallest crocodile) which grows to about 1.7 m in length and weighs 6.0 to 7.0 kg, and the saltwater crocodile (the largest crocodile) that could grow up to 6.0 m long or more and can weigh up to 900 kg or even more (**Figure 1**). Crocodiles are carnivores, eating fish, birds, frogs, and crustaceans in the wild, and in captivity, *e.g.* in zoos, eating small animals that have already been killed for them, such as rats, fish or mice (Bradford, 2014).

Figure 1. Saltwater crocodile commonly found in Asia

Alligators can be differentiated from crocodiles by the form of their jaw and teeth (Encyclopaedia Britannica, 2019). Alligators possess a broad, U-shaped snout and have an "overbite"— that is, all the teeth of the lower jaw fit within (lingual to) the teeth of the upper jaw, while crocodiles have a narrow, V-shaped snout and the large fourth tooth on each side of their lower jaw projects outside the snout when their mouth is closed (**Figure 2**). Like the crocodiles which are

Figure 2. American alligator *(above)* *Source: Google;* and Asian crocodile *(below)*

carnivorous in nature, alligators also live along the edges of permanent bodies of water, *e.g.* lakes, swamps, and rivers.

Utilization of Crocodilian Skins

The Crocodile Specialist Group (2019) reported that the first records of commercial use of skins of crocodilians in the 1800s were found in North America, which indicated that right after the American Civil War (1861-65) the demand was high for footwear in particular, and also for belts, saddlebags, cases, and similar items. For such purpose, the American alligators (*Alligator mississippiensis*) were hunted for their skins to be processed into leather products. However, the demand had exceeded the wild alligator stocks, so the other species of crocodilians found in other parts of the country, *e.g.* Mexico and in Central America, were also utilized. The extensive and unregulated hunting of crocodilians had devastated the wild populations with most populations being greatly depleted (Martelli, 2019).

After the Second World War and during the subsequent economic revival in the Americas, crocodilian skins were again in demand, and to satisfy the North American markets, many stocks were again subjected to massive hunting not only the Nile crocodiles (*Crocodylus niloticus*) of Africa but also the crocodile stocks in South and Southeast Asian countries, as well as those in Australia and the Pacific island countries, resulting in the severe reduction of the wild populations of the saltwater crocodile (*C. porosus*) and other crocodile species.

Even the caimans in South America had been targeted for commercial hunting that began in the late 1950s, especially the black caiman (*Melanosuchus niger*), whose skin is regarded as the most valuable of all the caimans. When the wild black caiman populations dwindled and hunting was no longer profitable, other caiman species, *e.g. Caiman crocodilus* in the Amazon Basin, were utilized. Nevertheless, there were some species of caimans (*e.g.* dwarf caimans *Paleosuchus* spp.) that were not commercially-exploited due to their large bony deposits, and were not hunted for their skin. Nonetheless, their meat was harvested for the subsistence of local people. Such extensive worldwide exploitation during the 1950s, 1960s and 1970s resulted in the depleted populations of most crocodilian species, where in some extreme cases the stocks had been rooted out from parts of their range.

The relative value of the skin of different crocodilian species depends on a number of factors, including the degree of ossification (bone) in the belly, classifying the skins of crocodiles into two: the classic skins and the caiman skins (Crocodile Specialist Group, 2019). Considered the best in the world, the skin of the saltwater crocodile (*C. porosus*) has more commercial value because there is no bone in its belly scales, there is high number of belly scale rows in the belly, and the species grows very fast. Caldwell (2010) reported that from 2000 to 2008, the main producers of (*C. porosus*) skins are Australia (from crocodiles raised through captive breeding and ranching), Indonesia (captive breeding and ranching), Papua New Guinea (captive breeding and hunted from the wild), and Thailand, Singapore, Malaysia (captive breeding).

After the removal of the skin at culling, this is cured with salt to prevent from rotting and then converted to leather by soaking the skin in water to restore its original state. After the keratinous scales are removed, the skin is converted to leather through a series of chemical processes, then dyed and made ready for manufacture into various products (Fuchs, 2006). In general, the processes for converting skin into leather could also vary according to the species. There are many tanneries dealing with crocodile skins throughout the world, but according to the Crocodile Specialist Group (2019) considerable expertise producing the highest quality of crocodilian leather products could be found in Singapore, Japan and Europe (*e.g.* France, Germany, Italy).

International Trade of Crocodilian Skin

The trade records at CITES provided by the UNEP World Conservation Monitoring Centre (WCMC), indicated that the current international trade involves over 1.5 million crocodilian skins per year that are legally traded by about 30 countries (Caldwell, 2010; Caldwell, 2014; Caldwell, 2015). Specifically, between 2011 and 2013, the international trade averaged 1.57 million skins per year, comprising 47% classic skins and 53% caiman skins (**Table 1**). In spite of the reduced demand for crocodilian products, *e.g.* during the global financial crisis in 2009-2010, the market for the very highest quality crocodilian products has remained strong.

In 2013, caiman skins were more heavily traded at 1010.3 thousand skins than the classic skins at 878.3 thousand skins. The most traded was the skin of *Caiman crocodilus fuscus* from Colombia (856.6 thousand skins), followed by the skin of *Alligator mississippiensis* from USA (481.3 thousand skins), the skin of *Crocodylus nilotucus* from Africa (258.0 thousand skins), and the skin of *Caiman yacare* from Brazil, Argentina, and Bolivia (102.2 thousand skins). The other skins being traded internationally are from the *Crocodylus porosus* (Australia, Papua New Guinea, Indonesia, Malaysia, Singapore, Thailand), *C. siamensis* (Thailand, Vietnam, Cambodia), *C. novaeguineae* (Papua New Guinea, Indonesia), *C. acutus* (Colombia, Honduras), *C. moreletii* (Mexico), as well as from *Caiman crocodilus crocodilus* (Colombia, Bolivia) and *C. latirostris* (Argentina).

The Crocodile Specialist Group (2019) added that aside from their skins, crocodilians are also being exploited for their meat as the main by-product and also other parts of their body. Between 1990 and 2005 meat exports were relatively stable at around 400 metric tons (mt) per year (Caldwell,

Table 1. World trade (1000 of skins) in classic crocodilian and caiman skins, 2006-2013 (Caldwell, 2015)

Species	2006	2007	2008	2009	2010	2011	2012	2013
Alligator mississippiensis	422.9	262.1	230.5	297.2	369.7	312.5	326.5	481.3
Crocodylus acutus	0.1	0.4	1.4	1.5	0.2	1.4	1.6	1.9
Crocodylus moreletii	0.2	-	0.7	0.5	-	0.2	0.7	1.3
Crocodylus niloticus	156.2	148.3	161.7	149.1	167.8	212.8	204.3	258.0
Crocodylus novaeguineae	38.6	28.7	25.6	26.2	24.5	16.6	23.5	25.9
Crocodylus porosus	34.2	45.2	52.8	46.1	58.2	63.4	73.3	64.7
Crocodylus siamensis	48.0	54.3	63.5	34.4	33.1	38.2	35.5	45.1
Total: classic skins	**700.2**	**539.1**	**536.2**	**554.9**	**653.5**	**645.1**	**665.4**	**878.3**
Caiman c. crocodilus	34.2	45.2	52.8	46.1	58.2	63.4	73.3	64.7
Caiman c. fuscus	972.0	671.0	533.5	406.4	651.1	634.8	625.1	856.6
Caiman latirostris	1.7	1.1	0.8	0.4	1.9	3.0	4.6	6.0
Caiman yacare	50.5	65.5	51.3	48.8	29.7	58.4	81.5	102.2
Melanosuchus niger	-	-	-	-	-	-	0.3	-
Total: caiman skins	**1093.8**	**782.4**	**622.6**	**499.3**	**707.4**	**740.4**	**758.6**	**1010.3**
Total	**1794.0**	**1321.6**	**1158.8**	**1054.2**	**1360.9**	**1385.4**	**1424.0**	**1888.6**

2010), derived mainly from the American alligators, Nile crocodiles and Siamese crocodiles. China and Hong Kong are the main importers of crocodile meat. Other crocodilian parts are also being utilized, *e.g.* their blood for production of pharmaceutical products, the bones and fat for traditional medicines, while the teeth, heads, skulls are used to manufacture curios for the tourism industry. Minor trade in live crocodilians also occurs, *e.g.* for zoos and the pet trade. On a larger commercial scale, live crocodiles are also exported for farming (*e.g.* 268,000 hatchlings of the Nile crocodiles from Mozambique to Zimbabwe and South Africa over a 7-year period, the Siamese crocodile hatchlings from Cambodia to Viet Nam and Thailand), and also for food (*e.g.* 466,000 juvenile Siamese crocodiles from Cambodia, Viet Nam, and Thailand were exported to China between 1998 and 2008).

Crocodile Farming Industry

Considering the steep decline in the wild populations of crocodilians in the 1960s and 1970s, crocodile farming was perceived by many countries as an alternative industry, not only to reduce pressure on the wild populations but also as means through which the conservation of crocodilians could be sustained. Many countries then enacted legislations to protect the various species of wild crocodilians and promote crocodile farming and by the late 1970s and 1980s, captive breeding programs were being developed for such species as *C. niloticus* (Zimbabwe), *C. porosus* (Australia, Papua New Guinea, Indonesia), *A. mississippiensis* (USA), *Caiman crocodilus* (Venezuela), and *C. novaeguineae* (Papua New Guinea, Indonesia). Since one of the most depleted crocodilians was the saltwater crocodile *C. porosus*, where the wild populations had drastically declined in many countries due to over-exploitation because of the high commercial and economic value of its skin, meat and other body parts, several governments and agencies in the South and Southeast Asia were activated to initiate conservation measures. For the same reason, the International Union for Conservation of Nature and Natural Resources (IUCN) formed the Crocodile Specialist Group to be actively involved in the welfare of the world's crocodiles, especially the saltwater crocodile species (Jelden, 2004; MacGregor, 2002).

Meanwhile, the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) had listed all species of crocodilians on its Appendices, regulating their international trade. Countries that are signatories to CITES and utilize the wild crocodilian resources, must demonstrate that such utilization does not threaten the survival of the species by establishing the non-detriment findings, through regular monitoring of the wild population to assess the impacts of the exploitation, and regulating the trade of their products. As a result, crocodilian skins involved in the international trade are uniquely numbered with non-reusable tags attached to confirm the legality of the skins being traded (Webb, 2004).

Countries signatory to the CITES had been encouraged to protect these reptiles from overhunting and to conserve their habitats as the crocodilian species are almost in the verge of extinction, more specifically, the *Crocodylus porosus* which is listed on Appendix I of CITES throughout its Indo-Pacific range with the exception of Papua New Guinea (Appendix II), Indonesia [provisional Appendix II with a quota] and Australia [Appendix II (ranching)]. The transfer of the Australian population of *C. porosus* from Appendix II (ranching) to Appendix II (unqualified) will not have any impact on the international trade-protective status of the species. Although the international trade for the CITES Appendix I listed species is prohibited, crocodilian species in the CITES Appendices could still be traded provided it is established that these come from closed-cycle captive breeding without detriment to the

wild populations. To be able to trade the cultured reptiles internationally, their breeding facilities must be registered as "CITES-registered captive breeding operations." To date, captive breeding facilities had already been established in many countries for a number of crocodilian species, including *A. sinensis, C. moreletii, C. acutus, C. porosus,* and *C. siamensis*, leading to the emergence of the concepts of "crocodile farming" and "crocodile ranching."

"Crocodile farming" is the activity of breeding and/or growing crocodilians for commercial purposes, while a "crocodile ranching" involves then collection of wild crocodile eggs, hatchlings and/or juveniles and growing them in captivity. From the CITES perspective, three production systems apply to crocodilians: ranching, captive breeding, and wild harvest. Crocodile production through captive breeding is a form of intensive animal husbandry, where the culture requirements are similar for all crocodilian species, although some aspects vary and are species-specific. For example, the Siamese crocodile (*C. siamensis*) is considered a good "farm" species relative to the saltwater crocodile (*C. porosus*) as the latter is much more territorial and aggressive. A general guide to the farming of crocodilians was compiled by Hutton and Webb (2002; 2003). Unlike the conventional domesticated animals, that are raised for their meat and leather is a by-product, the main product from crocodilians is the skin, and their meat is a by-product. For this reason, care is taken during the rearing to minimize damages to the belly skin, either from the substrate surface or from social interactions with other crocodiles. The density at which crocodiles are maintained is reduced as they grow larger, to reduce interactions (including fighting) between individual reptiles and to promote good growth of the reptiles.

Crocodile Breeding in Myanmar

Aung Moe (1993) reported that some crocodilian species, *e.g. Crocodylus porosus, C. siamensis, C. palustris* and *Gavialis gengeticus* had existed in Myanmar based on the historical record of the occurrence of crocodilians. However, Thorbjarnarson *et al*. (1999) confirmed that only one species of crocodile, *Crocodylus porosus* (Schneider, 1801) now definitely exist, mainly in the Delta Region of Myanmar. *C. porosus* prefers to inhabit the tidal mangrove forests, brackishwater estuarine environments, and small creeks and streams, which are present in Myanmar and where the tidal water reaches in its Delta Regions. In the Meinmahla Kyun, Bogalay Township, Ayeyarwady Delta Region, about 136 km^2 has been designated as a wildlife sanctuary since 1944, and in 1999, about 100 crocodiles were spotted and recorded (Thorbjarnarson *et al*., 1999). Meinmahla Kyun was then established as protected area also for the wild life population of the crocodilian species *C. porosus*. However, the effect of urbanization, industrialization and agriculture led to the destruction of the habitats and nesting grounds of the crocodiles, *e.g.* the loss of mangrove forests. Therefore, strict conservation measures for crocodilian species and their habitats could be the most appropriate way to save the crocodiles from extinction (Ohn, 2003). With these factors taken into consideration, a Crocodile Breeding Farm was set up by the Government of Myanmar at Thaketa Township in Yangon Region in 1978, and placed under the supervision of the Ministry of Livestock and Fisheries.

The Crocodile Breeding Farm at Thaketa Township is mainly involved in the R&D on crocodile conservation, sustainable utilization of crocodile skins, development of public recreation and tourist attraction, enhanced public awareness of conservation of wild life and endangered species, and dissemination of knowledge and experiences to students and the youth, with the university students being enjoined to cooperate in the R&D activities. At present, the Farm is reported to have approximately 280 adult crocodiles with another 120 sub-adults and 136 juveniles. The experiences from the Thaketa Crocodile Breeding Farm with respect to conservation, management and breeding of *C. porosus* taking into consideration their characteristics and behavior are compiled below, in order that such information could also be shared with the other countries in the Southeast Asian region.

General morphometric characteristics of *C. porosus*

The head of *C. porosus* is broad and triangular in shape with long beak-like snout, sharply demarcated from the head. The 4th lower tooth is visible from outside when the mouth is closed. Dorsally, the color of the body is yellow with dark blotches in young crocodiles and yellowish dark color in adult. Ventrally, the color of the body is white in both young and adult (**Figure 3**). Males and females could be distinguished based on the nature of their snouts (broader in male than in female) and body size (males are larger than females).

Figure 3. Adult crocodiles at Thaketa Crocodile Breeding Farm, Myanmar

Breeding behavior of *C. porosus*

Lang (1975) had worked on the reproductive ecology of *C. porosus*, especially on their pre-copulatory and copulatory

behaviors, the males defending their territories during the breeding season, as well as courtship and mating. Lang (1979) observed that during the pre-copulatory activity, males and females are engaged in a variety of species-specific behaviors, *e.g.* snout contact, snout lifting, head and body rubbing and riding, where the conspicuous male displays vocalizations and exhalations, produces narial and guttural bubbling sounds, and undergoes circling actions including periodic submergence and re-emergence. Mating occurs when the male mounts the female by moving on to her dorsum, position its tail and vent underneath the female's tail, and inserts the anteriorly curved penis into the female's cloaca. Copulation is however difficult to observe because it occurs underwater but successful copulation appears to take several minutes that could last 10-15 minutes or longer. The crocodiles mate during the day time, while nest construction and egg-laying take place at night. The crocodile breeding season starts from February and lasts until September.

Courtship and mating behavior of *C. porosus*

Lang (1979) also noted that courtship and mating in *C. porosus* usually occur from February to May. As a sign of courtship, a male crocodile searching for its mate produces a loud vocal sound through head or jaw slapping performed at the surface of the water. During the head or jaw slapping, its widely opened mouth is lifted above the surface and only the lower jaw is visible. The loud sound is produced when the raised upper jaw is lowered in a biting motion, making a loud popping sound as the jaws closed, followed immediately by a resounding splash at the water surface. If a female accepts the courtship, the female whose body remains submerged below water lifts its head and produces croaking sounds louder than the sound produced by the head slapping of the male. If the courtship is not accepted, the female rapidly swims away from the chasing male. The male that had been accepted by the female is most aggressive when another male approaches its mate, driving away the intruder by knocking it away with its head and rapidly protecting its mate. The accepted male then approaches its mate with its fore limbs over the back of the female, and swims around to climb on to the back of the female. If not successful at the first attempt, the male swims around the female two to four times before it climbs on to the back of the female.

The male on the back of the female turns the female ventrally to be in contact with its ventral side. The female is submerged under water except the head and twisted part of its tail with the male once the mating is secured. Fertilization is internal and the mating process could last for more than 10 minutes.

Nest construction and egg-laying behavior

The nesting season of *C. porosus* starts from May until July. During this time, a female crocodile with eggs that can be distinctly recognized by the expanded abdominal part of its body comes up to a forested area approximately a week before egg-laying to select its nesting area. Usually, an area that cannot be flooded when the water level rises and where there is penetration of light is selected by the female. The nest is constructed by the female by making mounds of leaves, twigs and soil.

Once the area has been selected, the female starts to collect the plant materials from shrubs, climbers and grass around the chosen area aided by its strong teeth. The plant materials as well as the fallen twigs and debris are drawn forward with its fore and hind limbs and piled up in the selected area and pressed down with its belly. This manner is repeated for three to four days. One day before egg-laying, the female crocodile makes a hollow in the nest by pushing out the nest materials with its hind limbs. The following day, the female crocodile lays eggs into the hollow and when the egg-laying process is completed the hollow is covered by pulling the pushed away plant materials using its fore and hind limbs, and pressing down with the abdominal part of its body. The eggs could be collected for incubation in the nursery units (**Figure 4**).

Figure 4. Collection of crocodile eggs from a crocodile nest inside the compound of the Thateka Crocodile Breeding Farm

Nest defense behavior

The behavior of crocodiles defending their eggs could vary between species and within one species over the different geographic areas. In saltwater crocodiles, intruders are chased immediately upon approaching the nest areas and will bite at anything within their reach. The female crocodiles tend to stay at or near the nest throughout the incubation period. The features of the terrestrial habitat of the nesting females and recently hatched young crocodiles are important information that could be used to define the habitat requirements, and identify the nesting areas as well as the type of habitat into which the young crocodiles are born. Such information is crucial for the management of the crocodile farms.

Thaketa Crocodile Breeding Farm

The Thaketa Crocodile Breeding Farm is located on the bank of Nga Moe Yeik also called Pazundaung Creek comprising

the total area of 16 ha at Mya Khwar Nyo Road, Industrial Quarter, Thaketa Township, Yangon (**Figure 5**). The Farm was established in May 1978 by the Peoples Pearls and Fisheries Corporation (PPFC) under the Myanmar Fisheries Enterprise. At the beginning, wild crocodiles were bought from Bogalay Township, Ayeyarwady Delta Region and reared at the Thaketa Farm. Since 1982, the Farm has been promoting crocodile egg-laying and hatching. Records showed that from 1983 to 1989, the Farm exported 1,830 live crocodiles to Thailand and Singapore on FOB price of US$ 162,689. In 1992, a total of 1,076 eggs were collected from 26 nests, and in 1994, there were nearly 830 crocodiles of all sizes reared at the Farm.

Figure 5. Map of Myanmar *(left)* and Yangon Region *(right)* showing Thaketa Township (site of the Thaketa Crocodile Breeding Farm)

In 1995, management of the Farm was transferred from the Peoples Pearls and Fisheries Corporation under Myanmar Fisheries Enterprise to the Department of Fisheries under Ministry of Livestock and Fisheries. The Farm has several types of facilities for crocodile breeding and rearing, *i.e.* concrete tanks as nursery and shelters for juveniles and sub-adults, comprising Unit No. 1 measuring 100 x 30 x 8 feet for nursing crocodile hatchlings 7-10 months to 2 years old with lengths of up to 1-3 feet, Unit No. 2 measuring 250 x 110 x 9 feet where 3 to 5 years old with lengths of up to 3-5 feet juvenile crocodiles are nursed, and Unit No. 3 measuring 100 x 50 x 8 feet where 6-7 years old with lengths of up to 6-7 feet sub-adults are kept. Newly-hatched crocodiles are nursed in intensive care nursery unit and cared up to 7-10 months. Approximately 280 adult crocodiles 8-30 years old with lengths of up to 8-15 feet are reared in 450 x 350 x 10 feet concrete and natural earthen ponds. These adults are nesting from May to August in a 2.5-ha mangrove forest within the area of the Thaketa Crocodile Breeding Farm.

Duties and responsibilities of Farm staff

The Farm is run by a number of staff members who continuously and carefully watch the animals to ensure their safety as well as that of local people and foreigners visiting the Farm every day. Some staff take charge of demonstrating and coordinating the daily crocodile performance show for visitors; maintaining the cleanliness and hygiene in the crocodile nursery units and shelters; feeding shrimps with vitamins every day for the 1-3 feet crocodile hatchlings at nursery Unit No. 1; feeding marine fishes 2 times per week to the 3-5 feet crocodiles in nursery Units No. 2 and No. 3; and feeding marine fishes 2 times per week for the 6-10 feet crocodiles in concrete and natural ponds. The total quantity of feeds given could reach to 400 kg of marine fishes fed twice per week for adult crocodiles in the Farm. The staff regularly clean the Farm compound, offices and public rest rooms; check and observe the crocodile nests at a nearby mangrove forest during the mating season; collect the eggs from crocodiles' nests; monitor and control the temperature and moisture for the eggs during the incubation period at the incubation boxes and in hatching rooms; provide nursing and intensive care to the crocodile hatchlings in intensive nursery care units; measure the length and weight of crocodiles every three months; monitor and evaluate the number of eggs, hatching rate, survival rate, mortality, growth rate, and so on.

Eggs of crocodiles

Eggs are translucent white and vary in sizes of up to 40-140 g, but all have hard calcified shell attached to a fibrous eggshell membrane (**Figure 6**). Inside the eggshell membrane is albumen and yolk, where the yolk is itself enclosed within a very thin membrane (the vitelline membrane). The calcified portion of the shell can appear smooth or rough, but always contains a network of fine pores passing through it, which might not be obvious to the naked eye. The pores are vital for oxygen (into the embryo) and carbon dioxide (out from embryo).

Figure 6. Egg of *C. porosus (left)* and developed embryo *(right)* at Thaketa Crocodile Breeding Farm, Myanmar

Table 2. Size and Number of crocodiles in 2019 at Crocodile Breeding Farm Thaketa

Nursery/Culture Unit	Size (feet)											Total
	1	2	3	4	5	6	7	8	9	10	> 10	
Nursery Unit 1	78	32	4									114
Nursery Unit 2					9	6	1					16
Nursery Unit 3				48	60							108
Concrete/Natural Ponds						62	103	80	21	15	17	298
Total	**78**	**32**	**4**	**48**	**69**	**68**	**104**	**80**	**21**	**15**	**17**	**536**

If an egg is placed under water, gas exchange ceases and the embryo dies. Inside the egg, a yolk sac membrane is developed to transport the nutrients to the embryo that measures about 5 x 1 mm. In 2019, there were 536 crocodiles in varying sizes, nursed and reared in the Farm (**Table 2**).

Incubation of crocodile's eggs

The incubation environment for the crocodile's eggs is extremely important as it influences the rate of embryonic development and growth, hatching time, embryonic mortality rate, and sex. After hatching, the incubation conditions affect the growth and survival rates of the crocodiles. The three major variables of the incubation environment are temperature, humidity and gas exchange. All crocodilians have temperature dependent sex determination. Typically high and low temperature females (< 31 °C and >33 °C), with a band of males in the middle close to 32 °C. In this crocodile breeding farm artificial incubation technique was applied by using styrofoam boxes (60 x 40 x 30) cm, crocodile eggs were collected shortly after laying by opening the mound surface once the female was driven out of the nesting place for safety. Eggs are handled very gently to avoid from being damaged as even a slight shake could damage the eggs.

Figure 7. Crocodile eggs for incubation in the intensive care nursery unit

The collected crocodile eggs (**Figure 7**) are placed in a basket and covered with straw to prevent the effect of direct sunlight while transporting them to the incubation unit. The eggs are transferred into styrofoam boxes for artificial incubation and where the temperature is maintained at around 30 °C using wood sawdust. The relative humidity should be adjusted to 90% and the mound is frequently sprinkled with water to maintain the required humidity. The hatching performance of the eggs of *Crocodylus porosus* at the Thaketa Crocodile Breeding Farm is shown in **Table 3**.

Nursing of the crocodile hatchlings

Hatching of eggs occur after 90 days of incubation period and the entire egg has become opaque. Eggs are examined by patting the nest mound to listen to the call of hatchlings. When the call is heard, the mound is removed and the hatching eggs are extracted from the stock. The egg shell should be gently opened so that the hatchlings could emerge easily (**Figure 8**). A healthy hatchling will have a scar-line on the belly where the body wall is almost closed over the mass of yolk. A newly hatched hatchling consists of a yolk sac (3.9 x 1.8) cm protruding through the slit in its abdomen (**Figure 9**) with the protruding yolk sac covered with a fine membrane. The hatchlings with yolk sac are then reared in intensive care nursery units. Hatchlings should be kept out of water for at least 24 hours after hatching so that the membranes can dry, shrivel and break away. No attempt should be made to wash the hatchlings or pick them clean by hand. Premature hatchlings should be kept out of water until the yolk has been absorbed and the abdomen has closed. Drinking water should be provided for the hatchlings in a small container. Hatchlings are nursed for about 90 days and kept dry to lessen the risk of the yolk becoming infected. Mesh-covered incubation boxes are suitable containers to keep the premature hatchlings (inside the incubation room) for the first few days, while keeping away flies, ants and other insects. Temperature should be maintained at 34 °C to speed up absorption of the yolk and strengthen the hatchlings as quickly as possible.

Table 3. Hatchability of *Crocodylus porosus* at Thaketa Crocodile Breeding Farm

Place	No. eggs per clutch		No. of Hatchlings		Hatchability (%)	
	Range	Mean	Range	Mean	Range	Mean
Thaketa Crocodile Breeding Farm	30-60	43.2±10.4	2-38	20.1±10.2	7.5-90.0	44.7±10.5

Figure 8. Hatching of crocodile eggs

Figure 9. Hatchling of crocodile with a yolk sac protruding through a slit in the abdomen, for rearing in the intensive care hatchery unit

Since the young crocodiles do not require food for a few days after hatching because of their remaining yolk supply, their immediate need is for warmth and behaviorally for seclusion. The saltwater crocodile hatchlings at the Thaketa Crocodile Breeding Farm usually measure 28-30 cm and are kept at the nursery intensive care unit for 7-10 months they reach about 45 cm in length.

Issues and Constraints

The successful breeding and rearing of crocodiles in a crocodile farm is necessary to comply with the requirements specified under Appendix II of CITES allowing for international trade of live crocodiles and their products only from captive-bred crocodiles. This has been the mission of the Thaketa Crocodile Breeding Farm, to adopt good management and culture practices for the captive-bred crocodiles. It should be noted however that there is a possibility of cross-breeding of crocodiles in the Farm considering that in 1978, the Farm initially reared *C. porosus* collected from the wild in Meinmahla Kyun, Bogalay Township, Ayeyarwady Delta Region but during the same year, three *C. siamensis* were received as present during a State Visit in Cambodia and stocked in the Farm. This might have resulted in the hybridization of the crocodiles in the Farm. Therefore, it is necessary to undertake a genetic study of the crocodiles at the Thaketa Crocodile Breeding Farm to determine their population structure. However, this would mean necessitating the services of experts to undertake such genetic analysis.

There are other issues that confront the breeding of the crocodile *C. porosus* in Myanmar, which should be addressed for the breeding activities to be successful, and inputs from the other Southeast Asian countries would be much welcome to improve the situation at the Thaketa Crocodile Breeding Farm in Myanmar. The issues include: inadequate knowledge and technology not only for the commercial breeding of crocodiles based on international standards but also for the processing of crocodile products, *e.g.* crocodile meat, skin for leather products, and other parts for various accessories. For the survival of the Farm, stunt shows are arranged for visitors and tourists, however, the Farm has insufficient knowledge and experiences in the area of crocodile shows and farm-based tourism. The Farm is also saddled with constraints with respect to its budget which is limited for the crocodile's feeds and infrastructure maintenance of the Farm. The supply of fresh feeds becomes limited at times, considering that the small fishes are delivered by communal and private fishing vessels that do not necessarily consider such deliveries as urgent. Generally, the financial support for public awareness and research services is not adequate.

The Farm could also experience annual flooding by high tide from Ngamoyeik or Pazutaung Creek during the monsoon season, and is not very accessible by public transportation so that special transportation is needed to bring the public and tourists to the Farm, while the entrance fee is only 500 kyats (12 Thai Baht or 0.40 US$) for locals and 1000 kyats (25 Thai Baht or 0.80 US$) for foreigners. There is also a need to develop the Farm to enhance public attraction for recreation and promotion through advertisements and in the media. At this juncture, the collaboration of relevant international organizations should be tapped to support the breeding activities at the Farm and enhance the capability of the staff assigned at the Farm, making sure that the operations of the Farm adhere to the relevant international standards for crocodile breeding and rearing in captivity.

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About the Author

Dr. Myo Min Hlaing is Deputy Director of the Department of Fisheries, Ministry of Agriculture, Livestock and Irrigation of the Republic of the Union of Myanmar. He was the Regional Fisheries Policy Network Member for Myanmar assigned to the SEAFDEC Secretariat in Bangkok, Thailand in 2014.

Re-establishing the Sea Cucumber Resources in the Philippines: the Masinloc Experience

Marlon B. Alejandro

Sea cucumber of the Family Holothuriidae and Stichopodidae, is among the most commercially-exploited aquatic species in Southeast Asia in view of the increasing demand of their processed form in the international market. Together with its products, sea cucumber is called by many names in the Southeast Asian region, *e.g.* "*trepang*" in Indonesia, "*gamut*" in Malay, "*balatan*" or "*balat*" in the Philippines. In the international market it is popularly known as "*beche-de-mer*" which literally means "sea worm." Next to Indonesia, the Philippines is among the top Southeast Asian countries that produce sea cucumber from capture fisheries and aquaculture, where it is processed immediately through direct sun-drying after harvest or sold fresh in local markets for domestic consumption. Most of the reported 100 or more species of sea cucumber found in Southeast Asian waters belong to the Genera *Holothuria* (*e.g. Holothuria scabra*, *H. fuscogilva*); *Actinopyga*; *Bohadschia*; *Stichopus*; and *Thelenota*. The Philippines is blessed with high density of various sea cucumber species that inhabit its wide sea grass beds, soft bottom sea areas, and coral reefs, making the country one of the largest exporters of the processed sea cucumber to the world market. However, wild stocks of sea cucumber in the Philippines have long been depleted due to increased fishing pressure, prompting the Philippine Government through the Bureau of Fisheries and Aquatic Resources (BFAR) to regularly monitor and assess the population of sea cucumber in the country's waters, the results of which are used as basis for enhancing the country's sea cucumber resources to curb the near extinction of such commercially exploited aquatic species, and at the same time, meeting the demand for sea cucumber in the international market. The effort of the Philippines to revive and re-establish the stocks of sea cucumber in its waters is also meant to prevent the inclusion of more commercially-important species of sea cucumber in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species that serves as basis for CITES to re-evaluate sea cucumber stocks' status for possible listing of the species into the CITES Appendices. Thus, BFAR has been promoting trials in its field stations to culture the local commercially-important sea cucumber species *H. scabra* from hatchery to grow-out. The sea cucumber juveniles produced from BFAR field stations are used not only for resource enhancement but also for the development of viable culture technologies that could be adapted by impoverished fisherfolks who have always relied on the collection of sea cucumber from the wild.

Sea cucumber is an important economic resource in Southeast Asia because of its potentials to alleviate poverty if cultured and processed properly, providing not only livelihoods to peoples in near-shore areas but also channels for investment opportunities. Sea cucumber is a multi-million dollar industry (FAO, 2008), especially in the food business and in pharmaceutical industries as well. There is a big export market for sea cucumbers, *e.g.* Hong Kong SAR, China, Taiwan, Republic of Korea, Japan, and in the United States, where dried sea cucumber could easily command high prices that range from US$180 to US$250 per kg. Bruckner *et al.* (2003) reported that approximately 80% of the overall international trade of sea cucumber is destined for China and Hong Kong SAR.

Sea Cucumber Resources of the Philippines

In the Philippines (**Figure 1**), collection from the wild and processing of sea cucumbers have been practiced throughout the country but most especially in the Provinces of Pangasinan, La Union, Cagayan, Zambales, Quezon, Batangas, Cebu, Negros Occidental, Surigao del Norte, South Cotabato, and Tawi-Tawi (Trinidad-Roa, 1987). Akamine (2001) added that sea cucumbers are also harvested in the southern part of the Palawan and in Leyte (Shoppe *et al.*, 1998), and in Misamis Occidental (Heinen, 2001). Sea cucumbers are collected by subsistence and artisanal fisheries in West Central Visayas (Nievales, 2007), Iligan Bay (Metillo *et al.*, 2004), and Davao Gulf (Gamboa *et al.*, 2004). During the 1900s, Seale (1911) reported that supplies of processed sea cucumbers are regulalry transported to Manila from Leyte, Quezon, and Camarines Provinces.

Figure 1. Map of the Philippines showing the major sea cucumber collection hotspots

Trinidad-Roa (1987) also reported that in recent years, Zamboanga City and Puerto Princesa City were the largest suppliers of processed sea cucumbers in the Philippines, where such commodity is commercially important not only because of its export potential but also for its nutritious value as tonic food having high protein and low fat contents. Treated as luxury food, sea cucumber is exported by the Philippines to oriental markets that include Hong Kong SAR, the Republic of Korea, Malaysia, Singapore, Taiwan, and to China where it is used as an important ingredient for the production of traditional medicine (Ferdouse, 2004).

The Philippines is among the Southeast Asian countries that exploit the different species of sea cucumber (Devanadera *et al*., 2015) as shown in **Table 1**, although information on the total production from capture fisheries as well as from aquaculture is rather scarce. Recent available data however showed that the Philippines ranked second to Indonesia as the largest producer of sea cucumber from capture fisheries (**Table 2**).

Although sea cucumber is a major export commodity of the Philippines, the assessment by Conand *et al*. (2014) indicating that the Philippines is a hotspot country for sea cucumber fisheries, had alerted the Philippines to explore the means of restoring the almost depleted sea cucumber resources. The country is therefore evaluating the status of its sea cucumber resources as some of these species could be subjected to possible listing into the CITES Appendices.

Philippine Sea Cucumber R&D Program

The Philippines has therefore launched a national program that promotes the culture of sea cucumber in various BFAR research outreach stations to field test and compare the most efficient culture technology viable for the local fisherfolks. Through this program, the Philippine Government expects to develop the means of diverting the uncontrolled collection of sea cucumber from the wild as practiced by fisherfolks, and promoting stock enhancement as well as meeting the market demand. Through the efforts of BFAR, sea cucumber resource enhancement has been advocated in strategic waters of the country, while viable culture techniques are being developed, especially for the local species *H. scabra* also known as sandfish. Furthermore, BFAR has also been promoting the sustainable management of the country's natural stocks of sea cucumber through the issuance of Fisheries Administrative Circular No. 248 Series of 2013 that sets the size limit for harvesting and processing sea cucumber at 320 g/piece (BFAR, 2013). This has provided the enabling policy for improved production of premium grade-size sea cucumbers to curb untoward depletion of the country's sea cucumber resources. BFAR has also been collaborating with various national and international agencies for its R&D Program on Sea Cucumber (Juinio-Meñez *et al*., 2012), *e.g.* Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), Department of Science and Technology (DOST), Aquaculture

Table 1. Sea cucumber species exploited by Southeast Asian countries (adapted from Devanadera *et al*., 2015)

Family	Genus	Scientific Name	Countries involved in the exploitation
Holothuriidae	*Actinopyga*	*Actinopyga echinites*	Viet Nam
		A. lecanora	Philippines, Viet Nam
		A. mauritiana	Indonesia, Philippines
	Bohadschia	*Bohadschia atra*	Indonesia
		B. marmorata	Indonesia, Malaysia, Philippines, Thailand, Viet Nam
		B. vitiensis	Viet Nam
		B. subrubra	Thailand
	Holothuria	*Holothuria atra*	All throughout Southeast Asia
		H. coluber	Indonesia, Philippines
		H. cinerascens	Philippines
		H. edulis	Indonesia, Malaysia, Philippines, Thailand, Viet Nam
		H. impatiens	Indonesia, Viet Nam
		H. leucospilota	All throughout Southeast Asia
		H. notabilis	Indonesia
		H. pervicax	Indonesia
		H. scabra	All throughout Southeast Asia
		H. scabra var. versicolor	All throughout Southeast Asia
	Pearonothuria	*Pearonothuria graeffei*	Indonesia, Malaysia, Philippines
Stichopodidae	*Stichopus*	*Stichopus chloronotus*	Viet Nam
		S. herrmanni	Indonesia, Malaysia, Philippines, Thailand, Viet Nam
		S. horrens	Indonesia, Malaysia, Philippines
		S. quadrifasciatus	Indonesia, Philippines
	Thelenota	*Thelenota ananas*	Indonesia, Malaysia, Philippines, Thailand, Viet Nam

Table 2. Sea cucumber production of Southeast Asia from capture fisheries and aquaculture (metric tons (MT))

	2011	2012	2013	2014	2015	2016
Capture Fisheries: sea cucumber						
Indonesia	5,768	6,500	4,390	5,428	6,480	3,901
Philippines	924	800	732	692	686	747
Aquaculture: sea cucumber						
Indonesia	2,019	475	206	138	-	-
Malaysia	-	-	-	-	-	54
Total sea cucumber production	**8,711**	**7,775**	**5,328**	**6,258**	**7,166**	**4,702**
Marine capture fisheries production						
Indonesia	5,328,637	5,400,977	5,707,020	5,967,139	6,065,060	6,070,965
Philippines	2,171,770	2,145,233	2,127,368	2,131,872	2,094,346	1,994,338
Aquaculture production						
Indonesia	7,928,962	12,969,364	13,147,288	14,187,124	15,634,093	16,675,033
Malaysia	287,042	283,559	260,774	524,565	506,465	407,689
Total fisheries production: Southeast Asia	**33,654,492**	**39,491,091**	**40,150,808**	**42,117,647**	**43,998,242**	**45,336,312**

Source: SEAFDEC (2017, 2018)

Department of the Southeast Asian Fisheries Development Center (SEAFDEC/AQD), and the Australian Centre for International Agricultural Research (ACIAR), among others. In addition, BFAR also works closely with academic and research institutions in the Philippines, *e.g.* University of the Philippines - Marine Science Institute (UP-MSI), UP in Los Baños (UPLB), and with the private sector, *e.g.* the Palawan Aquaculture Corporation (PAC) and Alsons Aquaculture Corporation (AAC) that serves as partners in technology verification (Juinio-Meñez and Samonte, 2016).

Breeding Experiments in Masinloc, Zambales

One of the sites identified by BFAR for the breeding and culture trials for sea cucumber is Masinloc in Zambales (**Figure 2**) considering several factors that include the established sea cucumber hatchery facilities at the DA-BFAR Technology Outreach Station: Marine Waters (TOSMW) in Bamban, Masinloc; the presence of intertidal zone (0.5 m in depth at the lowest tide) in Masinloc Bay; type 1 climate of Zambales, *i.e.* two pronounced seasons: dry in December to May, and wet in June to November; and the presence of organized fisherfolks in the area. The sea cucumber species *H. scabra* (**Figure 3**), which is considered as the commercial species suitable for mariculture in the Philippines, is being used because of its capability to grow in captive conditions while its adults could command a fairly high price in the market.

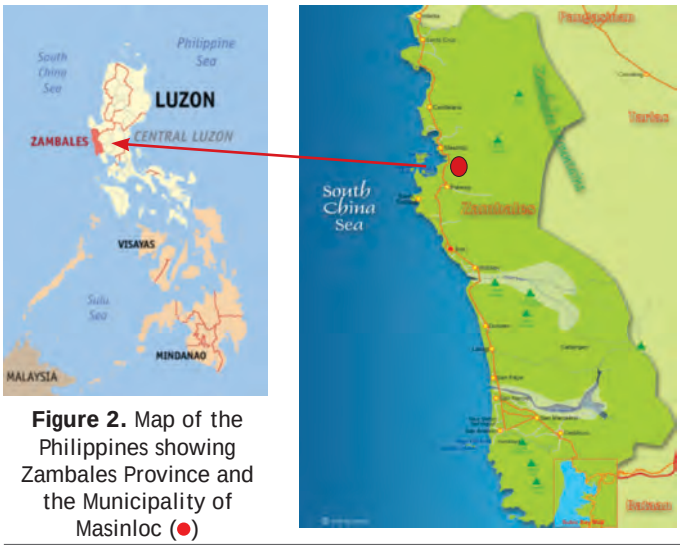

Figure 2. Map of the Philippines showing Zambales Province and the Municipality of Masinloc (●)

At the outset, the DA-BFAR TOSMW refined the breeding and culture techniques developed by the University of the Philippines-Marine Science Institute (UP-MSI) for *H. scabra* using broodstocks from the wild, to suit the environmental conditions of Masinloc, Zambales. The DA-BFAR TOSMW also adapted the breeding and hatchery technologies developed by SEAFDEC Aquaculture Department (SEAFDEC, 2015) for the sea cucumber, resulting in continuous supply of seeds (**Figure 3**) for the mariculture trials and stock enhancement activities in Masinloc Bay, Zambales.

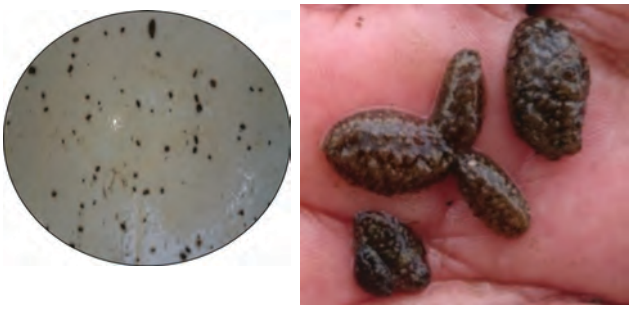

Figure 3. Sea cucumber seeds produced at the DA-BFAR ROSMW for mariculture trials in Masinloc Bay, Zambales

Grow-out Culture Experiments in Masinloc Bay, Zambales

Tuwo (2004) reported that Indonesia has already led the culture of *H. scabra*. Although the biology of *H. scabra* is not specifically explained, the organism could be cultured in cages, pens or ponds until the specimens are large enough

to be sold or processed, or used for resource enhancement. Nonetheless, BFAR recognizes that there is a need to conduct grow-out culture trials to determine the growth performance of sea cucumber in natural waters.

As part of the Philippine Sea Cucumber R&D Program, BFAR has therefore intensified the culture of sea cucumber in its research outreach stations to field test and compare the most efficient culture technology viable for adoption by local fisherfolks, divert the uncontrolled practice of collecting sea cucumber from the wild, and promote the re-establishment of the country's sea cucumber resources. Labe *et al.* (2007) reported that although some fishers collect sea cucumber as by-catch from traditional fisheries, other fishers collect by diving into deeper reefs to individually glean the sea cucumber unmindful of their sizes since middlemen buy all their catch that usually comes in various sizes.

Moreover, the inadequate monitoring and recording of the catch had made it difficult to determine the actual situation of the country's sea cucumber resource. However, some fishers had been saying that recently, it had taken them longer time to collect a considerable volume of sea cucumber (Labe *et al*., 2007). This is the same scenario that encouraged SEAFDEC to carry out in 2007 the Regional Comprehensive Compilation of Data and Information on Sea Cucumbers, the results of which had been used for the management of the sea cucumber resources by concerned Southeast Asian countries (Bumrasarinpai, 2007). Thus, BFAR has been conducting culture experiments of sea cucumber using its field stations, one of which is the DA-BFAR TOSMW in Masinloc, Zambales.

The sea cucumber pen culture site in Masinloc Bay is in a 200 m^2 sea area and follows the prescribed bottom substrate criteria which should be with muddy bottom and salinity that range from 35 to 40 ppt (SEAFDEC, 2014). The pen was set-up in an intertidal zone with 0.5 m depth at the lowest tide and was stocked with 500 pcs of sea cucumber at an initial average weight of 50 g/pc (**Figure 4**). No feeding was done since sea cucumbers could rely on the natural nutrients found on the bottom substrate. The culture period was from April to December 2014.

While stocking was done at the near end of the dry season in April, the incoming wet season from June to November, has laid a good culture environment for the sea cucumber as indicated by its increasing growth trend. Although in some parts of November the growth rate slowed down, still the sea cucumber gained increases in body weights (**Figure 5**). Therefore, future culture trials should be carried out to establish the optimum and poor months for culturing sea cucumber based on the climate type of Zambales.

Figure 4. Sea cucumber juveniles for mariculture trials at Masinloc Bay, Zambales

Figure 5. Premium size sea cucumber for resource enhancement as well as processing

At the end of the culture period, 321 pieces of sea cucumber have been recovered indicating a survival rate of 64%. Average body weight after eight months was 444 g with an average weight gain of 135 g and growth rate of 52% (**Table 3**). The presence of juveniles at 3-5 cm was observed inside and outside the pen at a density of 2 juveniles/m^2 inside and 300 individuals outside at 50 meters transect line, a phenomenon that was replicated three times. Results of the experiment also showed that the growth trend of sea cucumbers was continuously increasing even beyond eight (8) months of culture. A sudden increase in growth rate was observed between the second and third month (from June to July) with 142 g weight gain from 108 g to 250 g or growth rate of 131% growth rate. Meanwhile, the percent lowest weight gain at 10% was observed in June, the second month of culture.

Overall, the growth performance after eight months of sea cucumber pen culture in Masinloc Bay attained a 52% monthly average growth rate with weight gain that ranged from 10 to 328 g every month averaging at 135 g. Although this could be comparable to that of Indonesia's experience considering the same species cultured in the same tropical environment, the feat attained in Masinloc Bay is much higher than that of Indonesia's 28-33 g wet weight gained per month (Tuwo, 2004), and is still higher compared with Indonesia's target increase of 32-73 g wet weight per month using different doses of organic matters (Pirdausi, 1989 as cited by Tuwo, 2004). From 30 g to 50 g initial weight, the *H. scabra* in Indonesia's trials was harvested after six (6) months of rearing, reaching 200-250 g in weights and lengths at 15-20 cm, whereas, in the Masinloc Bay experience, *H. scabra* gained mean body weights of 701 g after six months of culture as shown in **Table 3**. The survival rate of 64% in pen culture was also higher compared with that of Indonesia's 50% survival in ponds.

The weight increase attained by the sea cucumber beyond eight months of culture in Masinloc Bay, and the presence of

Table 3. Monthly sampling results of sea cucumber cultured in marine pen in Masinloc Bay, Zambales

Months of culture	Total Stocks	Mean Initial Weight (g)	No. of Months of Culture	Mean Body Weight (g)	Mean Body Weight Gain (g)	% increase / %growth rate
April 2014	500	50	0	50	-	-
May			1	98	48	96
June			2	108	10	10
July			3	250	142	131
August			4	350	100	40
September			5	508	158	45
October			6	701	193	38
November			7	803	102	15
December	321		8	1131	328	41
	Average			**444**	**135**	**52**

Figure 6. Adult sea cucumber for processing and marketing

juveniles could be indications that the sea cucumbers might have spawned during the span of the culture period. Considering its fast growth, the culture period of *H. scabra* could be shortened to four months, wherein the sandfish have reached 350 g, the size ideal for marketing and processing (**Figure 6**). As reported by Tacio (2009), 250 g is the desired weight in the export market, so that results from the Masinloc trials that gave 350 g had overshot the 250 g requirements of DA-BFAR. The 250 g is the weight yield after four months culture in ponds, while the pen culture showed higher weight yield.

The growth performance in this experiment is indeed promising although continuous research would be necessary for comparison of the results of field demonstrations in other DA-BFAR research stations. Furthermore, the government should also consider providing support to the field demonstrations, assisting in the analysis of the data, providing fora where the results could be presented and discussed, and fully supporting the publication of the results from such research efforts in order that the data could be made available for resource management as well as resource enhancement of the country's sea cucumber stocks.

Figure 7. Results after eight months mariculture in Masinloc Bay, Zambales: from an average of 30-50 g *(left)*, the final yield had an average weight of 1.11 kg *(right)*

After eight months of mariculture using 30-50 g juvenile sea cucumber, the final harvest had an average weight of 1.11 kg/ adult sea cucumber (**Figure 7**).

Enhancement of the Sea Cucumber Resource in Masinloc Bay, Zambales

BFAR has always advocated the sea ranching of sea cucumber considering its behavior in the culture area, especially in terms of its movement, traveling just one to two meters a day and about one kilometer in a year. Since BFAR has recently established the country's commercial hatchery for sea cucumber producing 60,000 "juveniles" every month, the juveniles could be distributed to fish farmers for pond culture or for sea ranching by stocking the sea cucumber in designated areas in the sea to be gathered by them later, thus enhancing the massive culture of the commodity nationwide. Using the juveniles produced from the hatchery facilities of the DA-BFAR TOSMW, BFAR Region III together with the Provincial Local Government Units of Zambales and Local Government Units of Masinloc cooperatively launched the sea cucumber stock enhancement and sea ranching project in Masinloc Bay on 21 May 2019 and in nearby San Salvador Island also in Masinloc, Zambales (**Figure 8**).

The sea cucumber stock enhancement and sea ranching project in Masinloc Bay is aimed at increasing the population of sea cucumber in the wild as well as enhancing the role that sea cucumber plays in the ecosystem specifically filtering sediments and recycling the nutrients back to the sea. With increased population of sea cucumber in the wild, the oceans would be cleaner and healthier.

Conclusion and Discussion

Another culture experiment in four months should be pursued to reconfirm the results of the trials conducted by DA-BFAR TOSMW. Once proven and tested, such scheme would guarantee good marketability making the culture technology in pens viable to local fisherfolks specifically for those who have long depended on collecting sea cucumber from the

Figure 8. Sea cucumber being prepared by the DA-BFAR ROSMW for resource re-establishment activities *(left)*, and resource enhancement *(middle)* and sea ranching *(right)* in Masinloc, Zambales

wild as their source of livelihood. Nevertheless, beyond four months of culture, juveniles could be spilling over in adjacent areas and thus, facilitating stock enhancement which is also in line with the efforts of the Philippine Government to revive the natural stocks of sea cucumber in the country which is feared to be almost at the verge of collapse.

The advances made by many agencies in the Philippines with regard to seed production and mariculture of sea cucumber could be tapped to facilitate the re-establishment of the depleted natural stocks of sea cucumber in the country by properly releasing juveniles for restocking (SEAFDEC, 2014; SEAFDEC, 2015; SEAFDEC Aquaculture Department, 2018), as well as for stock enhancement (Dance *et al*., 2003; Bell and Nash, 2004; Choo, 2008). Aquaculture and stock enhancement are considered the best approaches to address the over-exploitation trends of the sea cucumber resources, as the technologies for spawning as well larval and juvenile rearing have already been developed for some commercially important sea cucumber species (Lovatelli *et al*., 2004), *e.g. H. scabra*. In the Philippines, steady supply of sea cucumber seeds and juveniles is available. However, access to their source for mariculture and resource enhancement in Philippine seawaters should be facilitated by the government in order that such activities could be sustained by the stakeholders. Moreover, continuous research to improve breeding and hatchery techniques of sea cucumber, especially the sandfish, as well as mariculture, either in ponds and pens should therefore be pursued in order to re-establish depleted stocks. The release strategies that have been developed for sea cucumber could be adapted to suit the local conditions of the prospective release sites.

Way Forward

There are many factors that contribute to the overexploitation of sea cucumber. In their adult stage, sea cucumbers have limited mobility, mature late and with density-dependent reproduction, tend to have habitat preferences, and have low rates of recruitment. Their large size makes sea cucumbers very easy to detect and collection is easy as this does not require high-technology fishing methods while processing is simple. As the demand for sea cucumber in the world market has been increasing, other species are now being targeted as the high-value species in the wild are almost depleted and getting more scarce.

The Philippine Government is exerting much effort in refining the sea cucumber culture techniques from hatchery to grow-out by tapping the available resources and expertise nationwide, and strengthening the collaboration with national agencies and institutes involved in sea cucumber culture and stock enhancement. In addition, BFAR intends to enhance the capability of its field stations in the massive raising of sea cucumber nationwide, especially the field hatcheries and nurseries in order that juveniles could be distributed to fish farmers who are interested in fish pond culture or sea ranching. This is considering that culture of sea cucumber is profitable and environmentally-friendly, and provides livelihood industry for coastal communities. Moreover, once sea cucumbers are placed in the seafloor or in ponds, the survival rate could be almost 100%.

Furthermore, efforts would also be intensified to address habitat degradation in many coastal areas due to unmanaged resource use and management issues. In the case of Masinloc Bay, findings of the Masinloc Integrated Coastal Resources Management (ICRM) on the adverse impacts of rapid growth of coastal settlements, inappropriate coastal land use schemes, destructive fishing practices, excessive sediment loading, pollution and generally the demand for greater economic outputs, would be addressed. This forms part of the nationwide plan to rehabilitate the coastal habitats that host various natural resources, including echinoderms, *e.g.* sea cucumber, as marine productivity continues to decline and fishing communities are increasingly encountering economic difficulties due to the declining catch per unit during the past years. Concerns on institutional deficiencies and low awareness on proper coastal resource management would also be addressed by the government by building the capacity of concerned national government staff especially those working in the field stations of BFAR, as well as enhancing the capability of the field stations and similar units under BFAR.

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About the Author

Mr. Marlon B. Alejandro is the Philippine Regional Focal Person for Sea Cucumber Project, and Hatchery Manager and Assistant Station Head of BFAR 3 TOSMW. He was a Member for the Philippines of the 2016 Regional Fisheries Policy Network attached with the SEAFDEC Secretariat in Bangkok, Thailand from January to December 2016.

Capacitating the Local Farmers to Enhance Global Marketing of Thailand's National Aquatic Animal, the Siamese Fighting Fish

Amonrat Sermwatanakul

The Siamese fighting fish (*Betta splendens* Regan, 1910) also commonly known as betta or betta fish, is a popular fish in the aquarium trade and was declared on 5 February 2019 as Thailand's National Aquatic Animal. Centuries ago, the Siamese fighting fish or betta fish was initially bred to enhance their aggression for sparring competitions as a form of entertainment and gambling. But later on, local breeders in Thailand developed different varieties of the fish through selective breeding to attain an assortment of colors and fins that are appealing to customers. As additional business ventures, the unique and striking appearance of betta fish inspired numerous artistic works and creative products, such as in photography, painting, sculpture, weaving, 3D graphics, furniture, cosmetics, fashion, and so on, which could have also built up the popularity of betta fish. For many years, the betta fish industry has generated millions of dollars for Thailand. However, despite the high revenue gained from trading betta fish in the international market, the economic condition of local breeders in Thailand remained low because they lack the knowledge and skills in marketing. In order to uplift the livelihood of small-scale betta fish farmers, the Department of Fisheries (DOF) under the Ministry of Agriculture and Cooperatives of Thailand implemented the Ornamental Fish Strategy Plan in 2013-2016 in collaboration with partner agencies. Aside from financial assistance and transshipment support, capacity development through training was also provided to betta fish farmers for them to learn effective online marketing strategies and be successful farmer-entrepreneurs. Recently, the Office of Small and Medium Enterprises Promotion (OSMEP) of Thailand committed its full support to the home breeders of betta fish to achieve sustainable livelihood by enhancing their capacities to compete in the international market and adding value to products from backyard farms.

Cultural and Historical Legacy

The earliest record of popularity of the betta fish in Thailand was during the Thonburi Period (1767–1782) when Amphawa locals raised and fought the fish in gambling games (Kruangam, 2016). However, animal fights (including cocks, quails, Srichompu birds as well as betta fish) were banned during the reign of King Rama I (1782–1809) and was revived during the reign of King Rama II (1809–1824). Starting from the reign of King Rama III (1824–1851), the fish was used also as gift and souvenir, and it was widely raised and became popular in home aquaria during the reign of King Rama IV (1851–1868). Since the reign of King Rama V (1868–1910), the betta fish has become the most expensive freshwater fish in Thailand. An example of betta fish fights is shown in **Figure 1**.

Figure 1. Thai locals enjoy laying wagers on the sparring Siamese fighting fish

Source: Young, 1898

King Rama III himself owned betta fish and gave some to a Thai man, who later handed over the fish to Theodore Edward Cantor, a Danish physician, zoologist, and botanist. In 1849, Cantor named the fish as *Macropodus pugnax*. But in 1909, Charles Tate Regan, a British ichthyologist, reviewed and verified the fish and scientifically renamed it as *Betta splendens*, which literally means splendid warrior. The word "*Betta*" was derived from the legendary warrior-like tribe named "Bettah" and "*splendens*" stands for "splendid" describing the appearance of the fish. Siam is the old name of Thailand, thus, the common English name is Siamese fighting fish, and it is locally known in Thailand as *pla kad* (*pla* is fish and *kad* is bite) which means biting fish. Regan (1909) emphasized that *B. splendens* has an outstanding appearance compared to other fishes around the world, and he assigned Thailand, particularly Chao Phraya River, as the standard reference location of the fish where it was first discovered (Sermwatanakul, 2018).

Considering its rich cultural and historical background and huge economic opportunities, the betta fish was declared as Thailand's National Aquatic Animal as proposed by the DOF and petitioned by the public through Change.org (2019) that garnered more than 17,000 supporters. The prestigious recognition of betta fish could enhance the cultural and ecological preservation efforts as well as commercial breeding for income generation.

Trade of Betta Fish in Global Market

Ornamental fish production in Thailand continues to be a steadily growing industry where the production of high quality ornamental fish is facilitated by lush natural resources and traditional experience. Thailand is among the top-ranked sources of ornamental fishes in the world (Dey, 2016). For many years, the betta fish has been the most exported aquatic animal and gained the highest value. In 2018, the exported volume of betta fish was around 22.82 million with an estimated value of US$ 5.55 million (**Figure 2**).

Even before it was declared as the country's National Aquatic Animal, betta fish persisted to be in great demand both locally and abroad. From 2014 to 2018, the average volume per year and average value per year of exported betta fish were 23.92 million and US$ 4.29 million, respectively. In 2018, even though the exported volume abruptly decreased, the value significantly increased to about US$ 5.55 million which was the highest revenue during the five-year period (2014-2018) (**Figure 3**). The escalating popularity and value of betta fish in the global market could be attributed to the application of effective online marketing strategies, especially enhanced advertisements through social media, that the local betta fish farmers learned from the capacity development trainings organized by DOF during 2013-2016.

Betta fish of different features and qualities have different prices and markets. For those living in the US and Europe, the betta fish is generally kept as pretty pets. In the Middle East, people like to give the colorful fish to others as a gift on special occasions. People from the Asian countries usually prefer to buy high quality fish that can be entered into fish contests. Whereas some people buy betta fish at wholesale prices and sell them at higher prices.The top five destination countries in terms of value of exported betta fish in 2018 include the USA, China, France, Iran, and Singapore (**Figure 4**). Even though the volume of exported betta fish to France is lowest among the top five importing countries, the high quality of fish and high logistical costs made betta fish the most expensive in this country at about US$ 0.50 per fish.

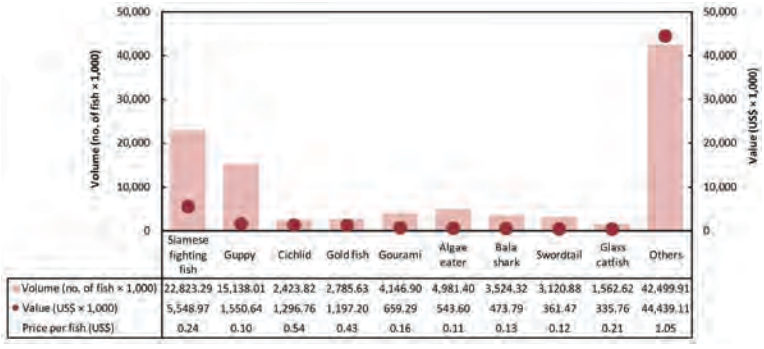

Figure 2. Major ornamental fish species exported by Thailand in 2018 by volume (number of fish) and value (US$)

Source: DOF, 2018

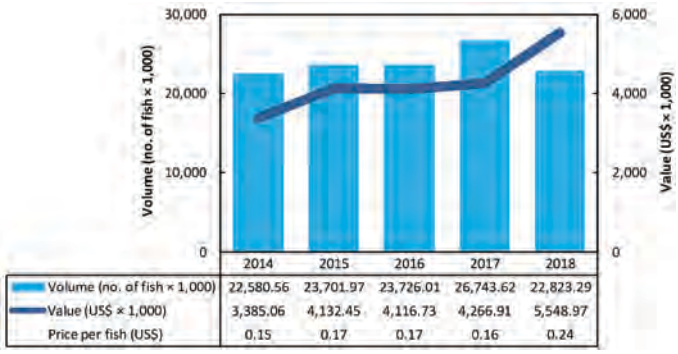

Figure 3. Volume (number of fish) and value (US$) of Siamese fighting fish exported by Thailand in 2014-2018

Source: DOF, 2018

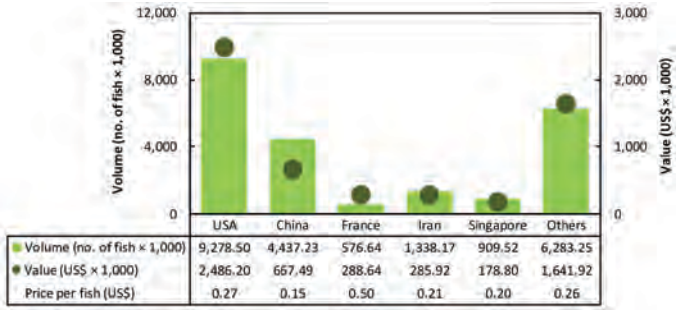

Figure 4. Top five destination countries of Siamese fighting fish exported by Thailand in 2018 in terms of value (US$)

Source: DOF, 2018

Visiting local shops is the most common way for customers to see and buy betta fish. On the other hand, online marketing extensively reaches the domestic and international markets. Many people from all over the world opt for online means such as fish auction websites and social media. The pricing of betta fish varies according to colors and fin forms, which can go from as low as less than a dollar to outrageously more than a thousand dollars. The most expensive betta fish so far was the one with the colors of the Thai national flag (**Figure 5**) which was sold at US$ 1,530 from an online auction (Bangkok Post, 2016).

Figure 5. Siamese fighting fish with the colors of the Thai national flag (blue, red, and white), the most expensive type of betta fish so far, sold at US$ 1,530 from an online auction

(Photo by Mr. Patchara Aunsangchan, bred by Mr. Piphut Jittreesilp)

Ecology and Biology of *Betta splendens*

The many varieties of betta fish are geographically distributed in tropical areas with temperatures between 24 °C and 30 °C, which include Thailand, Indonesia, Malaysia, Viet Nam, and parts of China. They are also found in the Malay Peninsula and across the Strait of Malacca to adjacent parts of Sumatra. The occurrence in Sumatra is probably due to human introductions. betta fish can be found in floodplains, canals, rice paddies, ponds, slow-moving streams, swamps, and medium to large rivers (Taki, 1978; Rainboth, 1996; and IBC, 2019).

B. splendens are anabantoid fish distinguished by their possession of a lung-like labyrinth organ that enables them to breathe air from the water surface. This allows them to live in low-oxygen water, which is why they can be kept in smaller containers and easier to transport than other tropical fish. They feed on zooplankton and larvae of mosquito and other insects in the wild (Rainboth, 1996). In captivity, they can be fed with Moina (water fleas), brine shrimp, fish feed, and egg tofu. Their lifespan is generally two years according to Hugg (1996) and sellers.

Both males and females have an elongated body with an average total length of 6.5 cm and vary in color in the wild and in captivity depending on its breed. The wild type appearance of both male and female is black or dark green color and simple short fins. Because they have been bred over time into many colors and fin forms, the primary type of betta fish that is seen in pet stores have evolved far beyond their original wild type appearance. The hybrid male species is usually brightly colored with large flowing fins, whereas the female is pale and has small simple fins. Males are known to be extremely territorial and aggressive, thus holding of the males in very small containers is discouraged because they will attack each other if housed in the same tank (Riehl & Baensch, 1991). On the other hand, females can be housed together in a large enough space. Male and female can be kept together temporarily for breeding purposes, and that only one female should be brought into the 20-liter or 30-liter breeding tank.

Figure 6. Female (pink) and male (dark blue) *Betta splendens* mating under bubble nest

(Photo by Mr. Manutham Harnnarongphanich)

The male builds bubble nest on the surface of the water, generally under a plant leaf, to attract females even if one is not in the tank. Once the male and female have bred, they place the eggs in the bubble nest (**Figure 6**). The male chases the female away and protects the bubble nest and the eggs until hatched. If the female is allowed to stay for extended period of time she will begin eating the eggs that she spawned.

Since it has become increasingly rare in the wild, *B. splendens* has been listed as a vulnerable species by the International Union for Conservation of Nature (IUCN) (Vidthayanon, 2011). The main threats to the species are habitat degradation and pollution especially in central Thailand where most of their suitable lowland habitat had been converted into intensive farmland and urban areas. Another threat is the farmed stock that escaped into wild habitats which causes genetic erosion (IUCN, 2011). Betta fish lovers are hoping that the national designation of the betta fish would lead to stronger conservation efforts in Thailand.

Proper Care for Betta Fish as a Pet

Many appreciate having pet fish as a fun hobby and looking at an aquarium is known to reduce stress in humans. However, betta fish are sold to customers who are often uneducated about proper care, thus creating stress to the fish. Fish hobbyists should ensure that their betta fish pet is provided with warm water and regular feeding and tank cleaning. Infection with *Mycobacterium* spp. (harmful bacteria) should be managed as well because it is abundant in betta fish, live betta food, and betta farms, which has possible pathologic consequences for infected fish. Aquarium size is another potential welfare issue because of the tendency to keep betta fish in small vases. Besides, vegetation as environmental enrichment in betta aquaria is advisable because their natural habitat consists of thick vegetation to hide from predators. Environmental enrichment in aquaria like plants and caves to explore may have sheltering and stress-reducing effects on betta fish (Pleeging and Moons, 2017; National Geographic, 2019; PETA, 2019).

Farming of Betta Fish

There are more than 1,000 betta fish farms all over Thailand that are either home breeders (small-scale) and commercial (large-scale), the economics of which are shown in **Table 1**. A betta farm, whether small- or large-scale, is divided into three zones: breeding, nursery, and culture (**Table 2**). Usually, the whole family is involved in betta fish farm activities including women, men, children, and the elderly.

Betta Fish Supply Chain

Over the last fifty years, Thai fish farmers have successfully bred local and exotic species of ornamental fish resulting in a plethora of new varieties and an increase in production. This

Table 1. The economics of large-scale and small-scale betta farms in Thailand in 2018

	Home breeders	Commercial
Capital (US$)	20,000-35,000	200,000-300,000
Size (m^2)	200	400-800
Production volume (number of fish sold/month)	200-500	200,000
Production cost (US$/fish)	3.3	1.5
Selling price (US$/per male fish)	15-20	0.16-3.0
Selling price (US$/per female fish)	10	0.3
Income from international market (US$/month)	8,000-1,200	10,000-15,000
Common problem	Production of betta fish to meet the high quality standard demanded by the market	Insufficient supply in some season
Opportunity	Availability of SFF varieties to serve the specific demands of consumers	The demand is all year-round

Table 2. The three zones (breeding, nursery, and culture) in Ratree Betta Farm in Nakhon Pathom Province, Thailand owned by *Ms. Ratree Sae Lee*

	Breeding zone	Nursery zone	Culture zone
			
Materials	> 500 plastic bowls (100 ml each)	1,000 concrete tanks (100 L each)	300,000 glass bottles (50 ml each)
Number of fish per container	1 pair	300-500	1 (all male)
Duration	6 days	1.5 months	1.0-1.5 months
Water maintenance	NA	Change half of water in tank every 3 days	Water is changed every 3 days
Water temperature (°C)	25-29	25-29	25-29
Water pH	7-8	7-8	7-8
Feeding (feed and frequency)	Moina, once per day	Moina, once per day	Moina and/or ground boiled egg, once per day
Mortality rate (%)	Negligible (well-experienced betta fish farmers)	Negligible (proper live food feeding and routine water change)	Negligible (only high quality betta fish are raised in the bottles)
Average fish size (total length cm)	NA	1-1.5 cm	2-2.5
Number and task of female workers	1 Assist in breeding	2 Assist in nursery works	2 Photography, online marketing, contact customers
Number and task of male workers	1	1 Live food preparation, feeding, fish health monitoring	1 Live food preparation, feeding, fish health monitoring
Number and task of children	Assist parents after school or during holidays	Assist parents after school or during holidays	Assist parents after school or during holidays
Number and task of elderly workers	1-2 All tasks depending on heath condition	1-2 All tasks depending on heath condition	1-2 All tasks depending on heath condition

has led to the necessity to improve the logistics in the supply chain from farm to customer in order to reduce losses and sustain or increase the market value of products. Therefore, in collaboration with the DOF and OSMEP, Thailand Post has launched in December 2018 the special delivery service for betta fish parcel.

Figure 7. Packaging of betta fish for domestic delivery

Figure 8. Preparing the betta fish for international delivery at JJ Betta Farm in Nakhon Pathum Province, Thailand owned by *Ms. Nattha Thannawong*

This special service is aimed at supporting the betta fish farmers to supply the high demand especially from abroad under the "safe and fast" concept. The parcel comes with a special betta fish sticker to notify the handlers. For the direct delivery of betta fish from farm to the customer (hobbyist or pet shop), each fish is packed in a double layer of plastic bags and enclosed in banana trunk for insulation before placing in the delivery box (**Figure 7**).

For the export delivery, each fish is packed in small plastic bowls or small plastic bags (**Figure 8**). All shipments are attached with health certificate issued by the DOF under World Organisation for Animal Health (OIE) standards. Before departure from the airport, the fisheries inspectors ensure that the delivery boxes do not contain illegal items such as animals under the CITES list.

Empowered Women and Men in Betta Fish Farming

The betta fish farmers in Thailand have extensive knowledge on the breeding and culture of betta fish, and they are successful in producing high quality fish that meet the standards of domestic and global markets. However, most of the local breeders lack the channels (low marketing knowhow, poor English communication, and so on) to access global markets. Because of high supply of betta fish for limited customers, the farmers were forced to reduce the wholesale price of the fish to as low as US$ 0.10-0.16 per fish to attract customers. For most home breeders, they lack the capital when they wish to expand their business.

In order to alleviate the livelihood of betta fish farmers, the DOF and partner agencies implemented the Ornamental Fish Strategy Plan during 2013-2016 with the vision of making Thailand as the number one exporter of ornamental fish in Asia. The objectives of the Plan include 1) improving the production quantity and quality of ornamental fish; 2) enhancing the domestic and international ornamental fish trade; and 3) developing the capacity of ornamental fish farmers to become successful farmer-entrepreneurs. One of the crucial action plans was to produce value-added and creative products, specifically of the betta fish which was selected as the most significant fish. The information on Ornamental Fish Strategy Plan was disseminated to ornamental fish farmers through announcement posted in the government website and announcement in fisheries provincial offices. The ornamental fish farmers all over Thailand are required to voluntarily register under the DOF for them to avail of several privileges offered by the government, *e.g.* training courses on capacity development for registered ornamental fish farmers (**Box**).

Box. Training courses that also cover effective online marketing strategies

- classification and pricing of fish based on color and fins
- photography and videography using smartphones and setting up DIY studio at the fish farm
- creating accounts in social media, auction websites, online payment schemes, etc.
- simple English communication using language translation apps
- value-added and creative product

Moreover, the Office of Small and Medium Enterprises Promotion (OSMEP) also provides financial assistance to betta fish farmers through the group called Cluster Plakad 2019. The group comprises 700 betta fish farmers all over Thailand with one cluster in each of the five regions of the country including North, Northeast, South, Central, and Nakhon Pathum. The Cluster Plakad 2019 aims to: 1) provide a better understanding of the concept and practice of entrepreneurship, 2) promote connectivity among betta fish farmers, 3) raise awareness of market demands, and 4) boost the capacity of betta fish farmers to compete with other farmers and sellers at the domestic and international markets.

The interventions of the government have had a remarkable impact to the betta fish farmers who are now fully equipped to market their products and earn the high profit that they deserve from their hard work. Numerous betta fish farmers have become self-sufficient farmer-entrepreneurs by selling their fish all over the world. They used to earn THB 15,000/month but now they are earning as much as THB 30,000-100,000/month. Betta fish farmers are now able to take

advantage of the availability and advances in information technology for the online marketing of their fish. Photographs of betta fish are taken in a do-it-yourself (DIY) studio at the farm and uploaded in various online platforms, such as *www.aquabid.com*, company website, and social media. The buyer pays the betta fish farmer through online payment schemes such as Paypal, Western Union, Money Gram, bank to bank transfers, and others.

As of May 2018, there were 413 (163 female and 249 male) registered beta fish farmers in Thailand. Interestingly, a good number of women are not only betta farm owners, but are also actively engaged and proficient in online marketing. Also, more and more young people are motivated in putting up their own betta fish farms and some have even given up their day jobs to become full-time betta fish farmers.

Way Forward

The Government of Thailand, through the DOF and partner agencies, would continue to support the local betta fish farmers by promoting sustainable betta fish farming and systematic supply chain management by means of 1) effective utilization of information technology, 2) proper planning of production, sales, and cost reduction; and 3) active exchange of information on activities organized by public and private sectors. Also, the Government is planning to provide more support the community to develop betta fish farms as tourist destinations by promoting not only the betta fish but also the value-added and creative products as souvenir items that will be produced by the community.

It is hoped that the designation of betta fish as the country's National Aquatic Animal would lead to sound conservation actions. The IUCN (2011) strongly recommends captive breeding from wild populations and management of known habitats. Research and monitoring of population size, distribution, and trends are also necessary. Presently, there are conservation groups of fish farmers in several areas of the country who advocate on the breeding wild betta fish and releasing some of the fish back to their natural environment. The DOF, in close collaboration with the community and provincial government, would tap the conservation groups of betta fish farmers in developing a model of conservation and area-based management plan that will be implemented in Bangkok, Samut Sakhon, and Buriram as areas of resource conservation and habitat protection.

One of the most important awareness raising activities that the DOF, in partnership with betta fish farmers, plans to carry on is during the Children's Day, an event that Thailand celebrates every second Saturday of the year. Last 12 January 2019, around 3,000 betta fish were distributed to the many children who came to the event organized for the first time at the Government House in Bangkok (**Figure 9**). It was a successful event where the DOF and betta fish farmers joined hands in educating the Thai people, especially the children in a fun and exciting way about proper care of the betta fish as a pet and raise their awareness of betta fish as the country's National Aquatic Animal.

The local breeders and sellers in Thailand believe that the betta fish industry could definitely grow even bigger because the existing supply is not enough to cater to varying demands. Betta fish farming could be a promising livelihood opportunity also for aspiring betta fish farmers from other ASEAN Member States (AMSs); especially that *B. splendens* is also naturally abundant in many areas of AMSs. Certainly, establishing betta fish farms and making it successful is a lengthy process and full of challenges along way.

By learning from the experiences of Thailand and strong commitment, the governments of AMSs could gain from the benefits of sustainable betta fish farming in empowering the local fish farmers and eradicating poverty in small-scale fishing communities.

Figure 9. The first joint activity of the Department of Fisheries and betta fish farmers during the Children's Day organized in Government House, Bangkok, Thailand on 12 January 2019

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About the Author

Dr. Amonrat Sermwatanakul (also known as **Dr. Noi**) is the Head of Senior Fisheries Experts of the Department of Fisheries, Bangkok, Thailand. She passionately promoted gender equality and women empowerment in ornamental fish industry in Thailand, and for that she received awards from various national and international organizations for her gender advocacies. She was the principal proponent of recognizing the Siamese fighting fish as Thailand's National Aquatic Animal. *Dr. Amonrat* can be contacted at *noidof@gmail.com*.

Equipping Fishing Fleet with Vessel Monitoring System for Sustainability in Fishing Operations:
A Case Study in Khanh Hoa Province, Viet Nam

To Van Phuong and *Nguyen Huu Huy Hoang*

The fisheries sector in Viet Nam is encountering several difficulties, especially in terms of the management and monitoring of its fishing vessels that could have led to their continued engagement in illegal, unreported and unregulated (IUU) fishing activities and consequently resulted in the issuance of a "yellow card" by the European Union (EU). The installation of vessel monitoring system (VMS) on fishing vessels has been recommended as one of the essential actions to address the concerns on continued IUU fishing activities, ensure that fishing operations are sustainable, and improve the maritime safety of the fishing vessels and crew. A pilot research study was carried out to assess the impacts of installing VMS on the offshore fishing vessels of Khanh Hoa Province, by making use of the "BlueTraker" VMS device which was chosen from among the many devices available in the market. The results of the study showed that: i) the percentage level of the message transmittal using this VMS device based on national regulations was from 85.5% to 97.3%; ii) the VMS terminals have low power consumption and no impact on the other equipment used onboard the fishing vessels, and is flexible as direct power or backup battery could be used when needed (within 3 full days); iii) the cost of the VMS device is lower compared with other devices for the same purpose so that the concerned fishers expressed their willingness to equip their fishing vessels with such device upon approval by the national fisheries authorities to manage and provide counterpart support, and issuance of other relevant policies; and iv) more than 80% of fisher-respondents were satisfied with the performance of the "BlueTraker" VMS device as a whole. Since it is necessary to combat IUU fishing activities of the country's fisheries sector, and considering that installation of VMS is one of the measures to address such concern, the use of the VMS device should be required for all offshore fishing vessels throughout the country for the effective management and monitoring of the performance of such vessels through the use of modern technologies.

In October 2017, the Directorate General for Maritime Affairs and Fisheries of the European Commission (EC) issued a "yellow card" to the capture fisheries industry of Viet Nam for its rather sluggish compliance with the requirements for combating illegal, unreported and unregulated (IUU) fishing. As a consequence, the seafood products from Viet Nam have to face many technical barriers to be able to penetrate the European market, greatly affecting the country's fisheries trade. Bearing the brunt of the effect of such warning, the fishers working in offshore fisheries have also suffered, making their lives extremely difficult. In order that the fisheries industry of Viet Nam would improve, the EC suggested several recommendations that focus on addressing the issues related to the prevention and elimination of IUU fishing as well as improvement of the traceability of its fish and fishery products. Specifically, the recommendations include among others, the promotion of fishing fleet management and regulating the fishing effort; installation of the Vessel Monitoring System (VMS) on fishing vessels; development and implementation of the system of catch documentation and traceability; and strictly controlling the country's so-called "blue boats" from engaging in illegal fishing activities in international waters. Since then, the Government of Viet Nam has been taking measures to address these concerns, the most significant of which was the amendment of its Fisheries Law which was approved in November 2017 and implemented starting 1 January 2019. The amendments include compliance based on the conditions of the country, with several relevant international regulations including the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU).

Under the new Fisheries Law of Viet Nam, the local fisheries authorities are mandated to implement the international regulations, especially the strict measures to manage the licensing of fishing vessels, port-in port-out controls, increased patrols for preventive inspections and control at sea, and strict provisions for handling violations and imposing sanctions against IUU fishing vessels. Moreover, the country's Fisheries Law 2017 also includes a regulation on VMS, stipulating that all offshore fishing vessels are required to install VMS which should be operational on 24/24 hour basis.

Viet Nam's "blue boats" *(Photo: pacifictuna.org)*

Fisheries Industry in Khanh Hoa Province

Khanh Hoa Province (**Figure 1**) is one of the few provinces in Viet Nam with the most developed fisheries. In 2017, the Province has five (5) fishing ports, dozens of small fish landing sites, 44 seafood processing enterprises, and 9,837 fishing vessels, of which more than 1,300 have capacities that are greater than 90 Cheval Vapeur or 90 CV (equivalent to 90 horsepower) and engaged in offshore fishing operations (Viet Nam MCS Department, 2018).

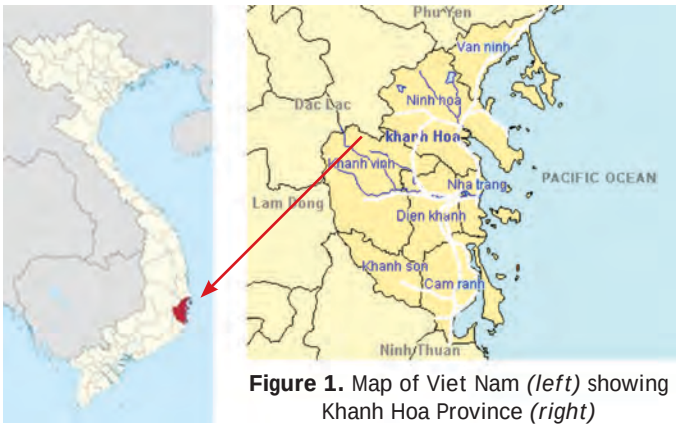

Figure 1. Map of Viet Nam *(left)* showing Khanh Hoa Province *(right)*

The fisheries industry in Khanh Hoa Province has been generating job opportunities for more than 60% of the total number of fishery workers of the Province, responsible for providing nearly 60% of the Province's fisheries production in terms of value in 2017 (Khanh Hoa Fisheries Department, 2017; Khanh Hoa Fisheries Department, 2018). However, concerns on traceability and IUU fishing activities have caused difficulties in sustaining the fishing operations, procurement and fish export activities in Khanh Hoa Province. In an effort to address the issues on IUU fishing activities and minimize the impacts of the "yellow card" on the fish and fishery products intended for export to international markets, a pilot research study was carried out on the application of modern VMS in the fishing vessel management of Khanh Hoa Province with the specific objectives of meeting the requirements for the development of modern fisheries, enhancing fisheries productivity (To, 2017), improving the safety at sea for fishers, and at the same time, safeguarding the country's national defense and security.

Management and monitoring of offshore fishing vessels in Khanh Hoa Province

The Department of Fisheries of Khanh Hoa Province is responsible for the regular inspection and control of its fishing vessels, especially the offshore fishing vessels (**Figure 2**) in accordance with regulations enforced by the Government of Viet Nam, to ensure that such vessels comply with international regulations. The inspection processes include: i) checking the vessels before leaving the fishing port for proper licensing, gear and equipment including safety measures; and

Figure 2. A typical fishing vessel from Khanh Hoa Province, Viet Nam

ii) inspecting and monitoring the vessels' fishing operations at sea as well as checking the vessels' catch upon landing. Khanh Hoa Province has many offshore fishing vessels, so that the management and monitoring of these vessels still face many difficulties due to limited human resources, inadequate budget, and few number of patrol vessels (Vu, 2018). Moreover, in monitoring the operations of the fishing vessels, patrol vessels are used but these have not been installed with modern surveillance technology, *e.g.* GPS (Alum-Udensi *et al.*, 2016).

Records of the Department of Fisheries of Khanh Hoa Province have also indicated that in 2017, a total of 73 patrol trips were conducted, 171 fishing vessels were inspected at sea (comprising 63 vessels from Cam Ranh, 35 vessels from Van Ninh, 23 vessels from Ninh Hoa, and 50 vessels from Nha Trang. From such inspections, 48 fishing vessels were found to have violated the regulations, and were therefore handed certain forms of disciplinary actions.

The Department of Fisheries of Khanh Hoa Province has also been quite active in its information dissemination efforts. Their records have shown that during the period from 10/2017 to 08/2018, a total of 21 training workshops were organized: 8 in Nha Trang, 4 in Ninh Hoa, 4 in Van Ninh, and 5 in Cam Ranh. The training workshops were attended by a total of nearly 2,000 vessel owners, vessel captains and crew, who were provided with and shared relevant information, and whose awareness about the impacts of IUU fishing activities had been enhanced, while also given the vision on the need to combat illegal fishing not only in their national waters but also in foreign waters as well, for the sustainability of capture fisheries as a whole.

Vessels Monitoring System

There are many types of vessel monitoring system (VMS) devices in the world. However, based on the capacity and support provided by the suppliers, the research team from the Department of Fisheries of Khanh Hoa Province selected the "BlueTraker" brand of VMS provided by the EMA Group of the Republic of Slovenia. Many countries all over the world

have also been using this VMS equipment, *e.g.* Slovenia, Thailand, Indonesia, Norway (BlueTraker, 2018).

Pilot Research Study on the Application of Modern VMS Technology

The study which was conducted in 2018 focused on the assessment of the efforts of Khanh Hoa Province to manage its offshore fishing vessels and promote the application of modern VMS technology for the Province's fishing fleet, and finally to analyze and evaluate the results of the study for the formulation of policy options and recommendations. Secondary data, obtained from statistical reports and published research papers, were used as source of information necessary to assess the status of fisheries as well as vessel monitoring and management in Khanh Hoa Province, and also for the assessment of the current status of VMS technology being implemented in Khanh Hoa Province. The compiled secondary information which also included those provided by the officers and experts from the Province, were then utilized for analyzing the advantages and disadvantages of the proposed application of the modern VMS technology.

In order to also obtain the primary data, a questionnaire survey was conducted on 93 offshore fishing vessels at Hon Ro Port in Khanh Hoa Province as well as the fishers and fisheries managers from the Department of Fisheries of Khanh Hoa Province and the Khanh Hoa Fisheries Association, with respect to maritime equipment and supplies for offshore fishing activities and vessel monitoring (Yamane, 1967). The primary data were used to conduct a pilot VMS application study on the impacts of the application of modern VMS technology taking into account the probabilities of receiving transmitted messages on regulation's time (under 72 minutes), the accuracy of vessel positions displayed on the SecondScreen Software accessed on land, the level of power consumption, the influence level on other equipment in operation onboard, and the quality of signal transmissions. Satisfaction level of the VMS equipment would also be derived from the pilot study and from the relevant stakeholders directly utilizing the technology.

The Department of Fisheries of Khanh Hoa Province cooperated with the EMA Group, a leading traceability specialist in Slovenia (European Union) that established the "BlueTraker" brand for utilization in the field of VMS systems for fisheries and commercial vessels. For the pilot research study, the EMA Group provided the "BlueTraker," which is a satellite-operated equipment to support the surveillance of vessels at sea. The "BlueTraker" VMS system includes: i) terminal equipment mounted on the top of cabin to receive the satellite signals from the global positioning system (GPS), ii) conbox box mounted in the cabin to perform the collection of basic information and features; and iii) an interface Secondscreen Software that could be accessed through smart phone or computer with internet connection to based on land and where the features of the VMS system are displayed. Three (3) offshore fishing vessels of Khanh Hoa Province were involved in the pilot research study which covered a complete analysis of the data transmission in terms of signal and frequency as well as the accuracy of the coordinates where data is transmitted, and other basic features for the Secondscreen Software of the VMS device.

Results of the Pilot Research Study

Based on the secondary data compiled during the pilot research study, it could be gleaned that the fisheries activities of Khanh Hoa Province are concentrated in the coastal districts of Nha Trang, Van Ninh, Ninh Hoa, and Can Ranh. As of 2017, the number of fishing vessels in the Province totaled 9,817 units (**Table 1**), the informatrion also indicated that at the provincial level, Nha Trang has the most number of vessels at 3,693 units followed by Van Ninh District at 2,266 units, Cam Ranh at 1,961 units, and Ninh Hoa at 1,317 units.

The data provided by the respondents during the questionnaire survey, indicated that 100% of the offshore fishing vessels are equipped with global positioning system (GPS) device to determine their locations and routes, while only 92.5% are installed with long-range communication equipment, *e.g.* high frequency (HF) transceivers (**Table 2**). The study also showed that 68 of the 93 vessels sampled or 73.1% have been supported by the Government of Viet Nam under Decision No 48/2010/QD-TTg on fisheries development policies, in terms of fuel and oil support, and use of the Vortex Standard 1700 (VX-1700) to assess the usefulness of the equipment in offshore fishing operations. The efficiency of the VMS equipment (Movimar) installed in another 11 vessels out of the 93 sampled, were also assessed with respect to the

Table 1. Distribution of fishing vessels by locality in Khanh Hoa Province (Khanh Hoa Fisheries Department, 2018)

Locality	Year				
	2013	2014	2015	2016	2017
Nha Trang City	3,603	3,622	3,656	3,690	3,693
Van Ninh District	2,260	2,261	2,262	2,266	2,266
Ninh Hòa Town	1,299	1,303	1,311	1,317	1,317
Cam Ranh City	1,952	1,953	1,956	1,961	1,961
Others	580	580	580	580	580
Total	**9,694**	**9,719**	**9,765**	**9,814**	**9,817**

Table 2. Maritime equipment utilized by the offshore fishing vessels in Khanh Hoa Province

Maritime Equipment Used	Off-shore Fishing Vessels	
	Number	Percent (%)
Short - Range communication equipment - MF Transceiver	82	88.0
Long - Range communication equipment - HF Transceiver	86	92.5
Navigation GPS Chart Plotter	93	100.0
GPS Chart Plotter – AIS Combo	66	71.0
Vertex Standard 1700 (VX-1700)	68	73.1
Movimar VMS equipment	11	11.8

equipment's performance in offshore fishing operations. The results indicated that these 11 vessels were confronted with many issues including high amount of fuel consumption, incorrect positions recorded, frequent signal interference, and unstable transmission of the radio-equipment signal.

Installation of the "BlueTraker" VMS equipment

For the pilot research study, three (3) offshore fishing vessels in Khanh Hoa Province were installed with the "BlueTraker" VMS device, the details of which are shown in **Table 3**.

Installation of the "BlueTraker" VMS device (**Figure 3**) on the fishing vessels is simple as the equipment has only one (1) terminal, a transceiver for transmitting GPS signals placed at the roof of the cabin, and 1 box of conbox placed in the cabin. On the station on land, the system operates through the SecondScreen Software which runs on any web platform. In fact, the system can run on every smart devices (smartphones, tablets) or computer units with internet connections.

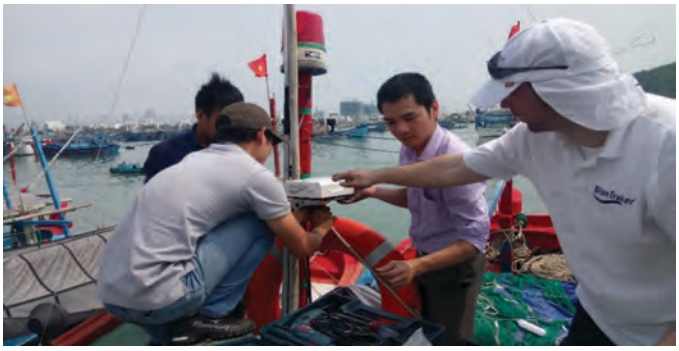

Figure 3. Installing the "BlueTraker" VMS on a fishing vessel in Khanh Hoa Province

Performance of the installed "BlueTraker" VMS equipment

In evaluating the levels of signal transmissions and assessing the performance of the device installed in fishing vessels (**Figure 4**), specifically the transmission capacity of the device, the research team considered a one-week transmission data from 07 April 2018 to 14 April 2018 for the analysis. Results of the analysis are shown in **Table 4**.

Signal transmission level of the device

As shown in **Table 4**, during the one week first pilot study trip, the vessel with device No. 18156 obtained 186 transmission signals, the vessel with device No. 18146 obtained 223, and the device No. 17618 obtained 179 transmission signals. The data transmission frequency of the three (3) devices is considerably good enough to meet the requirements of EU (which typically requires that transmission should be for every 2 hours). Specifically, the rates of message transmission to the management software after every 72 minutes (based on the "BlueTraker" VMS setting) of the 3 devices, namely: 18156, 18146, and 17618 were 98.3%, 97.3%, and 85.5%, respectively.

Table 3. Information of the offshore fishing vessels installed with the "BlueTraker" VMS device

Device Code	Vessel information			
	Registration No./Vessel Name	Cheval Vapeur (CV)	Owner	Type of Fishing Gear
17618	KH97176TS/ Vuong Len 2, Truong Sa 4	400	Vo Ngoc Tung	Gill net
18146	KH98246TS/ Truong Sa 2, 2016	800	Mai Thanh Phuc	Handline
18156	KH91934TS	450	Vo Van Mai	Handline

Table 4. Interaction signals between the fishing vessels installed with the "BlueTraker" VMS device and the designated station on land

Device code	Number of signals received	Green signal (good condition)		Yellow signal (unstable condition)	Red signal (loss of signal)	Channel	
		Quantity	Percent (%)			Iridium	GPRS*
18156	186	183	98.3	2	1	174	12
18146	223	217	97.3	3	3	223	4
17618	179	153	85.5	20	6	179	0
TOTAL	**588**	**553**	**ave: 94.0**	**25**	**10**	**576**	**16**

**GPRS or general packet radio service is a data transmission system through the mobile phone network while GPS is a satellite tracking and navigation system*

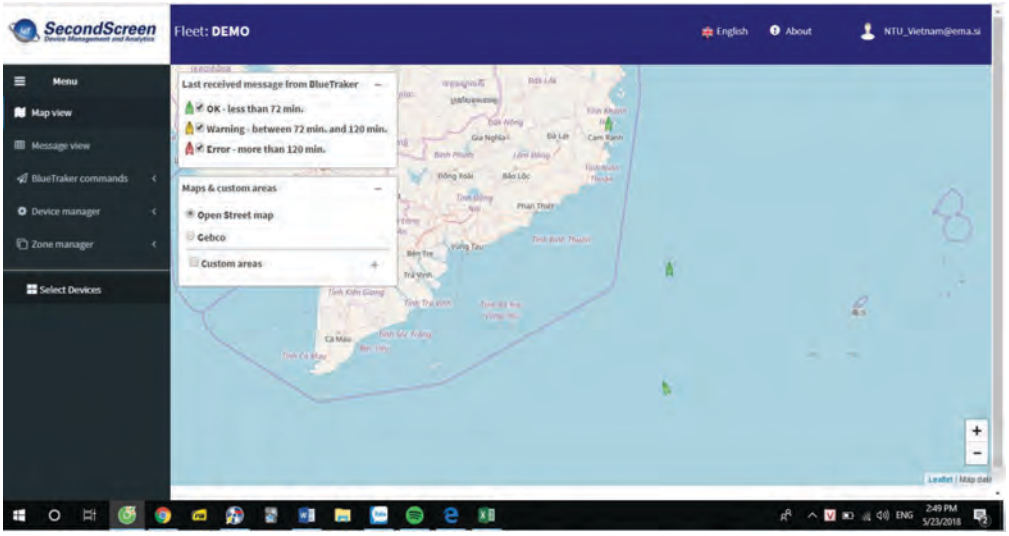

Figure 4. Status of the signals transmitted by the VMS device installed in 3 pilot vessels

Quality of the coordinate data transmitted

The research team selected the one-week data of the second pilot study trip from 16 May 2018 to 22 May 2018 to analyze and evaluate the quality of the GPS signals of the device with respect to the vessels' positions. The results are shown in **Table 5**.

Table 5. Statistics on the quality of the device' signals based on position data

Device code	Number of transmission signals	The number of qualified signals	Percent (%)
18156	160	152	95.0
18146	171	165	96.0
17618	204	200	98.0

Table 5 shows that the number of data transmission signals (*i.e.* the accuracy of vessel coordinates) with a qualified GPS quality, accounted for a very high proportion in all three devices. Specifically, the rate of qualified signals of the 3 devices: 18156, 18146, and 17618 were 95.0%, 96.0%, and 98.0%, respectively.

In particular, to carefully verify the accuracy of the coordinate data, the research team asked the vessel owners and captains to engage in a communication using the VX-1700 and HF transceiver. This would also verify the coordinates at the time of communication (*i.e.* compare the position displayed on GPS equipment onboard the vessel with the position displayed on the Secondscreen Software on land), along with verifying the message of VX-1700 sent to the Department of Fisheries of Khanh Hoa Province. The results showed that the position of the vessels are the same and correct (**Figure 5**). The vessel position information is being constantly updated to help the authorities and vessel owners determine the route of the vessels at sea.

Power consumption of the VMS device

The electric consumption parameter of the device according to the EMA Group was only 2.0 Watts. During the 6-month pilot study, the 3 vessel captains and owners evaluated the power consumption of the VMS device and concluded that the electric consumption was very low, and had absolutely no effect on other equipment onboard the vessels. Moreover, the power usage of the "BlueTraker" device is very flexible, as it can be connected directly to a power source or to backup batteries if necessary, making the device more advantageous than any of the VMS devices commonly used by fishers in Viet Nam. One of the vessel captains also noted that when the device bearing the code 17618 was disconnected from the direct source of power and connected to a backup battery, it

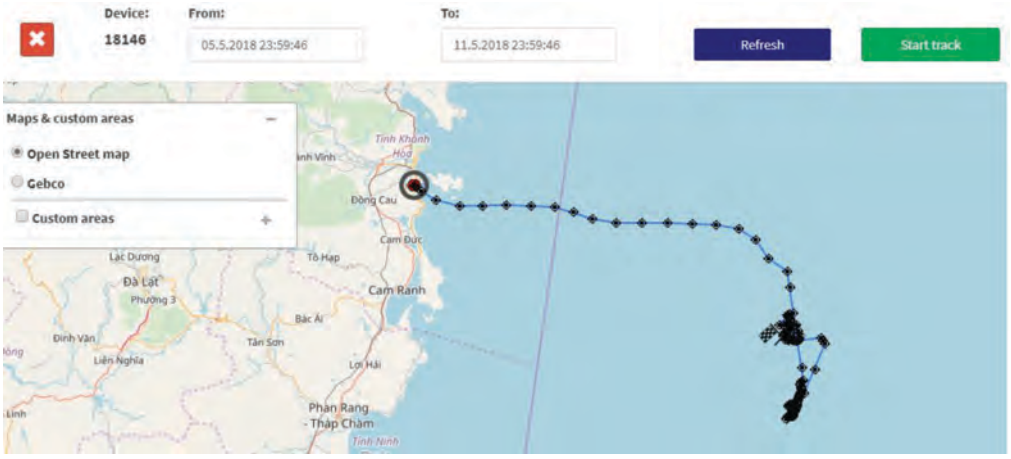

Figure 5. Position-tracking mode of the fishing vessels during the pilot study trip

still maintained the transmission quality of the satellite signal for three (3) days or 72 hours.

Access to the Secondscreen Software

Secondscreen is a software that runs on any normal web platform, so that users (*e.g.* fisheries authorities, fishers, vessel owners, crew members) can use any mobile device (*e.g.* smartphones, computers) with internet connection to access necessary information (account number and password are required) and use wherever their locations may be (**Figure 6**). Results of the survey to determine the satisfaction level of using the Secondscreen Software of "BlueTraker" VMS device showed that the users were appreciative of the Secondscreen Software interface at satisfaction level of 93% (20% were very satisfied and 73% were satisfied). The respondents also noted that the software has eye-catching 2D and 3D map modes giving a lively vessel position display, the signal level of the device could be easily distinguished, and the system is simple and suitable for all users as the functions are basic with understandable instructions.

Figure 6. A vessel owner from Khan Hoa Province accessing the Secondscreen Software on land at a certain port in the Province, using a smartphone

In spite of the high satisfaction level of the Secondscreen Software, 5% of the respondents were less satisfied with the software for two main reasons: the language used during the trial period was English, and ii) some fishers were still not familiar with the modern features on a smartphone. Nonetheless, the "BlueTraker" VMS device received high satisfaction level by the respondent-users during the pilot study. In particular, the fishers were satisfied with the mounted hardware of the device because of its compact design and low power consumption. In addition, the users also appreciate the Secondscreen Software which comes with benefits such as: signal transmission between terminal – GPS – Secondscreen Software at the station on land could be generated automatically, and the features are simple and easy to use, with very useful tracking mode.

Cost of installing a VMS system

The price of a "Bluetraker" VMS system is about 1,000 USD (mounted, and comes with a terminal, conbox, cable, and Secondscreen Software), and an additional fee of about 25 USD/month is necessary for satellite connections and telecommunication services. All of the fishers interviewed indicated that the cost of installing a VMS system is suitable for offshore fishing vessels, especially with the current situation wherein a "yellow card" had been issued to the fishing industry of Viet Nam and the urgent requirement of installing a VMS system to help fishers and fisheries managers in managing and on the hourly and daily basis, monitoring the vessels' positions.

This is considered extremely urgent as it could convince the EU to lift the "yellow card" from the country's fishing industry. The existence of the Secondscreen Software also helps the relatives of fishers on land to feel more secure as the vessels' positions at sea are constantly being updated. In particular, a bulk purchase of the device would lessen the cost as the device could be purchased at discounted price. The fisher-respondents expressed the willingness to equip their vessels with the most efficient and effective VMS system, but also proposed that the Government partially support the cost of the device. They also suggested that the country's fisheries authorities should recognize the usefulness of the device and use the information from the Secondscreen Software to confirm the performance of the device under the support programs of the Government based on Decision No 48/2010/QD-TTg on fisheries development policies.

In general, the "BlueTraker" VMS device was found to be practical and can greatly support the fishing vessel management of Khanh Hoa Province to meet the current regulations of Viet Nam and the requirements of international organizations. The system could also help the fisheries authorities in managing the operations of offshore fishing vessels as its usage could strengthen the monitoring of domestic fishing vessels while at the same time, save cost for patrolling. However, the current trial is still on a small-scale basis with the use of few devices. There is a need to confirm the results of the pilot research study in a larger scale in the near future, to obtain more accurate assessment and recognition.

Conclusion and Recommendations

After the capture fisheries sector of Viet Nam was issued a "yellow card" by EC requiring the sector to combat IUU fishing, efforts were made to improve the country's fisheries legal system leading to the amendment of its Fisheries Law in 2017 which was adopted in early 2019. The Fisheries Law 2017 stipulates among others, that offshore fishing vessels are obligated to install and use VMS on a 24/24 basis. Such installation would also respond to the need of vessel owners and relatives of fishers on land to know the position and the safety of the vessels at sea, and support maritime safety and accident prevention at sea.

The Government of Khanh Hoa Province has been requested by vessel owners to consider providing full or partial support

to equip their vessels, starting with offshore fishing vessels, with VMS system to address the aforementioned concerns, especially on the need to have a road map for vessels to comply with the required management of fishing capacity, and as part of the Government's social responsibility. Cost-sharing could be applied with funds provided by the Government and reciprocal funds from vessel owners, as well as from the telecommunication companies. However, there is a need to replicate the results of the pilot study on the use of VMS model devices in a larger scope through the promotion of applied research studies or fisheries extension projects on the installation of VMS system on all offshore fishing vessels. An additional topic for research could include study on the integration of VMS devices and other maritime equipments with the objective of lessening the cost of the whole system.

The fisheries authorities of Khanh Hoa Province have been concerned with the sustainability of the country's capture fishing operations, after the EC issued the "yellow card" as this could impact on the fisheries trade of the country, of which the Province has been contributing a big share the country's total fisheries production. Therefore, the concerned stakeholders in the Province have been exerting efforts to comply with the national, regional and international requirements towards the sustainability of fishing operations. Considering that the installation of VMS devices on fishing vessels could contribute to the solutions that could possibly lift the "yellow card," the Province has been doing its part to ensure that all its fishing vessels, especially the offshore fishing vessels would be installed with VMS. Such installation would also help the fisheries authorities of the Province in monitoring and controlling the fishing vessels at sea 24/24.

Based on the Province's experience in VMS devices, the "BlueTraker" VMS device was chosen for trial in a pilot research study to reinforce the previously conducted researches and scientific evidence. Aside from the modern technology internal to the "BlueTraker" VMS device, the results of the pilot research study conducted in 2018 proved the effectiveness and efficiency of using the device, especially the high quality of the GPS signals, that meet the requirements of the EU. Moreover, the "BlueTraker" VMS device requires low power consumption, does not affect the other equipment on board, and is flexible that it could be used with direct power supply or through a backup battery within 72 hours.

Considering the affordable cost, many fishers and vessel owners from Khanh Hoa Province expressed their readiness to equip their vessels with the "BlueTraker" VMS device provided confirmation of support from the Government is assured. The fishers therefore suggested that the Department of Fisheries of Khanh Hoa Province should consider the development of policy recommendations for the Government of Viet Nam to support the installation of VMS devices for the increased effectiveness of the management and monitoring of offshore fishing operations and ensure that these are responsible and aim for the sustainability of the fishery resources, and most especially, to show that such fishing vessels are not engaged in IUU fishing activities.

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About the Authors

Dr. To Van Phuong is from the Institute of Marine Science and Fishing Technology, Nha Trang University, Viet Nam. His research orientations are towards the establishment of solutions for responsible fishing and sustainable fisheries management. Email: *phuongtv@ntu.edu.vn*. Address: 02 Nguyen Dinh Chieu, Vinh Tho Ward, Nha Trang City, Viet Nam.

Mr. Nguyen Huu Huy Hoang is from Viet Nam Tuna Association, and is in charge of the Projects "Vietnam Yellowfin Tuna Fisheries Improvement" and "Vietnam Skipjack Tuna Fisheries Improvement" through the Public-Private Partnerships (PPP) mechanism. Email: *huyhoang21096@gmail.com*. Address: 09 Nguyen Dinh Chieu, Vinh Tho Ward, Nha Trang City, Viet Nam.

CALENDAR OF EVENTS

Date	Venue	Event	Organizer(s)
2019			
16-20 June	Kuala Terengganu, Malaysia	Regional Training and Workshop on Chondrichthyan Taxonomy, Biology and Data Collection	SEAFDEC/MFRDMD
20-21 June	Chonburi Province, Thailand	Gulf of Thailand Sub-regional Monitoring, Control and Surveillance (MCS) Network Meeting	SEAFDEC-Sweden Project
24 June – 7 July	Tigbauan, Iloilo, Philippines	Training Course on Marine Fish Hatchery Operations	SEAFDEC/AQD
25-27 June	Iloilo City, Philippines	International Workshop on Promotion of Sustainable Aquaculture, Aquatic Animal Health, and Resource Enhancement in Southeast Asia	SEAFDEC/AQD
27-29 June	Da Nang, Viet Nam	27th Meeting of the ASEAN Sectoral Working Group on Fisheries (ASWGFi)	ASEAN
5-9July	Samut Prakan, Thailand	Regional Review Training Program on Optimizing Energy and Improve Safety at Sea for Small Fishing	SEAFDEC/TD
9 July	Samut Prakan, Thailand	Workshop on the Development of the Action Plan for SEAFDEC Gender Strategy	SEAFDEC/TD
10-11 July	Samut Prakan, Thailand	Experts Consultation Workshop on Finalization of the Practical Guide for Gender Analysis in Small-Scale Fisheries and Aquaculture in Southeast Asia	SEAFDEC/TD
18-19 July	Samut Prakan, Thailand	National Workshop on CITES Listed Non-Detriment Findings Document	SEAFDEC EU/CITES Project-II
22-23 July	Bangkok, Thailand	3rd Regional Meeting on Enhancing Sustainable Utilization and Management Scheme of Tropical Anguillid Eel Resources in Southeast Asia	Secretariat JAIF project
22-26 July	Samut Prakan, Thailand	Regional Training Course on Port State Measures Implementation for Inspector	SEAFDEC/TD
25-26 July	Vientiane, Lao PDR	Regional Training Course for the Improvement on Management of Inland Fisheries	SEAFDEC/ IFRDMD
6-7 August	Tawau, Malaysia	National Workshop on CITES Listed Non-Detriment Findings Document	SEAFDEC EU/CITES Project-II
6-7 August	Chanthaburi, Thailand	National Forum on Sharing Lessons Learned and Knowledge on Habitat and Fisheries Management (by SDF) in Thailand	SEAFDEC-Sweden
14-15 August	Singapore	End-of-Project (EOP) meeting for Chemicals and Drug Residues in Fish and Fish Products in Southeast Asia – Biotoxins (ASP, AZA, and BTX) and Harmful Algal Blooms (HABs) in the ASEAN Region	SEAFDEC/MFRD
16-28 August	Geneva, Switzerland	18th Session of the Conference of the Parties to CITES	CITES
20-21 August	Thailand	Southern Andaman Sea Sub-region MCS Meeting	SEAFDEC-Sweden Project
4-5 September	Chonburi, Thailand	8th Meeting of the Gulf of Thailand Sub-region	SEAFDEC-Sweden Project
3-5 September	Kuala Lumpur, Malaysia	Terminal RTC for Combating IUU Fishing in the Southeast Asian Region through Application of Catch Certification for International Trade in Fish and Fishery Products Project	SEAFDEC/MFRDMD
10-11 September	Bangkok, Thailand	Meeting for Revision of Resolution & Plan of Action 2020	SEAFDEC Secretariat
12-13 September	Chonburi, Thailand	Sub-regional Consultation to Develop Action/Management Plan of Indo-Pacific Mackerel	SEAFDEC-Sweden Project
2-4 October	Bangkok, Thailand	Capacity Development Workshop on Estimation and Reporting of SDG Indicator 14.4.1 for the Asia and Pacific Region	FAO/HQ and SEAFDEC
3-4 October	Samut Prakan, Thailand	Regional Core Experts Meeting on Tropical Anguillid Eel Information Sharing	SEAFDEC Secretariat
8-10 October	Jakarta, Indonesia	Workshop on 5-Year of IFRDMD's Achievement	SEAFDEC/IFRDMD
15-17 October	Philippines	20th Meeting of SEAFDEC Information Staff Program (ISP)	SEAFDEC Secretariat
11-13 November	Chiang Mai, Thailand	42nd Meeting of SEAFDEC Program Committee	SEAFDEC Secretariat and TD
14-15 November	Chiang Mai, Thailand	22nd Meeting of the Fisheries Consultative Group of the ASEAN-SEAFDEC Strategic Partnership (FCG/ASSP)	SEAFDEC Secretariat

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.


Secretariat

TD


MFRD


AQD


MFRDMD


IFRDMD

SEAFDEC Addresses

Secretariat

P.O. Box 1046
Kasetsart Post Office
Bangkok 10903
Thailand
Tel: (66-2) 940-6326
Fax: (66-2) 940-6336
E-mail: *secretariat@seafdec.org*
http://www.seafdec.org

Training Department (TD)

P.O. Box 97
Phrasamutchedi
Samut Prakan 10290
Thailand
Tel: (66-2) 425-6100
Fax: (66-2) 425-6110 to 11
E-mail: *td@seafdec.org*
http://www.seafdec.or.th

Marine Fisheries Research Department (MFRD)

52, Jurong Gateway Road,
#14-01, Singapore 608550
Tel: (65) 9046-4787
Fax: (65) 6334-1831
E-mail: *Ong_Yihang@sfa.gov.sg*
http://www.seafdec.org

Aquaculture Department (AQD)

Main Office: Tigbauan,
5021 Iloilo, Philippines
(63-33) 330-7000
Fax: (63-33) 330-7002
Manila Office: Rm 102 G/F
Philippine Social Science Center (PSSC)
Commonwealth Avenue, Diliman
Quezon City 1101 Philippines
Tel & Fax: (63-2) 927-7825
E-mail: *aqdchief@seafdec.org.ph*
http://www.seafdec.org.ph

Marine Fishery Resources Development and Management Department (MFRDMD)

Taman Perikanan Chendering,
21080 Kuala Terengganu, Malaysia
Tel: (609) 617-5940
Fax: (609) 617-5136
E-mail: *mfrdmd@seafdec.org.my*
http://www.seafdec.org.my

Inland Fishery Resources Development and Management Department (IFRDMD)

Jl. Gub. HA. Bastari No.08
RT.29 RW.27 Kel. Silaberanti
Kec. Seberang Ulu I, Jakabaring, Palembang 30252
Sumatera Selatan, Indonesia
Tel: +627115649600; Fax: +627115649601
E-mail: *ifrdmd@seafdec.id*
http://www.seafdec.id

The third prize winner, *Kung Chhin Panha*, from the national drawing contest in Cambodia

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.