# FISH for the PEOPLE

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## SEAFDEC at 48:
### Steering Marine Fisheries Development of Southeast Asia towards Sustainability

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# Editorial

In numerology, the number 48 connotes majesty and greatness. The combination of 4 which is associated with determination and diligence in building solid foundation to attain greatness, and 8 manifesting perseverance to achieve prosperity and majesty, makes 48 a symbol of wealth and majestic progress as reward from hard work well done leading to auspicious new beginnings and opportunities. Thus, the number 48 depicts that hard work would reap abundance and wealth. The wealth that could be earned by working consistently, overcoming obstacles along the way, gaining steady progress, and in the end attaining prosperity. This is what SEAFDEC had achieved during the 48 years of its existence.

The Southeast Asian Fisheries Development Center (SEAFDEC) was established in December 1967 "to develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies, research and information dissemination activities". SEAFDEC operates through the Secretariat located in Bangkok, Thailand and five Technical Departments, namely: Training Department (TD) established in 1967 in Samut Prakan, Thailand; Marine Fisheries Research Department (MFRD) also in 1967 in Singapore; Aquaculture Department (AQD) in Iloilo, Philippines in 1973; Marine Fishery Resources Development and Management Department (MFRDMD) in Kuala Terengganu, Malaysia in 1992; and Inland Fishery Resources Development and Management Department (IFRDMD) in Palembang, Indonesia in September 2014. SEAFDEC has 11 Member Countries comprising 10 ASEAN Member States and Japan. The supreme organ of SEAFDEC is the SEAFDEC Council of Directors representing the Fisheries Agencies of the respective Member Countries.

In the span of 48 years, SEAFDEC has been persistent in promoting sustainable development of fisheries in Southeast Asia. As such, in the 48 years of its existence, SEAFDEC has majestically attained monumental technological advancements that veered the course of the region's fisheries development towards sustainability. Through diligence and perseverance, SEAFDEC has been able to reap the fruit of its hard work obtaining greatness in terms of the quality of its achievements.


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Volume 13 of *Fish for the People* shall chronicle the continuous efforts of SEAFDEC and the impacts of such efforts on the sustainability of the region's fisheries. Starting with marine fisheries development and management for the Volume's first issue, the next issue shall focus on the marketability of the region's fish and fishery products, and would finally be capped with the last issue on the major achievements of SEAFDEC in its 48 years of unending endeavors that has changed the direction of fisheries in the Southeast Asian region towards sustainability.

At the onset, TD since its establishment in 1967 has focused its activities on transferring fishing technologies and marine engineering concepts to the Southeast Asian countries, which later on had been shifted towards promoting responsible fishing gears and practices. In addition, through the R&D activities of MFRD which were initially concentrated on marine fishery resources evaluation and oceanographic studies in the South China Sea and adjacent waters before its thrust was shifted to post-harvest technology in the mid-1970s, promotion of sustainable marine capture fisheries development in the region has been enhanced. As a result, the efforts of TD and initial efforts of MFRD enabled the Southeast Asian countries to increase their production from marine capture fisheries in a responsible manner, nailing the gap between demand and supply of fish and fishery products.

Upon the establishment of MFRDMD in 1992, the programs of SEAFDEC had been strengthened as scientific-based concepts began to take shape for the sustainable development and management of the marine fishery resources in the region. Moreover, issues on conservation and management of important aquatic species such as marine turtles and sharks have also been addressed through the R&D activities of MFRDMD. Furthermore, considering the nature of fisheries in Southeast Asia which is small-scale, multi-gear and multi-species, and while maintaining its original thrusts, TD embarked on a new direction towards coastal fisheries management leading to the establishment of management mechanisms at community level that aim to attain improved incomes for people dependent on the coastal fishery resources for their livelihoods. The technological advancements of SEAFDEC have since then been mustered by the countries in the region and adapted in their respective jurisdictions gaining much momentum specifically in the aspect of an ecosystem approach to fisheries management.

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# Boosting Sustainable Development and Management of Marine Capture Fisheries in Southeast Asia

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The establishment of the Southeast Asian Fisheries Development Center (SEAFDEC) in 1967 was primarily gauged on the vital need to promote fisheries development in order to increase food supply and improve nutritional standards by increasing the supply of animal (fish) protein in the Southeast Asian region. Five Technical Departments have since then been set up in five SEAFDEC Member Countries with corresponding roles and responsibilities in pursuing such target. Three Technical Departments have concentrated their efforts on the sustainable development and management of marine and coastal fisheries in Southeast Asia. The Training Department (TD) has been focusing its efforts on the development of modern fishery techniques to aid regional fisheries in a more sustainable approach through the promotion of responsible fishing technologies and practices, exploration of marine resources, and advancement of the coastal fisheries management approach. Recent emphasis has been placed by TD on the promotion of coastal fisheries management to ensure responsible resource utilization and sustainable livelihoods in coastal communities, as well as on the exploration of off-shore fisheries through the development of best fishing practices and energy optimization technology to ensure stable supply of food fish and reduce fishing pressure in coastal areas. At the initial stages of its operation, the Marine Fisheries Research Development (MFRD) had been carrying out R&D activities on marine fishery resources evaluation and oceanographic studies until the mid-1970s when its thrusts had been shifted to post-harvest technology development. Meanwhile, the Marine Fishery Resources Development and Management Department (MFRDMD) conducts R&D activities on marine fishery resources focusing on biological studies of commercially important fish species, resource assessment and management, and conservation and management of aquatic species under international concern. In addition, MFRDMD also compiles information on small pelagic fish species, and develops indicators that could be used for the sustainable development and management of fisheries. Through the activities carried out by these SEAFDEC Departments while adhering to directives of the SEAFDEC Council of Directors and relevant international and regional instruments, sustainability in marine capture fisheries has been taking shape in the region leading to enhanced production from the fisheries and improved socio-economic benefits for stakeholders, more particularly the small-scale fishers.

During the past 40 years or so, the Southeast Asian countries had been producing significant amounts of fish not only to feed its people but also to improve the countries' economies. Although the total fisheries production of the region had been slowly growing at the rate of about 15% per year in the early 70s to mid-80s, it increased to 21%/year in the following decade, and more than 28%/year in the succeeding decade until the mid-2000s, after which the increase continued to go uphill reaching 38%/year during the period from 2009 to 2012 (**Table 1**). Correspondingly, production from marine capture fisheries also continued to increase although at a much slower pace.

The continuously increasing fisheries production of the region could have been brought about by many factors, *e.g.* improved fisheries and aquaculture technologies and management; increased awareness of stakeholders on responsible fisheries with increasing efforts in resources conservation; improved national regulations on sustainable fisheries management; adherence to international and regional guidelines and instruments on sustainable fisheries development and management; enhanced institutional and human resource capabilities; improved statistical data collection systems. For its part, SEAFDEC has contributed in one way or another, to such increases in fisheries production.

### Major Fish Producing Countries of Southeast Asia

In the early 70s until the early 80s, four Southeast Asian countries, namely: Thailand, Indonesia, Philippines and Viet Nam collectively contributed an average of more than 90%/year to the region's total fisheries production. Malaysia entered into the picture starting in the mid-80s and together with the aforesaid four countries collectively contributed about 99%/year to the region's total fisheries production until the early 2000s. Then, starting in mid-2000s, Myanmar joined the region's group of top producing countries, and altogether, these countries contributed about 98%/year to the region's total fisheries production. Since then, the major fish producing Southeast Asian countries had been dominated by Indonesia, Thailand, Philippines, Viet Nam, Myanmar, and Malaysia.

During the five-year period from 2008 to 2012, the Southeast Asian countries accounted for an annual average of 22% of the world's total fisheries production (**Table 2**). This signifies the important role that Southeast Asian fisheries play in the overall fisheries production of the world, and in which case, there is a need to manage the region's fisheries towards sustainability in order that its contribution to the food security of the region could be sustained if not enhanced, the countries' economies are improved, and the region's current niche in the overall global fisheries production is secured.

Furthermore, increases in the region's total fisheries production value had been steady from the mid-70s until the mid-90s, but a drastic rise occurred in the mid-90s until the late 2000s and early 2010s when the rate of increase has more than doubled as shown in **Table 1**.

**Table 1.** Trend of fisheries production with marine capture production in Southeast Asia (1974-2012): Quantity in 1,000 metric tons (MT); Value in 1,000,000 US$

| | 1974-1978[a] | 1979-1983[a] | 1984-1988[a] | 1989-1993[a] | 1994-1998[b] | 1999-2003[b] | 2004-2008[c] | 2009-2012[c] |
|---|---|---|---|---|---|---|---|---|
| **Total Fisheries Production of Southeast Asian (five-year averages)** | | | | | | | | |
| Quantity | 6,395.1 | 7,457.9 | 8,809.7 | 11,024.4 | 14,208.9 | 17,983.3 | 24,159.8 | 33,352.6 |
| Value | 2,567.1 | 4,127.3 | 4,361.5 | 5,307.0 | 8,244.9 | 11,802.8 | 19,910.6 | 39,175.3 |
| **Marine Capture Fisheries Production of Southeast Asia (five-year averages)** | | | | | | | | |
| Quantity | 5,543.1 | 5,860.6 | 6,867.5 | 8,377.7 | 9,852.0 | 12,255.0 | 13,755.6 | 14,925.3 |
| Value | 2,082.9 | 3,075.4 | 2,791.3 | 3,086.8 | 4,410.0 | 6,415.7 | 9,469.4 | 16,885.8 |

*Sources: SEAFDEC (1980), SEAFDEC (1984), SEAFDEC (1987), SEAFDEC (1992), SEAFDEC (1994), SEAFDEC (1997), SEAFDEC (2002), SEAFDEC (2006), SEAFDEC (2010), SEAFDEC (2014)*

*a Not including Lao PDR and Myanmar (Note: production from Hong Kong and Taiwan deducted from totals)*
*b Not including Lao PDR (Note: production from Hong Kong and Taiwan deducted from totals)*
*c For 10 Southeast Asian countries, including Lao PDR (land-locked country) for Total Production only*

**Table 2.** Contribution of Southeast Asian fisheries production to the global fisheries production (in thousand MT)

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| Global Fisheries Production (FAO, 2014) | | | | | |
| Capture: marine | 79,900.0 | 79,600.0 | 77,800.0 | 82,600.0 | 79,700.0 |
| Capture: inland | 10,300.0 | 10,500.0 | 11,300.0 | 11,100.0 | 11,600.0 |
| Aquaculture | 52,900.0 | 55,700.0 | 59,000.0 | 62,000.0 | 66,600.0 |
| **Total Global Fisheries Production** | **143,100.0** | **145,800.0** | **148,100.0** | **155,700.0** | **157,900.0** |
| Southeast Asian Fisheries Production (SEAFDEC, 2014) | | | | | |
| Capture: marine | 13,814.4 | 14,140.4 | 14,847.5 | 15,095.5 | 15,590.7 |
| Capture: inland | 2,329.5 | 2,397.3 | 2,377.3 | 2,641.1 | 2,820.0 |
| Aquaculture | 11,063.9 | 12,379.4 | 14,186.7 | 15,751.1 | 21,160.5 |
| **Total SEA Fisheries Production** | **27,207.8** | **28,917.1** | **31,411.5** | **33,487.7** | **39,571.2** |

*Sources: FAO (2014); SEAFDEC (2014)*

This could have been due to the corresponding annual increases in production, but most especially in view of the improvements made by the Southeast Asian countries in terms of the quality of fish and fishery products, especially those that are bound for the major importing countries as well as those exported within the region.

Specifically in 2012, Thailand and Viet Nam were among the top ten of the world's exporters of fish and fishery products, occupying the third and fourth places, respectively, with average annual percentages in 2001-2012 of 8.1% for Thailand, and 11.9% for Viet Nam (FAO, 2014).

## Status and Trend of Marine Capture Fisheries in Southeast Asia

In the marine capture fisheries sub-sector, production in terms of quantity and value had also been increasing during the 40-year period but at a rather slower pace (**Fig. 1**). For the Southeast Asian region, Thailand, Philippines, Indonesia, and Viet Nam were the highest producers of fish from marine capture fisheries from 1974 to 1983, joined by Malaysia from 1984 and by Myanmar from 1994 up to the present.

In the global scene, six Southeast Asian countries were among the 15 major marine fisheries producing countries in 2012 with Indonesia ranking second after China, Viet Nam in the 9$^{th}$ place, Myanmar in the 10$^{th}$, Philippines in the 12$^{th}$, Thailand in the 14$^{th}$, and Malaysia in the 15$^{th}$ place (FAO, 2014). For the Southeast Asian region, Indonesia ranked first followed by Thailand, Philippines, Viet Nam, Malaysia, and Myanmar (SEAFDEC, 2014).

The continuously increasing fish production from marine capture fisheries by Indonesia might have been influenced by sustained increases for the past 40 years in its production of six (6) major groupings of marine aquatic species, namely: tunas; red fishes, basses, congers, etc.; jacks, mullets, sauries, etc.; mackerels; herrings,

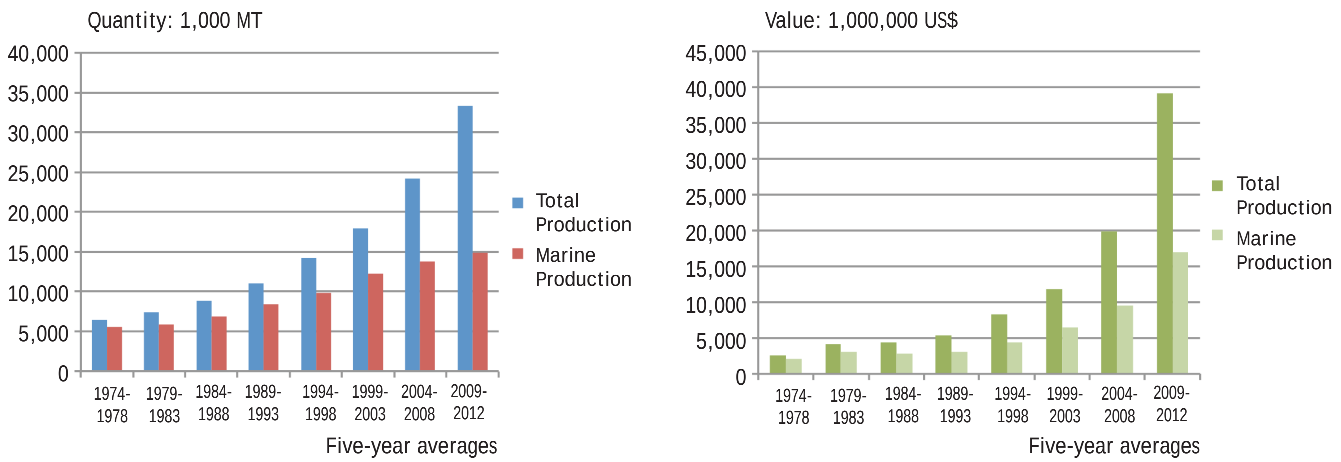



**Fig. 1.** Trend of fisheries production *vs.* marine capture fisheries production of Southeast Asia (based on 5-year averages from 1974-2012): *(left)* quantity in thousand MT, and *(right)* value of corresponding production in million US$

sardines, anchovies, etc.; and miscellaneous fishes. In 2012 for example (**Table 3**), Indonesia's total production of these six major groupings accounted for 85% of the country's total production from marine capture fisheries, 29% of the region's total production from marine capture fisheries, and 12% of the region's total fisheries production. Indonesia's production of tunas was dominated by skipjack tuna (*Katsuwonus pelamis*) followed by yellowfin tuna (*Thunnus albacares*), kawakawa (*Euthynus affinis*), frigate tuna (*Auxis thazard*), and other tunas such as longtail, big-eye, bullet, albacore, and southern bluefin. Its production of tunas accounted for 21% of Indonesia's fish production from marine capture fisheries, 7% of the region's fish production from marine capture fisheries, and 3% of the region's total fishery production.

The Philippines had also sustained its production of tunas; jacks, mullets, sauries, etc.; mackerels; and red fishes, basses, congers, etc. from marine capture fisheries. Meanwhile, from the aforementioned six major groupings of marine aquatic species, the production by major producing Southeast Asian countries such as Malaysia, Myanmar, Thailand, and Viet Nam was reported as miscellaneous fishes (**Table 3**), which could not be classified by species. Therefore, from Southeast Asia's total fish production from marine capture fisheries of 15,590,704 MT, more than 99% was contributed by these six major fish producing countries while less than 1% was contributed by the other three countries, *i.e.* Cambodia, Singapore, and Brunei Darussalam.

## Role of SEAFDEC in the Sustainable Development of Marine Capture Fisheries in Southeast Asia

As SEAFDEC continues to prosper in its fisheries R&D efforts during the 48 years of its existence, its mandate had been expanded to wit: "*to develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies, research and information dissemination activities*". For almost four decades, the fisheries R&D activities of SEAFDEC had been greatly influenced and guided by five major episodes (**Box 1**), namely: the adoption in 1982 of the United Nations Convention on the Law of the Sea (UNCLOS); promotion of the FAO Code of Conduct for Responsible Fisheries (CCRF) starting in

**Table 3.** Production from marine capture fisheries of major fish producing countries of Southeast Asia in 2012 (by major species group, in MT)

| Major species groupings | Indonesia | Malaysia | Myanmar | Philippines | Thailand | Viet Nam | TOTAL |
|---|---|---|---|---|---|---|---|
| Shads, milkfish, barramundi, etc. | 104,102 | 22,202 | - | 3,239 | 61 | - | **129,604** |
| Flounders, halibuts, soles, etc. | 24,663 | 6,496 | - | 851 | 2,005 | - | **34,015** |
| Red fishes, basses, congers, etc. | 938,167 | 290,725 | - | 336,221 | 187,391 | - | **1,752,504** |
| Jacks, mullets, sauries, etc. | 897,994 | 230,523 | - | 487,336 | 144,155 | - | **1,760,008** |
| Herrings, sardines, anchovies, etc. | 544,480 | 34,431 | - | 462,637 | 218,625 | - | **1,260,173** |
| Tunas | 1,134,288 | 66,193 | - | 511,681 | 38,891 | - | **1,751,053** |
| Mackerels | 544,801 | 34,431 | - | 462,637 | 218,625 | - | **1,260,173** |
| Sharks and rays | 102,054 | 26,244 | - | 6,597 | 7,093 | - | **141,988** |
| Miscellaneous fishes | 505,226 | 355,332 | 2,332,790 | 14,377 | 470,096 | 1,818,900 | **5,496,721** |
| Crabs | 73,036 | 12,275 | - | 27,513 | 28,546 | - | **141,370** |
| Lobsters | 13,549 | 794 | - | 260 | 1,080 | - | **15,683** |
| Shrimps, prawns, etc. | 160,591 | 46,172 | - | 38,926 | 46,935 | - | **292,624** |
| Miscellaneous crustaceans | 1,177 | - | - | - | - | - | **1,177** |
| Oysters | 383 | - | - | 116 | - | - | **499** |
| Mussels | 3,353 | - | - | 26 | 11 | - | **3,390** |
| Cockles, clams, etc. | 45,618 | 4,588 | - | 707 | 16,505 | - | **67,418** |
| Cuttlefish, squids, etc. | 167,343 | 86,579 | - | 62,924 | 124,709 | - | **441,555** |
| Mollusks | 99,924 | 74,150 | - | - | 3,884 | - | **177,958** |
| Invertebrates | 40,228 | 11,980 | - | 951 | 118,063 | - | **171,222** |
| Others | - | - | - | - | - | 692,000 | **692,000** |
| **TOTAL** | **5,400,977** | **1,472,239** | **2,332,790** | **2,145,233** | **1,612,073** | **2,510,900** | **15,474,212** |

*Source: SEAFDEC (2014)*
*Note: Total fishery production of the Southeast Asian countries from marine capture fisheries in 2012 was 15,590,704 MT*

**Box 1.** Important episodes that influenced the sustainable development and management of fisheries Southeast Asia, with focus in marine capture fisheries

**1982 United Nations Convention on the Law of the Sea (UNCLOS)**
UNCLOS is a comprehensive international proclamation aimed to create a unified regime for governance of the rights of nations with respect to the peaceful uses of the seas and oceans. Specifically, UNCLOS promotes equitable and efficient utilization, and conservation of the seas' and oceans' natural resources, and protection and preservation of the marine environment. By defining the rights and responsibilities of nations with respect to their utilization of the seas and oceans, UNCLOS promotes guidelines for the management of marine natural resources.

After its establishment in 1967, SEAFDEC has been assisting the Southeast Asian countries in the development of their respective fisheries industries. Starting with the conduct of stock assessment of economically important marine species in the region; to the surveys of fishing grounds to assess fish stocks in exploited and un-exploited waters; and then improvements of the efficiency of traditional fishing gears and crafts, and introduction of new and responsible gears appropriate for the region, particularly small-scale models. The R&D efforts of SEAFDEC were aimed at assisting the Southeast Asian countries in improving their respective fisheries policies and management schemes in accordance with the provisions of the UNCLOS.

**1995 Code of Conduct for Responsible Fisheries (CCRF) and Regionalization by SEAFDEC of the CCRF**
While UNCLOS provided a new framework for better management of marine resources and provided coastal States the rights and responsibility to manage and utilize the fishery resources within their EEZs, which in totality comprises about 90% of the world's marine fishery resources, this was not sufficient to promote effective development and efficient management as many coastal States continued to be confronted with complicated challenges while utilizing these resources as the world fisheries became market-driven. Many coastal States took the new regime under UNCLOS as an opportunity to invest in modern fishing fleet and fish processing plants to respond to the rapidly growing demand for fish and fishery products. As a result, since the fishery resources could no longer sustain the uncontrolled exploitation of the resources, calls were made by the international community for the development of new approaches to fisheries management that would integrate conservation and environmental considerations with sustainable utilization. Closely related concerns also emerged, one of which was on the unregulated fishing in the high seas and another on uncontrolled fishing of straddling and highly-migratory fish species within and outside the EEZs. Therefore, the Committee of Fisheries (COFI) recommended in 1991 that a concept that would promote responsible and sustained fisheries should be developed, and in 1992, the International Conference on Responsible Fishing in Cancún, Mexico asked FAO to develop an international Code of Conduct to address such impeding concerns. The resulting Cancún Declaration was adopted during the 1992 United Nations Conference on Environment and Development (UNCED) as part of its Agenda 21. Consistent with the Cancún Declaration and decision of UNCED as well as those of other related conventions, the FAO Governing Bodies recommended the formulation of a global Code of Conduct for Responsible Fisheries (CCRF) which should be non-mandatory but based on the principles and standards applicable to conservation, management and development of all types of fisheries (FAO, 1995). Adopted in October 1995, the CCRF is meant to provide the necessary frameworks for national and international efforts to ensure sustainable utilization of aquatic living resources in harmony with the environment.

After the adoption of the global CCRF, SEAFDEC with funding support from the Japanese Trust Fund (JTF) initiated a program on the Regionalization of the Code of Conduct for Responsible Fisheries (RCCRF) starting in 1998 with the main objective of facilitating better understanding of the global CCRF by all stakeholders in the Southeast Asian region (Kato, 2003). The RCCRF considered the complex nature of the region's fisheries which is multi-species and multi-gear in nature, as well as the region's varying cultures and fisheries structures and the region's ecosystems. During the RCCRF, SEAFDEC came up with regional guidelines that accommodate the specific concerns of the region with respect to the global CCRF but which the CCRF had not highlighted, bridging the gaps between the international initiatives and the actual implementation of the CCRF at national and local levels in the region. This was intended to ensure the effective and efficient adoption of the global CCRF in the region (Ekmaharaj, 2007). Through the RCCRF as SEAFDEC's efforts in promoting the implementation of the global CCRF in the region, SEAFDEC became a recipient of the Margarita Lizárraga Medal Award given by FAO in 2007 for the biennium of 2006-2007.

To ensure that the regional guidelines would be implemented by the AMSs and fully understood by the region's stakeholders, SEAFDEC with financial support from the technical cooperation with the Swedish International Development and Cooperation Agency (Sida) under the Swedish Board of Fisheries, launched a four-year project on Human Resource Development for Fisheries Management in the ASEAN Region (2003-2006). Focusing on human resource development to support the implementation of the CCRF, particularly the Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Fisheries Management (SEAFDEC, 2003), the project also facilitated the development of national frameworks on responsible fisheries by the respective AMSs (Wanchana, 2007).

The implementation of the regional guidelines by the AMSs was assessed during the Regional Seminar on the Implementation of the CCRF organized by SEAFDEC in October 2007, where the AMSs also agreed to mainstream the regional guidelines into their respective national policies under the framework of the CCRF. Nevertheless, taking into consideration their respective initiatives as well as laws and national priorities, SEAFDEC with assistance from collaborating partners responded to the request from the AMSs for continued support in furthering the implementation of the CCRF in their respective jurisdictions.

**1998 SEAFDEC Strategic Plan**
The 1998 SEAFDEC Strategic Plan which was crafted through a resolution during the SEAFDEC Special Consultative Meeting in December 1997 was adopted by the SEAFDEC Council in 1998. The development of the 1998 SEAFDEC Strategic Plan took into consideration the policies of the AMSs in planning their future fisheries directions and in ensuring the sustainable utilization of national and regional fishery resources. Thus, planning and implementation of programs and activities in the Southeast Asian region had been rationalized to respond to the changing paradigm in the region's fisheries management and requirements. The implementation of such programs and activities had been formalized when the ASEAN-SEAFDEC Fisheries Consultative Group (FCG) was established in 1998 to serve as a collaborative mechanism for the ASEAN and SEAFDEC to address regionally important issues and actions in sustainable fisheries development and management.

**Box 1.** Important episodes that influenced the sustainable development and management of fisheries Southeast Asia, with focus in marine capture fisheries (Cont'd)

| |
|---|
| **2001 Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region**<br>Amidst the backdrop of the 1998 SEAFDEC Strategic Plan, widespread regional concern on unsustainable fisheries practices in the Southeast Asian region continued to loom affecting the future supply of fish for food security as well as for the economic and social well-being of peoples in the AMSs (Vichitlekarn, 2003). While sustaining the collaboration between the ASEAN and SEAFDEC, and in order to address the aforementioned concern, the ASEAN and SEAFDEC with support from JTF organized the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium, "*Fish for the People*" also known as the Millennium Conference, in November 2001. The Millennium Conference adopted the Resolution on Sustainable Fisheries for Food Security for the ASEAN Region, as well as endorsed the corresponding Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region. These instruments provided the common fisheries policy framework and priority actions for the sustainable development and management of fisheries in the region. Based on the 2001 Resolution and Plan of Action, various collaborative projects and activities had been implemented in the AMSs addressing their respective priorities and requirements. Thus, the Special Five-Year Program on Sustainable Fisheries for Food Security in the ASEAN Region was developed to include projects relevant to marine fisheries, *i.e.* responsible fishing practices, coastal resource management, conservation and management of sea turtles, information collection for sustainable pelagic fisheries in Southeast Asia, among others. SEAFDEC spearheaded the development and implementation of such projects and activities in the AMSs with funding support from the JTF. |
| **2011 Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020**<br>The conduct of the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2010 in June 2011 was conceived in order to sustain the momentum developed after ten years from the Millennium Conference in 2001 (Pongsri, 2009). As a sequel to the Millennium Conference, the 2011 Conference was aimed at addressing the concerns on current fisheries situation and emerging issues that impede the sustainable development and contribution of fisheries to food security in the region. The Conference adopted the 2011 Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 that serve as regional policy framework and guiding principles for the AMSs in achieving sustainable fisheries for food security during the coming decades while also responding to the changing fisheries environment. Guided by the aforementioned Resolution and Plan of Action, SEAFDEC through its collaborative mechanism with the ASEAN, has since then been implementing programs and activities in the AMSs that are relevant to the promotion of sustainable fish production as well as towards addressing emerging issues that hinder all efforts to achieve food security in the region. SEAFDEC also supports the AMSs in achieving the objectives of the ASEAN Community building, particularly in enhancing the contribution of fisheries to the region's economic development, food security and poverty alleviation, taking particular attention on the emerging challenges and issues confronting the AMSs. |

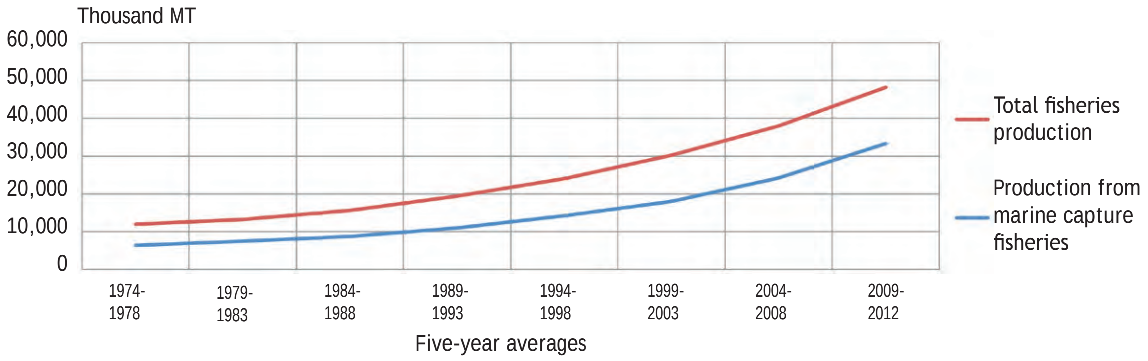
late 1990s and the corresponding effort of SEAFDEC to regionalize the CCRF from 1998 to early 2000s; adoption of the SEADEC Strategic Plan in 1998; adoption in 2001 of the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region; and the subsequent adoption in 2011 of the updated Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020. These regional pronouncements have served as frameworks for the development and implementation of programs and activities by SEAFDEC in the Southeast Asian region taking into consideration the priorities and requirements of the SEAFDEC Member Countries.

In order to facilitate the conduct of such programs and activities in the Southeast Asian region, SEAFDEC strengthened its linkage with the ASEAN under the ASEAN-SEAFDEC Fisheries Consultative Group (FCG) collaborative mechanism which was established in 1998, and the signing of the Letter of Understanding in 2007 for the ASEAN-SEAFDEC Strategic Partnership (ASSP). The impacts of SEAFDEC's efforts in promoting these pronouncements in the ASEAN Member States (AMSs) that led to sustainable production of fish from marine capture fisheries could be gleaned in **Fig. 2**. Moreover, while becoming more concerned on the sustainability of global fisheries, the international community came up with various international and regional declarations and instruments (**Box 2**) that require compliance by the AMSs, especially the exporting countries, with SEAFDEC providing technical assistance to the AMSs.

Furthermore, to enable the AMSs to adhere to international and regional instruments on sustainable fisheries development and management, especially with respect to small-scale marine fisheries, the assistance of SEAFDEC was sought. In responding to the requirements of the AMSs, SEAFDEC re-adjusted its projects and activities. The specific role of SEAFDEC in empowering the AMSs to comply with the requirements fundamental in such conventions and instruments are shown in (**Box 2**).

## Way Forward

Through its Training Department (TD), the efforts of SEAFDEC to facilitate the management and sustainable utilization of fishery resources in the Southeast Asian region would be continued. Specifically, R&D will be carried out on sustainable capture fisheries, optimum utilization of fishery resources, resource enhancement, fishing community resilience, and on emerging issues, *e.g.* optimizing energy use in capture fisheries, addressing issues on sustainable fisheries and IUU fishing. In addition, TD would also continue to conduct training courses in various aspects of sustainable capture fisheries, optimum utilization of fishery resources, resource enhancement,

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| SEAFDEC continued to carry out R&D activities in the ASEAN Member States (AMSs) based on its current mandate through the Training Department (TD) focusing on development of technologies for marine capture fisheries, under the framework of the exclusive economic zones (EEZs) introduced in mid-1970s and the 1982 United Nations Convention on the Law of the Sea. | Region's average annual rate of increase in production from 1974 to late 1980s: **15%** for total fisheries production; and **10%** also for marine capture fisheries production. |
| Establishment of SEAFDEC Marine Fishery Resources Development and Management Department in Kuala Terengganu in 1992 enabled SEAFDEC to expand R&D activities in AMSs on sustainable development and management of marine capture fisheries. | Region's average annual rate of increase in production from late 1980s to early 1990s: **21%** for total fisheries production; and 18% for marine capture fisheries production. |
| SEAFDEC promoted the adoption of CCRF in Southeast Asia by regionalizing the CCRF for better understanding and eventual adoption of the CCRF by the AMSs.<br>Guided by the CCRF, SEAFDEC with major funding support from the Japanese Trust Fund (JTF) implemented number of projects leading to the formulation of policies and development of technologies in sustainable fisheries. | Region's average annual rate of increase in production from early 1990s to early 2000s: **28%** for total fisheries production; and **17%** for marine capture fisheries production.<br>Technologies developed by SEAFDEC had been transferred to AMSs through capacity development and information dissemination with JTF support. |
| Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region adopted in 2001 was promoted by SEAFDEC for adoption by AMSs. | Region's average annual rate of increase in production from early 2000s to early 2010s: **26%** for total fisheries production; and 11% for marine capture fisheries production. |
| Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 adopted in 2011 was promoted by SEAFDEC for adoption by AMSs. | Region's average annual rate of increase in production in early 2010s: **38%** for total fisheries production; and **8%** for marine capture fisheries production. |

**Fig. 2.** Trend of fisheries production in Southeast Asia from 1974 to 2012, and corresponding efforts of SEAFDEC to assist the ASEAN Member States in attaining sustainability in fisheries through the promotion of responsible fishing technologies and improved fisheries management

coastal and small-scale fishery management and emerging issues and concerns in order that available fishery resources in the region are effectively and rationally utilized.

SEAFDEC/MFRDMD would also implement research, training and information activities that aim to promote sustainable development and management of marine fishery resources in Southeast Asia, where its focus would be on the conduct of R&D on the status of marine fishery resources and their exploitation, and stock assessment of important marine fish species. MFRDMD would also provide regional fora for consultation and cooperation in research,

**Box 2.** Major international and regional instruments that call for compliance and development of common position by the ASEAN Member States

**Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES),** which entered into force in July 1975 aims to ensure that international trade in wild animal and plants does not threaten the survival of the species. Countries that are parties to the Convention have the responsibility to protect endangered species and international cooperation is enhanced to protect certain species from over-exploitation through international trade. Species protected under CITES are listed in three Appendices, the listing of which is determined after detailed experts evaluation and scientific justifications.

As of 1996, all species of sea turtles have been classified as endangered by the International Union for Conservation of Nature (IUCN) Red List of Threatened Animals, and the global concern on these species being endangered have been increasing, due to indiscriminate exploitation of the species by humans for commercial gains. In order to address such concern, SEAFDEC/MFRDMD collaborated with the AMSs to promote the conservation and management of sea turtles in Southeast Asia. With funding support from JTF, the program on Conservation and Management of Sea Turtles in Southeast Asia was launched in 1998 with the objectives of compiling information on sea turtle stocks, and on the conservation and management activities undertaken by the countries, as well as establishing mechanisms for regional collaboration in research and conservation of sea turtles. Since then, various projects and activities had been carried out in the region including sea turtle hatchery management, tagging survey and satellite telemetry, development of sea turtle excluder devices (with SEAFDEC/TD), population and DNA studies, sea turtles-fisheries interaction, head starting technique, and sea turtle information dissemination, among others (Mahyam Mod Isa *et al*., 2008; Chokesanguan, 2008).

As early as 2002, some species of sharks and rays have been proposed for listing in the CITES Appendices to regulate their trade. Considering that fisheries of elasmobranchs including some species of sharks and rays are economically important in the Southeast Asian region, such proposal could affect the fisheries industry of the region. In response to such proposal, SEAFDEC convened a number of regional meetings where the AMSs asked SEAFDEC to carry out a project on Data and Information Collection on Status and Trends of Shark Fisheries and Utilization, and for SEAFDEC to assist the concerned AMSs to develop their respective National Plans of Action on Sharks (NPOA-Sharks) in line with the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks) to be supported by scientific evidence.

Thus, SEAFDEC with financial assistance from JTF has been undertaking a review of the region's information on sharks and rays as well as conservation measures to obtain scientific evidence on the status of the stocks of sharks and rays in the region (Chamsai *et al*., 2013). In addition, SEAFDEC has sought the assistance of the European Union (EU) for the conduct of capacity building activities with respect to the proposed listing of economically important marine species in the CITES Appendices for the benefit of the AMSs, which at the onset could include shark-related issues particularly taxonomy, DNA of shark fins, species identification, non-detriment findings (NDFs) in CITES, and updating of information on marketing of sharks and shark products in the region.

Moreover, SEAFDEC through its Aquaculture Department in the Philippines has also taken steps to conduct activities related to stock enhancement of threatened species of international concern, *e.g.* sea horses, giant clams, abalone, sea cucumbers, Napoleon wrasse. The details of which would be discussed in succeeding issues of *Fish for the People*.

**United Nations Framework Convention on Climate Change (UNFCCC)**, which was launched during the Earth Summit in Rio de Janeiro in June 1992 but entered into force in March 1994, mainly aims to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Although considered legally non-binding, UNFCCC provides a framework for negotiating specific international treaties (also known as protocols) that may set binding limits on greenhouse gases. For example, in 1997, the Kyoto Protocol was concluded and established legally binding obligations for developed countries to reduce their greenhouse gas emissions. The 2010 Cancún Agreements stated that future global warming should be limited to below 2.0°C (3.6°F) relative to the pre-industrial level. One of the tasks set by the UNFCCC was for signatory nations to establish national greenhouse gas inventories of greenhouse gas (GHG) emissions and removals, which were used to create the 1990 benchmark levels for accession of countries to the Kyoto Protocol and for the commitment of those countries to GHG reductions. The UNFCCC designated the United Nations Secretariat to support the operation of the Convention through the Intergovernmental Panel on Climate Change (IPCC), especially in getting consensus through meetings and the discussion of various strategies. In the subsequent Bali Action Plan adopted in 2007, all developed country Parties have agreed to "some quantified emission limitations and reduction objectives, while ensuring the comparability of efforts, taking into account differences in their national circumstances". Developing country Parties agreed to "the nationally appropriate mitigation actions [NAMAs] in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner". However, some developing country Parties have expressed the need for international support in their plans. The ultimate objective of the UNFCCC is to prevent "dangerous" anthropogenic (*i.e.*, human-caused) interference of the climate system, and requires that GHG concentrations are stabilized in the atmosphere at a level where ecosystems can adapt naturally to climate change, food production is not threatened, and economic development can proceed in a sustainable fashion. Since global warming that has already occurred poses a risk to some human and natural systems (*e.g.*, coral reefs), generally increasing the risk of negative impacts, it could lead to widespread loss of biodiversity and reduced global and regional food security.

In an effort to assist the AMSs in coping with the impacts of climate change that have affected their respective fisheries industries, SEAFDEC with financial support from Sweden is implementing a project on Improving Fisheries and Habitat Management, Climate Change Adaptation and Social Well-being in Southeast Asia. Comprising Phase II of the SEAFDEC-Sweden partnership (Phase I was known as the SEAFDEC-Sida Project), this five-year (2013-2017) Project aims to continue highlighting and addressing issues related to climate change and adaptive measures of fisheries stakeholders in one component, taking into consideration the lessons learned from Phase I which indicated that improved resources and environmental management could lead to building up the capability of communities' resilience and enhance their adaptive capacity to the impacts of climate change (Sam Ath *et al*., 2013).

Moreover, while recognizing that the fishery sector has been known as one of the sources of GHG emissions, SEAFDEC through its Training Department had been promoting the adoption of energy saving technologies and practices that reduce reliance on fossil fuel and eventually achieve improved national financial economies by coming up with management direction for energy use in fisheries (Chokesanguan, 2011). In order to reduce dependence on fossil fuel, it has become necessary to compile information on energy use and practices in the fishery sector, craft policy framework for managing energy use, as well as conduct of R&D on low impact fuel efficient (LIFE) capture fisheries technologies. LIFE fishing is a cost-effective technology that aims to modify or replace high-impact and fuel-hungry fishing techniques and practices by using gears that can create low impact on the environment and consume less fuel thereby, decreasing impacts to aquatic ecosystems, reduce GHG emission, and lower fuel costs (Chokesanguan and Suuronen, 2014).

**Box 2.** Major international and regional instruments that call for compliance and development of common position by the ASEAN Member States (Cont'd)

**International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU),** which was developed within the framework of the CCRF, is a voluntary instrument mainly aimed at preventing, deterring and eliminating IUU fishing that undermines all efforts to conserve and manage fish stocks in capture fisheries. IPOA-IUU provides all States with comprehensive, effective and transparent measures to address issues on IUU fishing and prevent the possible collapse of marine capture fisheries.

**EC Regulation No. 1005/2008 to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated (IUU) Fishing (EC Regulation)** is a non-discriminatory instrument applied to all fishing vessels under any flag which seeks to prevent, deter and eliminate IUU fishing in all maritime waters. The EC Regulation also aims to regulate the importation of fish and fishery products to the EU by ensuring full traceability of all marine fishery products traded to the EU through a catch certification scheme.

**Regional Plan of Action (RPOA) to Promote Responsible Fishing Practices including Combating IUU Fishing in the Region,** which is a voluntary instrument, aims to enhance and strengthen fisheries management so that the fishery resources and the marine environment are sustained and the benefits of adopting responsible fishing practices could be optimized. Covering the areas in the South China Sea, Sulu-Sulawesi (Celebes) Seas and Arafura-Timor Seas, the RPOA takes its core principles from existing international instruments, especially from the IPOA-IUU. With its Secretariat based in Indonesia, the RPOA is a collaborative arrangement among 11 countries, namely: Indonesia, Australia, Brunei Darussalam, Cambodia, Malaysia, Papua New Guinea, Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam.

As early as 2008, the SEAFDEC Council of Directors provided directives for SEAFDEC to provide technical support and advise as well as assist the AMSs in the implementation of the RPOA, particularly in supporting responsible fishing practices in the region and increasing the awareness of the AMSs in related laws and regulations to enhance compliance with the RPOA (Siriraksophon *et al.*, 2009). Thus, SEAFDEC has been conducting various fora to support the efforts of the AMSs in combating IUU fishing in their respective EEZs. Moreover, SEAFDEC through the SEAFDEC-Sweden collaborative arrangement also facilitated the development of the concept of sub-regional area management to enhance the promotion of sub-regional fisheries management arrangements. Such effort is meant to support the development and implementation of national plans of action (NPOAs) to combat illegal fishing in concerned countries (Torell *et al.*, 2010).

Meanwhile, with continued support from JTF, SEAFDEC has been assisting the AMSs in their efforts to combat IUU fishing through the implementation of activities that include promotion of fishing licenses, boats registration and port state measures as means of combating IUU fishing in the region. In addition, SEAFDEC also provides assistance to AMSs in the application and implementation of IUU fishing-related countermeasures that include the promotion of MCS management for sustainable fisheries in the region (Matsumoto *et al.*, 2012).

In accordance with relevant provisions in the ASEAN-SEAFDEC Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020, SEAFDEC has been implementing various activities that aim to control IUU fishing in the waters of Southeast Asia. These include activities that aim to prevent the export of IUU fishing products from the Southeast Asian region (Latun *et al.*, 2013) and enhance the sustainable development of fisheries in the region, facilitating the promotion of countermeasures that had been developed by SEAFDEC for combating IUU fishing in Southeast Asia (Kawamura and Siriraksophon, 2014). Such countermeasures include the compilation of Regional Fishing Vessels Record (RFVR) for fishing vessels 24 meters in length and over spearheaded by SEAFDEC/TD, the development of ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing into the Supply Chain by SEAFDEC/MFRDMD, development of the ASEAN Catch Documentation Scheme (ACDS) which is still ongoing, and the development of the RPOA-Fishing Capacity which is also in the offing. While the ACDS is being developed taking into consideration the EC Regulation 1005/2008 to facilitate the export of fish and fishery products to the EU by the AMSs, it would focus mainly on inter- and intra-regional trade of fish and fishery products from marine capture fisheries.

Furthermore, SEAFDEC in collaboration with the AMSs had initiated the development of the Regional Plan of Action on Sustainable Utilization of Neritic Tuna Resources in the ASEAN Region to ensure sustainable fisheries management to neritic tuna resources in the region. Plans for the conservation and management of eel resources had also been initiated to ensure the sustainable utilization of eel resources in Southeast Asia (Kawamura and Siriraksophon, 2014).

conservation and management of marine fishery resources, in addition to training programs on stock assessment, fisheries management and conservation of endangered, threatened and protected aquatic species.

SEAFDEC would therefore continue to enhance its technical capability in marine capture fisheries to address the needs, requirements and priorities of the AMSs, aiming for sustainability in marine fisheries. In so doing, SEAFDEC would also enhance its cooperation and collaboration with donors and other organizations working towards sustainable development of fisheries in the region to ensure that all efforts dovetail to the improvement of the contribution of fisheries to food security and poverty alleviation in the region amidst the backdrop of the ASEAN Economic Community integration by the end of 2015.

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# Balancing Fishery Resource Utilization and Conservation for Environmental Sustainability and Socio-economic Stability

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The coastal areas of Southeast Asia contain great biodiversity, where livelihoods of people are directly and indirectly dependent on the natural resources. In order to pursue sustainable development of the natural resources for rural area advancement, attempts have been initiated to harmonize the utilization of the resources with conservation. However, such efforts have encountered certain difficulties that hinder further development as the linkage between natural resources and ecosystem services and utilization represents a complex web of processes. It has therefore become necessary to study the relationship between the ecosystem and human capability as means of improving the management of coastal resources for the benefit of people dependent on such resources for their livelihood and well-being. It is under such scenario that the Research Institute for Humanity and Nature (RIHN) and some renowned universities in Japan partnered with research institutions and the academe in Southeast Asia to launch a joint research project on Coastal Capability Enhancement in Southeast Asia. Thus, a collaboration was forged by RIHN with the Southeast Asian Fisheries Development Center (SEAFDEC), as well as with the Eastern Marine Fisheries Research and Development Center (EMDEC) of the Department of Fisheries of Thailand, Faculty of Fisheries of Kasetsart University in Thailand, University of the Philippines in the Visayas, Aklan State University in central-western Philippines, and other related institutions/organizations to carry out the said project. By adopting the "holistic approach" to obtain full understanding of how people utilize the coastal resources against the backdrop of the so-called conservation, the project aims to establish rational and practical measures for social and ecological sustainability. Based on the holistic data and information, a new rural development concept known as "Area-Capability" would be crafted which demonstrates how the ecosystem health could be harmonized with the welfare of the people. Inventories of ecosystem services and livelihoods of coastal areas would be compiled for the development of necessary guidelines for the implementation of this new research approach, which is based on the concept of "Area-Capability," in coastal rural communities of Southeast Asia.

Coastal area ecosystem services refer to the benefits that human society derives from coastal area ecosystems that include coastal seas, sea grass beds, coral reefs, estuaries, mangrove areas, and kelp, among others. UNEP (2006) and Duffy (2006) reported that in addition to the benefits that human society could gain from biodiversity, various services offered by the coastal area ecosystems could also be availed of by humans. Such services could be grouped into four categories, namely: provisioning, regulating, cultural, and supporting services (**Table 1**).

UNEP (2006) also indicated that a majority of the world's population lives in coastal areas and are dependent on coastal area ecosystems and the resources available within, for their livelihoods and existence (**Table 2**). The information in **Table 2** also suggests that majority of coastal people takes advantage of the services offered by coastal area ecosystems. However, the irony is, anthropogenic activities are threatening and risking the sustainability of coastal area ecosystems and their resources, more particularly through changes in land utilization, over-exploitation of the resources, illegal fishing activities, ineffective utilization of resources, and pollution and other impacts from a rapidly increasing population. The inadequate efforts by stakeholders to conserve the resources therefore needs immediate attention and should be considered an urgent issue to be addressed at the national and/or regional levels in order to sustain the services offered by coastal area ecosystems.

Furthermore, there is also a need to sustain the close relationship between resource utilization and conservation in order that the resources could continue to provide services necessary for people to survive, especially those in rural coastal areas (Ishikawa and Arimoto, 2008). Considering that no research studies had been carried out to evaluate the health of coastal area ecosystems corresponding to the services that the ecosystems offer for the benefit of humans, the collaborative project on "Coastal Capability Enhancement in Southeast Asia" therefore envisions to adapt the concept of "Area-Capability" to pave the way for the sustainability of the ecosystems and at the same time enhance the livelihoods of peoples in the coastal areas of Southeast Asia (Ishikawa, 2014). Yap *et al.* (2013) specifically outlined the approaches necessary for the development of Area-Capability Concept, *i.e.* natural

**Table 1.** Ecosystem services that could be provided by coastal area ecosystems

| Major groupings | Estuaries and marshes | Mangrove forests | Lagoons and salt ponds | Inter-tidal zones | Kelp forests | Rocks and shell reefs | Sea grass beds | Coral reefs | Inner shelf |
|---|---|---|---|---|---|---|---|---|---|
| **Biodiversity** | X | X | X | X | X | X | X | X | X |
| **Provisioning services** | | | | | | | | | |
| food | X | X | X | X | X | X | X | X | |
| fiber, timber, fuel | X | X | X | | | | | | X |
| medicine, others | X | X | X | | X | | | X | X |
| **Regulating services** | | | | | | | | | |
| biological regulation | X | X | X | X | | X | | X | |
| freshwater storage and retention | X | | X | | | | | | |
| hydrological balance | X | | X | | | | | | |
| atmospheric/climatic regulation | X | X | X | X | | X | X | X | X |
| human disease control | X | X | X | X | | X | X | X | |
| waste processing | X | X | X | | | | X | X | |
| flood/storm protection | X | X | X | X | X | X | X | X | |
| erosion control | X | X | X | | | | X | X | |
| **Cultural services** | | | | | | | | | |
| cultural and amenity | X | X | X | X | X | X | X | X | X |
| recreational | X | X | X | X | X | | | X | |
| aesthetics | X | | X | X | | | | X | |
| **Supporting services** | | | | | | | | | |
| biochemical | X | X | | | X | | | X | |
| nutrient cycling and fertility | X | X | X | X | X | X | | X | X |

*Sources: Adapted from Millennium Ecosystem Assessment as reported by UNEP (2006) and Duffy (2006)*

science method to identify the key factors in maintaining ecosystem health and services; social and anthropological method to describe the patterns of resource use and how these could be linked to improved local livelihoods; and field research in collaboration with local people and government institutions to compile the information needed for the development of the concept. Once established, the "Area-Capability" Concept for the Southeast Asian region, the development of which is still ongoing, would be pilot-tested in the region to assess their adaptability and acceptability.

**Table 2.** World's population living in coastal areas

| Coastal Area Ecosystem Sub-types | Estimated Population | Share of World's Population (%) | Share of Coastal Area Population (%) |
|---|---|---|---|
| Estuaries | 1,598,940,542 | 24 | 27 |
| Coral Reefs | 710,583,010 | 11 | 12 |
| Mangroves | 1,030,295,102 | 16 | 17 |
| Sea-grass | 1,146,100,829 | 18 | 19 |
| Others | 610,883,710 | 9 | 10 |
| **TOTAL** | **5,996,803,193** | **78** | **85** |

*Source: Adapted from UNEP (2006)*
*Note: Estimated population in 2006: 6,555,000,000 (PRB, 2006)*

## Development of the Area-Capability Concept

The Area-Capability (AC) Concept has been framed with the idea that the finite nature of natural living resources requires consideration and awareness by users so that the resources could be utilized in a sustainable manner. At the onset, socio-ecological studies involving value chain research have been carried out to evaluate the linkage between natural resources and human activities, where certain resources that are commercially utilized with the particular functions of such resources as income generators, are highlighted (**Fig. 1**). Considering that people living in coastal areas utilize various types of resources for several purposes, it is necessary to improve the ecosystem health of coastal areas in order to achieve sustainable development. Such broad-scale improvement is crucial since intensive utilization of a particular living resource could deteriorate nearby and other resources through ecosystem linkages, *e.g.* felling of mangroves destroys the habitats of coastal aquatic animals creating negative impacts on the natural fishery resources. As a consequence, resource shrinkage occurs aggravating the competition and conflict among resource users, resulting in loss of sustainability of the

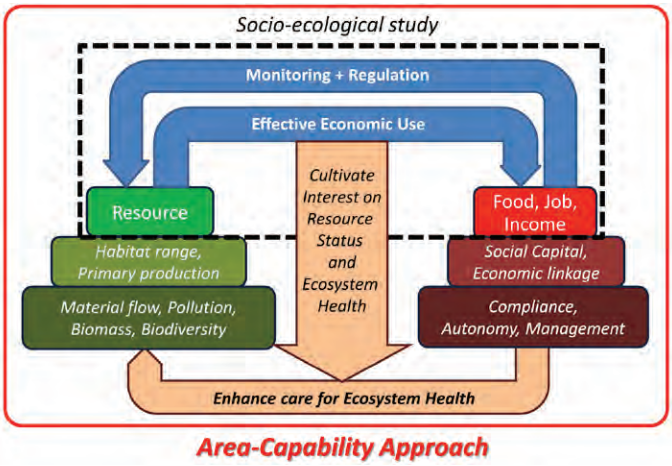



**Fig. 1.** Linkage between resource and food supply, income generation, and job opportunities established through socio-ecological study (black dashes) for the development of the AC Approach (the whole square) which encompasses not only the overall relationship but also the level of care for a range of habitats and the capabilities of user communities in caring the ecosystem health, including social capital and economic linkage

resources, a phenomenon which is known as the "tragedy of the commons" (Hardin, 1968).

While looking at ecosystem health in resource management, Smith and Maltby (2003) proposed an ecosystem approach in management but this entails collecting sufficient data to calculate the stock status for all species, which is an incredibly gigantic task, especially in coastal areas where the level of biodiversity is high. Moreover, determining an accurate assessment of the status of ecosystem health in an ecotone would be another challenging task due to high variability, since an ecotonal area often has higher density of organisms and greater number of species than in either flanking ecological community.

Nevertheless, in the development of the AC Concept, the main concern is to monitor the ecosystem health through the health status of habitats that comprise food webs and average trophic levels, range of the habitats, and the amount of primary production (**Fig. 1**). Furthermore, cultivating the interest and understanding of resource users on the importance of ecosystem health is another important aspect necessary for the development of the AC Concept.

## Development of Socio-ecological Linkage

In order to establish the linkage between natural resources and people's livelihoods, the capabilities of user communities are evaluated. As community capability usually involves various functions, the various means of resource utilization, social capital related to compliance of management rules and regulations, and development of autonomous management skills are important factors considered in the design of the AC Concept. Based on the data and information collected, the kinds of "care" activities that are indispensable for maintaining and/or enhancing ecosystem health are generated, and the ways on how such activities should be undertaken to enhance the level of "care" in the minds and activities of resource users are crafted. The AC Concept recognizes the role of natural resources utilization because in a coastal area with high biodiversity (*i.e.* one that contains many target resources), resource users are able to monitor and obtain data regarding the status of the resources with respect to users' daily lives, and only the resource users could conduct activities with sustained care for protecting the resources.

Therefore, the ways and means of effectively monitoring the status of resources are required for the development of the AC Concept. In addition, using the results of monitoring and/or data collection, management systems could be established and/or improved in order that the resource users' compliance with regulations on management of the resources is enhanced. In this regard, participatory approach is highly required for the effective management of resources, especially in Southeast Asia which harbor high bio-cultural diversity. In the participatory approach, dwellers in coastal areas could use several resources and conduct care activities. However, preventing the over-utilization and abuse of the natural resources, and achieving a good balance between appropriate utilization of living resources and habitat protection should be given high priority.

## Scientific Evaluation as a Collaborative Activity

In order to appropriately appraise the utilization of aquatic resources, especially those that show high levels of fluctuation, a detailed scientific evaluation is required. In this regard, collaboration between concerned rural communities and researchers is important in establishing the scientific evidence of sustainable development (**Fig. 2**).

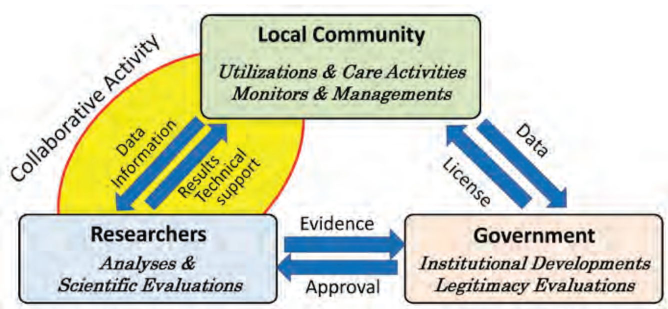



**Fig. 2.** Relationship between scientific evaluations by researchers and government support for community activities which is indispensable for the effective utilization of ecosystems services and fostering the care for ecosystem health by local communities

Moreover, considering that plans for expanding resource utilization and improving some commercial aspects of aquatic products would require approval and/or licenses, therefore, government support is also indispensable to promote and implement the participatory approach required for the AC Concept.

Thus, collaboration among the community, researchers, and government is another fundamental condition necessary for the development of the AC Concept (**Fig. 2**). The AC Approach focuses on the ripple effects of habitat health and community capability derived from communities' particular modes of utilizing the ecosystem services and/or conducting care activities for the natural resources to enhance ecosystem health.

If utilization of the ecosystem services is well balanced with user communities' care for ecosystem health, such utilization could be sustainable. The well-balanced linkage between utilization and care of resources is known as the AC Cycle, where researchers should also take the responsibility of evaluating the impacts of utilization and care activities on the habitat health as well as on social sustainability. Therefore, strategies aimed at facilitating spiritual and/or mind-set change of the users, including strengthening their pride and prospects of rural life, are equally important driving forces that would enable the AC Cycle to attain sustainable ecosystem service utilization (**Fig. 3**). If users do not foresee a future for themselves in rural areas for the long-term, they would not be able to recognize the importance of caring for the ecosystem health and achieving the sustainability of resources.

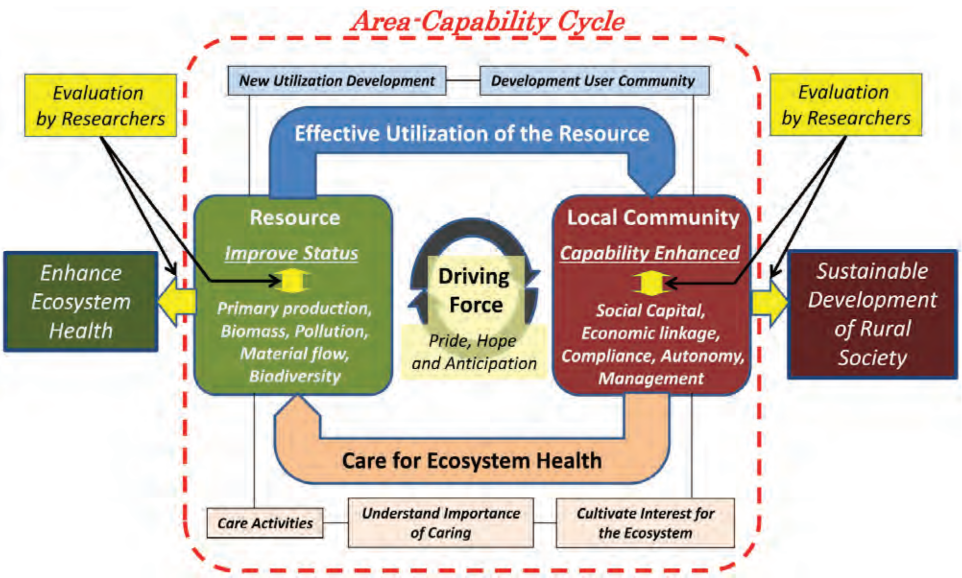
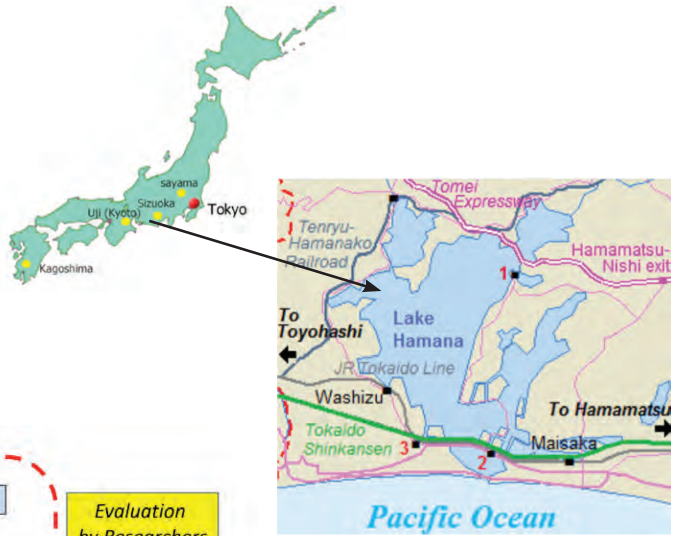



**Fig. 3.** Development of Area-Capability Cycle comprising the processes of finding new resource, effectively utilizing the resource, developing user community, enhancing users' capability, cultivating the interest of users on ecosystem health, understanding the importance of caring, promoting care activities for habitat and primary production of the resource, and fostering the pride and hope of users on their means of utilization and care of the ecosystem services

## Applicability of AC Cycle: Case Studies

In an area around Hamana Lake in Shizuoka Prefecture of Japan, the collaborative activities of community members, researchers, and government have resulted not only in enhanced prawn stock but also cultivated social capital resulting in novel utilization of the ecosystem services. Hamana Lake was once well known for its rich and productive fisheries several hundred of years ago, but since the mid-1960s, the coastal environment had been drastically changed owing to infrastructure development following the change of the economic system of Japan. Since such environmental changes had consequent negative impacts on the fishery resources, and as one of the countermeasures to address the protests of affected fishers, the Government of Japan initiated a stock enhancement project and established a stock enhancement center in each prefecture, where each Prefectural Government was given a budget to conduct artificial breeding of juveniles and larvae for release and stock enhancement (Shigen Kyokai, 1983).




Map of Japan showing Hamana Lake in Shizuoka Prefecture

For Hamana Lake, kuruma prawn (*Penaeus japonicus*) was selected as the target species for stock enhancement, and a stocking center was established near the Lake. However, since there was no aquaculture technology for kuruma prawn established in the center while environmental data of the Lake was not available, the center was unable to determine the optimal release sites and time. Moreover, competitive fishing which was standard among the villages at that time prevented the sharing of information and development of collaborative mechanisms, so that statistical data on prawn catch rates was insufficient to start the stock enhancement project (Ogata, 2015).

Given such a situation, the intermediate aquaculture technology for the kuruma prawn was modified by adjusting it to the environment of Hamana Lake while information on the environmental and stock aspects of the Lake was compiled. During the first year of the prawn stock enhancement project, about one hundred thousand prawn larvae was released (Ogata, 2015), and on the second year, fishers from Shirasu Village located near the intermediate aquaculture site on the west side of Hamana Lake collaborated with researchers of the center and together released approximately three million larvae (Nippon Saibai Gyogyo Kyokai, 1986). The released prawns contributed to the increasing catch of fishers living in villages other than Shirasu, allowing them to recognize the importance of this type of release program for their livelihood. As a consequence, many fishers from all villages surrounding Hamana Lake joined the government stock enhancement project (Ogata, 2015).

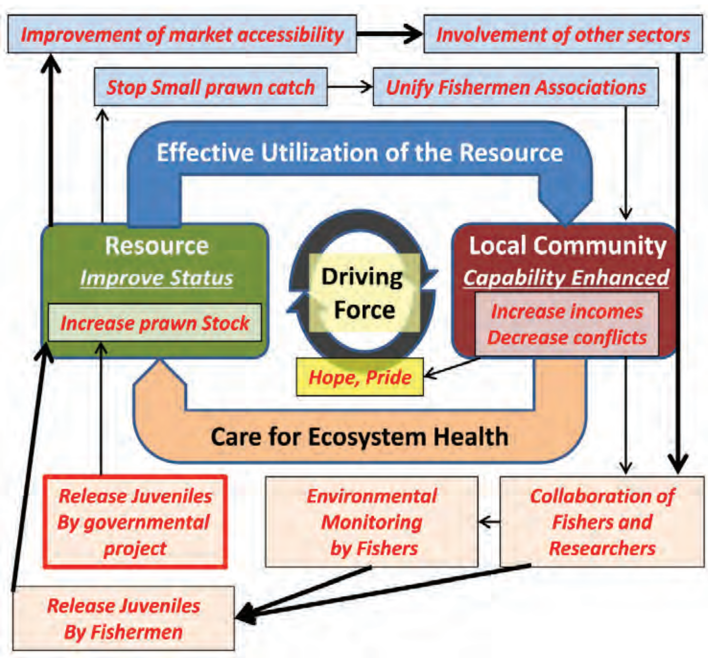



**Fig. 4.** AC Cycle model adopted for stock enhancement of kuruma prawns in Hamana Lake, Japan: from release of artificial larvae of kuruma prawns under a Government-sponsored project until the ultimate take over by fishermen's association after the Government-sponsored project had been phased out

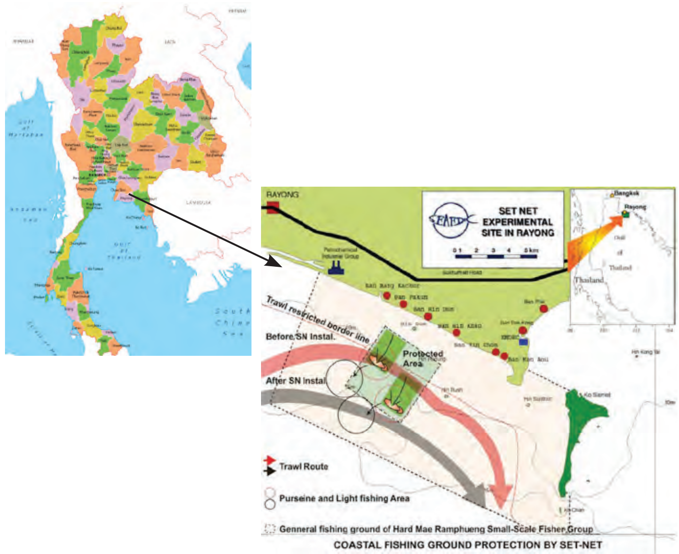



**Fig 5.** Map of Thailand showing the set-net site in Mae Ram Phueng Beach, Rayong Province (Adapted from Munprasit, 2010)

The project had succeeded in releasing 10 million larvae per year during the five-year project period, and the fishers participating in this project had reported increases in their catches, thus, ending the practice of catching small prawns from the wild (Ogata, 2015). Furthermore, the fishers also improved the system of selling prawns on their own, and after the Government's project was terminated, the fishers started their own prawn stock enhancement program, including intermediate aquaculture and release of prawn juveniles (Ogata, 2015). The linkage between the stock enhancement project and sequential changes of the community and resources, including the ripple effects based on the AC Cycle model is shown in **Fig. 4**.

Another case related to the development of the AC Cycle could be gleaned from the establishment of a community-based set-net fishery project in Rayong Province, Thailand by the Training Department (TD) of SEAFDEC. Since 2003, SEAFDEC/TD had been promoting the establishment of community-based set-net fishery as a tool for monitoring the resource status and management of fisheries in Rayong Province (SEAFDEC/TD, 2005; SEAFDEC/TD, 2008).

In 2003, a new community was established through the SEAFDEC set-net project, to operate a set-net fishery, and the community has been distributing their fish catch at a community fish market at the beach adjacent to the set-net installations (**Fig. 5**). By pooling the receipts from their sales of fish, information and data on fish catch, sales, and operation costs had been precisely recorded. After launching the set-net fishery in Rayong Province, Thailand, the local fishers were able to catch a much wider variety of fish using a set-net than before. Starting in 2006, the fishers' groups were able to obtain complete independence in the operation and management of the set-net fishery and in selling their fish catch (Munprasit, 2010).

The skills acquired by fishers in fishery management and operations were then transferred to new community members. The impacts of set-net installations on the habitat health have been examined by assessing the water and sediment quality, fish catch compositions, and the average trophic level of each catch, and the results suggested no particular deterioration of habitat health (Khrueniam *et al*., 2014; Kon *et al*., 2014). In addition, a socio-economic study of the set-net fishery suggested a constant increase in the quality of the catches and incomes of fishers without notable increase in the fish catch (Manajit *et al*., 2011). Nevertheless, the AC Cycle of this particular set-net fishery was observed to have a weak linkage between care activity and improvement of status of fish stock, as there is no direct care activity for the resources and habitat health by the community. However, since set-net could act as nursery and refuge for juveniles and larvae for many aquatic organisms, and if this function is proven to be valid, then the set-net installation itself could be an example of good care activity for stock status.

In this regard, researchers should collaborate with fishers in the community and prove that set-net could function as nursery and refuge of fish stocks. If the set-net could take on the function of conserving the ecosystem, the AC Cycle of the set-net fishery would be completed as shown in **Fig. 6**. More importantly, it should be noted that the AC Cycle as indicated in **Fig. 4** and **Fig. 6**, could easily illustrate the compilation of all aspects of community activities including those activities that are still required in order to achieve sustainable utilization of the ecosystem services for rural development, in addition to the respective roles and responsibilities of each player (*e.g.* community members, researchers) in achieving the desired goal.

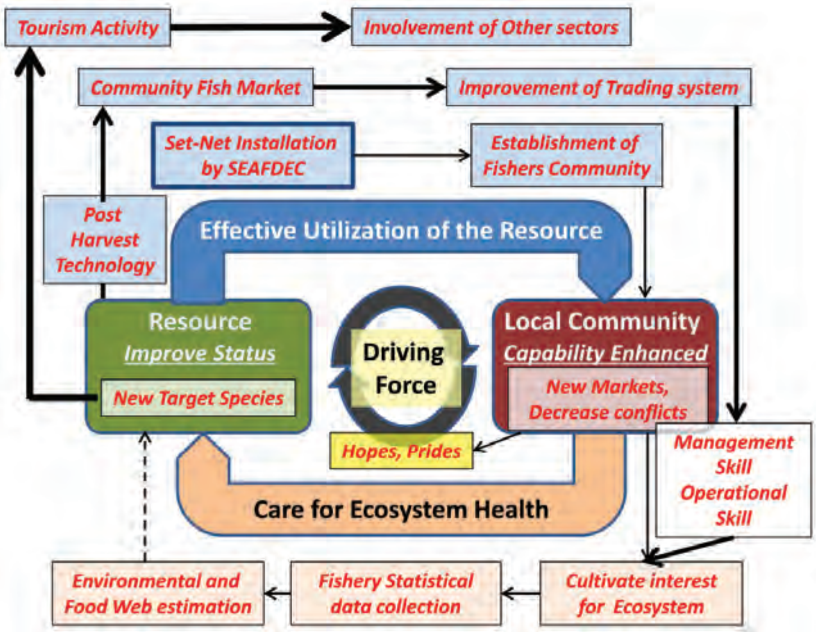



**Fig. 6.** AC Cycle of a community-based set-net fishery in Rayong Province, Thailand which started with installation of set-net by SEAFDEC/TD but since it does not show clear linkage between care for habitat health and resources, this case has been targeted for improvement through the adoption of the AC Approach

## Way Forward

Based on several case studies, including stock enhancement at Hamana Lake, set-net fishery at Rayong Province, and other sites of the SEAFDEC-RIHN collaborative research project (*e.g.* eco-tourism at Ishigaki Island and Mikawa Bay, Japan, and stock enhancement in Batan Bay, Philippines), eight key elements and conditions would be necessary for the successful adoption of the AC Cycle (**Box 1**). These key elements should be treated as essential items for any rural development planning and activities, in order to achieve a sustainable future.

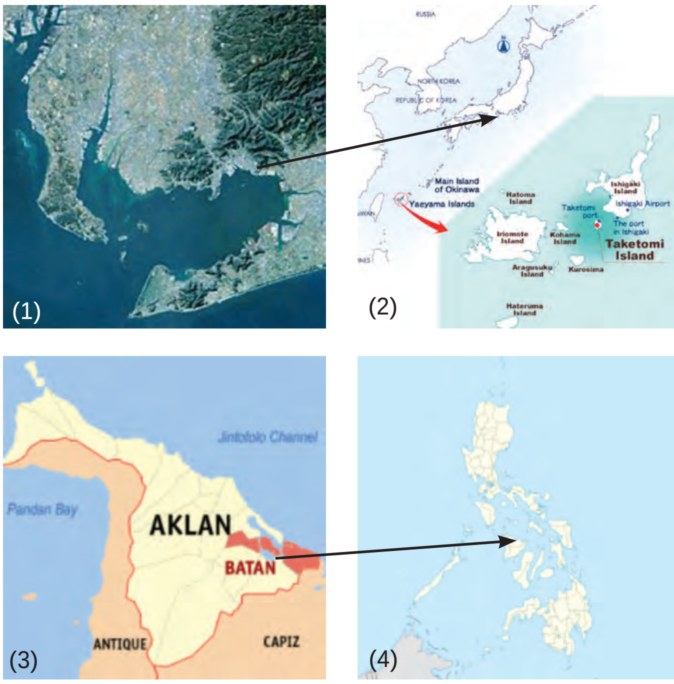
The unique features of coastal fisheries in tropical zones including Southeast Asia are their multiple species and

**Box 1.** Key elements and conditions to be considered in adopting the AC Cycle

1. Improvement and/or invention of utilization technology for ecosystem services
2. Development and strengthening of the community as a user group of the technology
3. Capability enhancement of community members through the utilization of ecosystem services
4. Cultivation of community interest for habitat health
5. Recognition of the importance and effectiveness of the care for ecosystem health
6. Promotion of care activities by the community with scientific evaluation
7. Improvement of stock status through the care activities conducted by the community
8. Strengthening the will of dwellers to remain in the area long-term while preserving nature

multiple fishing gears by nature, and are small-scale. This situation has been fostered by high level of bio-cultural diversity in the region, while the small stock size of each species also increases their vulnerability to intensive utilization. In addition, while human impacts on the environment had been increasing in recent years already affecting the global ecological system, any living resource is at risk of depletion due to regime shifts, even if placed under management and/or a traditional system of maintenance (Future Earth, 2013).

Therefore, adaptive utilization of natural resources, including changing methodologies and routine monitoring, with deep consideration of the ecosystem and its utilization features are required immediately and in the future. In this regard, the AC Cycle could serve as a concrete measurement tool. By applying the AC Cycle to each activity, it would be easy to examine whether or not an activity shows a good balance between utilization and care of resources. In other words, a specific activity and/or action that do not seem to achieve sustainable development could be revisited and revised by adopting the AC Cycle measurement, as exemplified in the set-net fishery system of Rayong Province of Thailand. Under conditions of high environmental variation and unexpected climate changes, increasing the potential of various ecosystem service utilization activities can help in supporting sustainable development in rural areas. In this regard, increasing the number of AC Cycles in each area is more important than establishing a system of monetary economic-scale expansion.




Other project sites of the SEAFDEC-RIHN collaborative project: (1) Mikawa Bay and (2) Ishigaki Island in Japan promoting ecotourism where environmental and ecosystem health assessments are undertaken based on the AC Cycle model; and (3) and (4) Batan Bay in the Philippines promoting stock enhancement where resource rehabilitation is carried out for sustainable coastal management and rural development in accordance with the AC Concept

The AC Concept and Approach are being developed by researchers from Japan and the Southeast Asian countries through this collaborative project spearheaded by SEAFDEC and RIHN. From the many case studies showing good practices of community activities in Japan and Southeast Asia, experiences could be gained and shared to help in extending the AC Concept for possible application in the region or even worldwide. Based on this collaborative project, it is expected that a balance could be struck between fishery resource utilization and conservation in order to achieve environmental sustainability and socio-economic stability. As soon as the SEAFDEC-RIHN collaborative project is completed in 2017, outputs useful for the Southeast Asian region could be generated as shown in **Box 2**.

**Box 2.** Outputs that could be generated from the SEAFDEC-RIHN collaborative project

- Inventory database and reference books on coastal fishery in Southeast Asia
- Inventory database and taxonomic field guide books on coastal resources in Southeast Asia, and population structure map of major marine fisheries target species in Southeast Asia
- Research protocol guidelines and reference books on ecosystem health assessment of coastal areas
- Research protocol guidelines and reference books on social aspects assessment of coastal areas
- Acoustic survey methodology and analysis systems for coastal areas
- Guidelines on community-based set-net fishery installation and utilization for coastal management
- Guidelines on community-based restocking activities for co-management of coastal resources
- Guidelines for Establishment of “Area-Capability Approach”, through the human networking among SEAFDEC Member Countries

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# Assessing the Status of Tuna Resources
## in Sulu and Sulawesi Seas through Collaborative Research Survey

*Worawit Wanchana, Isara Chanrachkij, Sayan Promjinda, Siriporn Pangsorn,* and *Virgilia T. Sulit*

Covering a total area of about 900,000 km$^2$, the Sulu and Sulawesi Seas (SSS) embrace an important large marine ecosystem in the tropical seas of Southeast Asia in terms of biological diversity. Bounded by three Southeast Asian countries, namely: Indonesia, Malaysia and the Philippines, the SSS has very rich fishing grounds for large and small pelagic as well as coastal and coral reef fishes, making it an important source of food and livelihoods for small-scale and commercial fishers. The SSS has tropical climate with a wide range of biophysical characteristics contributing to abundance of biodiversity including coastal and marine commercially important aquatic species. As part of the Coral Triangle, existing evidence have shown that the SSS is an important spawning and nursery grounds, and serves as migratory routes for the oceanic (bigeye, yellowfin, and skipjack) and neritic tunas. These tuna species are economically important for many Southeast Asian countries, not only for domestic consumption but also for export, making it imperative to assess the status and trend of tuna resources in the SSS for sustainable management and development of the resources.

In response to the request of the SEAFDEC Council of Directors for SEAFDEC to develop a collaborative mechanism under the SEAFDEC framework for the conduct of joint activities to determine the maximum sustainable yield of tunas in the Sulu and Sulawesi Seas (SSS), a series of sub-regional technical meetings were convened by SEAFDEC with financial support from the Japanese Trust Fund (JTF) to discuss the said concern. As a result, the **Joint Program on Tuna Research Survey in Sulu and Sulawesi Seas** was developed with the collaboration of concerned SEAFDEC Member Countries, namely: Indonesia, Malaysia, Philippines, and Viet Nam.


**Fig. 1.** Sulu and Sulawesi Seas bounded by Indonesia, Malaysia and the Philippines

Tunas are economically important to the peoples in Southeast Asia, especially for fishers in countries surrounding the SSS (**Fig. 1**) whose livelihoods depend on tuna fisheries. However, the unstable production of tunas in the region necessitates the development of a mechanism to collect information in order that the status of the tuna stocks could be established. Records have indicated that the highest producers of tunas in Southeast Asia are Indonesia, Philippines, and Malaysia (**Table 1**), and followed to some extent by Thailand.

The tunas produced by the Southeast Asian countries are the major oceanic tunas, such as skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and bigeye (*T. obesus*), as well as other oceanic tunas such as albacore (*T. alalunga*) and southern blue fin (*T. maccoyii*), and neritic tunas, namely: frigate (*Auxis thazard*), bullet (*A. rochei*), kawakawa (*Eythynnus affinis*), and longtail (*T. tonggol*) tunas. During the five-year period from 2008 to 2012, the abovementioned major tuna producing countries contributed an annual average of about 98% to the total volume of tuna production of Southeast Asia, more than

*Katsuwonus pelamis* (Skipjack Tuna)

*Thunnus albacares* (Yellowfin tuna)

*Thunnus obesus* (Bigeye tuna)

**Table 1.** Production of tunas by major tuna-producing countries of Southeast Asia (2008-2012)

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| **Indonesia** | | | | | |
| Quantity (in thousand metric tons (MT)) | 912.5 | 925.7 | 910.7 | 1,045.4 | 1,362.9 |
| Value (in million US$) | 949.5 | 312.1 | 1,077.0 | 1,272.3 | 972.4 |
| **Philippines** | | | | | |
| Quantity (in thousand metric tons (MT)) | 636.8 | 612.0 | 574.9 | 499.1 | 535.6 |
| Value (in million US$) | 895.6 | 767.3 | 800.3 | 800.0 | 971.2 |
| **Malaysia** | | | | | |
| Quantity (in thousand metric tons (MT)) | 67.2 | 56.0 | 50.5 | 60.1 | 72.9 |
| Value (in million US$) | 250.8 | 55.1 | 145.9 | 113.5 | 129.7 |
| **Total tuna production of Southeast Asia** | | | | | |
| Quantity (in thousand metric tons (MT)) | 1,662.6 | 1,633.6 | 1,588.3 | 1,641.4 | 1,987.1 |
| Value (in million US$) | 2,144.0 | 1,189.4 | 2,065.4 | 2,224.0 | 2,096.3 |

*Sources: SEAFDEC (2010), SEAFDEC (2011), SEAFDEC (2012), SEAFDEC (2013), SEAFDEC (2014)*

**Table 2.** Total fisheries production of Southeast Asia (2008-2012)

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| **Total fisheries production of Southeast Asia** | | | | | |
| Quantity (in thousand metric tons (MT)) | 27,207.8 | 28,917.1 | 31,438.5 | 33,487.7 | 39,571.2 |
| Value (in million US$) | 28,585.8 | 29,215.3 | 38,744.2 | 43,782.9 | 44,958.9 |
| **Southeast Asian production from marine capture fisheries** | | | | | |
| Quantity (in thousand metric tons (MT)) | 13,814.4 | 14,140.4 | 14,874.5 | 15,095.5 | 15,590.5 |
| Value (in million US$) | 12,338.2 | 10,416.7 | 15,898.8 | 21,178.8 | 20,049.0 |
| **Tuna production of Southeast Asian Countries** | | | | | |
| Quantity (in thousand metric tons (MT)) | 1,662.6 | 1,633.6 | 1,588.3 | 1,641.4 | 1,987.1 |
| Value (in million US$) | 2,144.0 | 1,189.4 | 2,065.4 | 2,224.0 | 2,096.3 |

*Sources: SEAFDEC (2010), SEAFDEC (2011), SEAFDEC (2012), SEAFDEC (2013), SEAFDEC (2014)*

11% to the marine fisheries production, and about 6% to the total fisheries production of the region (**Table 1** and **Table 2**).

According to FAO (2014), the share of tuna in the total export value in 2012 was about 8% although during the last three years, the global tuna markets had been unstable in view of the fluctuating tuna production by the major tuna-producing countries. This was also true at the regional scene where production of tunas had been at an unsteady pace over the past five years, not only in terms of volume but also in monetary value (**Table 2**).

In an effort to address the abovementioned concerns, the countries participating in the **Joint Program on Tuna Research Survey in Sulu and Sulawesi Seas** agreed to carry out a three-year plan of activities in the SSS using the M.V. SEAFDEC 2. Specifically, the focus of the Joint Program would be on the use of FADs in the SSS, status and trend of tuna stocks and estimated maximum sustainable yield of target tuna species, and spawning and nursery grounds of tuna resources. Considering that three major species of oceanic tunas are produced by the countries surrounding the SSS (**Table 3**), the participating countries therefore agreed that the Joint Program would put more emphasis on the yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), and skipjack tuna (*Katsuwonus pelamis*).

## The Joint Program on Tuna Research Survey in Sulu and Sulawesi Seas

Furthermore, as also agreed by the participating countries, the Joint Program should be spearheaded by the SEAFDEC Training Department (TD) and Marine Fishery Resources Development and Management Department (MFRDMD), with the JTF providing financial and technical support. Nevertheless, in terms of the operating expenditures under the Joint Program, the participating countries agreed to share the expenses incurred, especially when the cruise survey is conducted in their respective waters. In order to propel the objectives of the Joint Program forward, benchmark information and other relevant data with respect to tuna fisheries in the three participating countries were compiled as shown in **Box 1**.

**Table 3.** Production of oceanic tunas by major tuna-producing countries of Southeast Asia (2008-2012): Qty in thousand MT; Value in million US$

| | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Qty | Value | Qty | Value | Qty | Value | Qty | Value | Qty | Value |
| **Indonesia** | **453.6** | **466.3** | **458.9** | **108.1** | **513.0** | **689.4** | **614.7** | **804.4** | **702.8** | **670.0** |
| Skipjack tuna | 296.8 | 262.4 | 300.8 | 49.4 | 330.0 | 355.8 | 372.5 | 421.3 | 429.0 | 343.8 |
| Yellowfin tuna | 102.8 | 141.9 | 103.4 | 38.6 | 130.4 | 211.9 | 175.8 | 267.6 | 190.2 | 239.5 |
| Bigeye Tuna | 54.0 | 62.0 | 54.7 | 20.1 | 52.6 | 121.7 | 66.4 | 115.5 | 83.6 | 86.7 |
| **Philippines** | **425.6** | **646.1** | **409.8** | **316.9** | **387.2** | **565.3** | **330.0** | **561.8** | **344.3** | **714.3** |
| Skipjack tuna | 222.0 | 296.5 | 251.5 | 55.1 | 228.2 | 267.7 | 197.4 | 278.4 | 206.5 | 345.7 |
| Yellowfin tuna | 168.4 | 292.1 | 152.5 | 249.6 | 147.3 | 274.7 | 123.0 | 260.8 | 125.3 | 334.3 |
| Bigeye Tuna | 35.2 | 57.5 | 5.8 | 12.2 | 11.7 | 22.9 | 9.6 | 22.6 | 12.5 | 34.3 |
| **Malaysia** | **3.4** | **8.7** | **7.3** | **11.7** | **8.6** | **13.0** | **8.2** | **14.3** | **13.3** | **11.3** |
| Skipjack tuna | 0.3 | 0.4 | 4.5 | 6.1 | 5.2 | 6.4 | 6.3 | 9.4 | 5.5 | 8.0 |
| Yellowfin tuna | 1.5 | 3.8 | 1.4 | 2.7 | 2.2 | 4.6 | 1.2 | 3.7 | 1.1 | 2.2 |
| Bigeye tuna | 1.6 | 4.5 | 1.4 | 2.9 | 1.2 | 2.0 | 0.7 | 1.2 | 6.7 | 1.1 |
| **Total** | **882.6** | **1,121.1** | **876.0** | **436.7** | **909.8** | **1,267.7** | **952.9** | **1,380.5** | **1,060.4** | **1,395.6** |

*Sources: SEAFDEC (2010), SEAFDEC (2011), SEAFDEC (2012), SEAFDEC (2013), SEAFDEC (2014)*

**Box 1.** Information on tuna fisheries in three participating countries of the Joint Program on Tuna Research in SSS

**Indonesia**

The landing data of tuna and tuna like species in Indonesia has been compiled and reported by group level since 1977, but the country started to compile data on yellowfin and bigeye tunas, and kawakawa by species level starting in 2014. Moreover, Indonesia also collects fishing effort data based on five (5) fishing gears, *i.e.* longline, Danish seine, purse seine, handline, and pole and line. From the Sulawesi Sea, the major landings comprise mostly large pelagic species followed by small pelagic and demersal species. Length-frequency data for tuna had also been compiled although such data still need validation since local enumerators have not been adequately prepared in terms of capacity building, in the aspect of species identification. From 1980 to date, the country had conducted at least seven (7) resource survey cruises in the SSS, the result of which would be useful to understand the status of fishery resources and the environmental conditions in the SSS. The main fishing ports in the north Sulawesi Sea used for landing tunas are located in Tumumpa and Bitung in Indonesia.

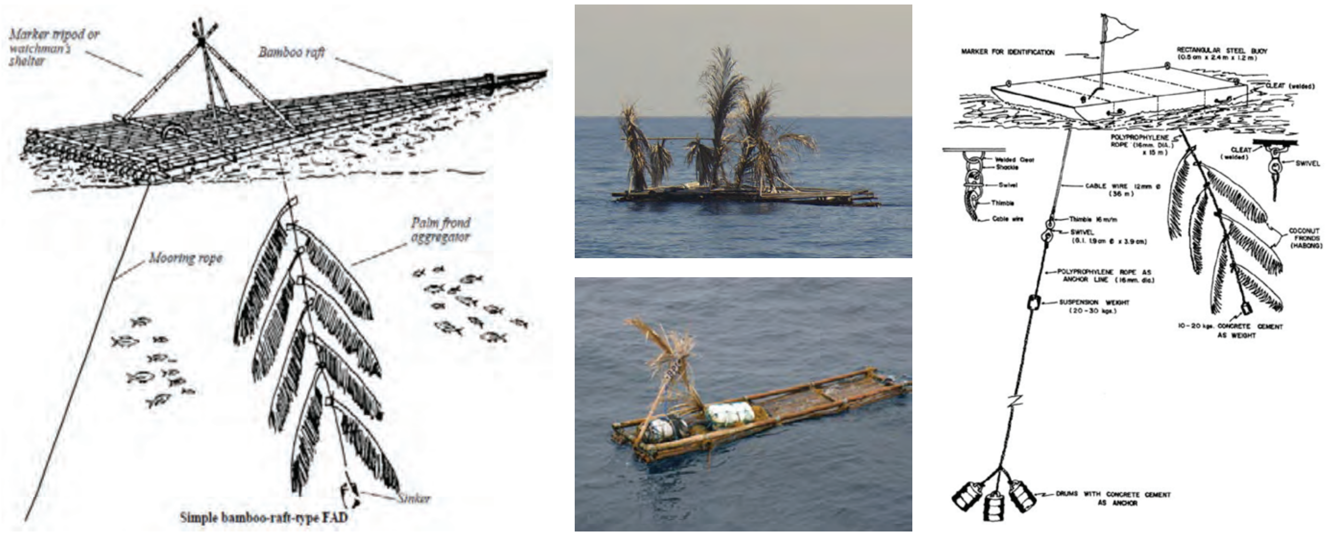
**Malaysia**

Tuna catch data has been compiled by Malaysia since 1991 based on tuna landed, however, Malaysia started to collect the monthly catch by species and effort data of handline only in 2008. For tuna purse seine, the total catch was recorded only for skipjack, kawakawa and other neritic tunas. Nevertheless, information on the number of Fish Aggregating Devices (FADs) in its waters had also been compiled. Recently, tuna stock assessment in Malaysia was carried out based on landing data at Semporna District compiled for Sabah State of Malaysia where most of tunas are landed. Currently, the Department of Fisheries (DOF) Malaysia is implementing two (2) tuna fishery programs: strategic action plan for tuna fisheries development industry (2013 to 2020) that focuses on catch and marketing data; and research program supported by the Coral Triangle Initiative (CTI) on resources and biology of tropical tunas in SSS (2012 to 2013) which aimed to establish effective measures for sustainable exploitation of shared tuna stocks within the tuna spawning areas and of juvenile stages that are adequately protected. In 2009, DOF Malaysia in collaboration with a university in Malaysia conducted a survey of large pelagic species in the SSS of Malaysian waters where several fishing gears were used. Data from such survey would be reviewed to obtain information about the condition of tuna resources in such waters. The data collected under this Joint Program, especially the relevant data from Indonesia and the Philippines would complement those from the current study conducted by Malaysia.

**Philippines**

The national initiatives of the Philippines on tuna data collection include the conduct of port sampling, use of log-sheets and observers program, vessel monitoring system, and from cannery receipts. The major fishing gears used for tuna fisheries in the Philippines include purse seine, ring net, and hand-line catching tunas near FADs. Tuna is a major export commodity for the Philippines, where several national institutes have been involved in the management of its tuna fishery resources. The country also promotes a number of management plans related to tuna fisheries, *i.e.* national tuna management plan; national plan of action to deter illegal, unreported and unregulated fishing; and national tuna FADs management policy. In addition, the country also conducted several research programs in the SSS, especially on resource assessment, biology of tunas, physiology of tunas, tuna tagging, boats and gear design, socio-economic as well as post-harvest technology. Moreover, a number of research activities had been planned for future work on tuna in the Philippines, *i.e.* genetic identification and characterization of tunas, oceanographic survey on major tuna fishing grounds, studies on mitigation the effect of FADs to fishery resources, and gear selectivity of tunas. Nevertheless, the Philippines still need capacity building on tuna assessment, especially for the researchers who are supporting its National Stock Assessment Program.

The participating countries also agreed that the specific activities to be implemented under the Joint program would include: (i) review of catch and effort, biological data/information on tuna harvested in SSS; (ii) primary data collection: tissue samples for genetic study, spawning ground information using the M.V. SEAFDEC 2; (iii) tuna




*Left-right:* traditional FADs, bamboo payaos (Philippines) and steel payaos (Philippines)

**Box 2.** Activities and work plan of the Joint Program on Tuna Research in SSS

**Review of catch and effort, biological data on tuna harvested from SSS**

- Identification of tuna landing sites in SSS
- Review of periodical tuna production from respective national fisheries statistics
- Determining the total catch from SSS including species composition, and identifying the needs for data collection
- Sharing of information on at-sea-observation/onboard observer program for identifying tuna spawning grounds and species composition
- Compilation of data for common use on regional stock assessment

**Primary data collection**

- Compilation of fisheries data from identified landing sites, including catch and effort and biological data (using simplified Standard Operational Procedures (SOPs) for data collection; and tissue samples for genetic analysis of major tuna as necessary
- Tuna spawning ground profiling using the M.V. SEAFDEC 2 in participating countries' jurisdictions

**Tuna stock assessment**

- Identification of peer reviewers/experts on tuna stock assessment in respective countries, in or outside the region
- Establishment of the experts working group for regional tuna stock assessment
- Standardizing the methodology for assessment of sub-regional tuna stocks
- Estimating the Maximum Sustainable Yield of the target tunas

**Determining of tuna spawning grounds in SSS**

- Identification of peer reviewers/experts on tuna larvae identification in respective countries, in or outside the region
- Establishment of experts working group for tuna larvae identification
- Utilizing the SEAFDEC standardized methodology for tuna larvae identification
- Identification of spawning grounds of the target tunas

**Assessment of FADs used for tuna fisheries in SSS**

- Evaluation of the concentration of FADs in SSS through collaborative survey onboard the M.V. SEAFDEC 2
- Determining species composition and size of tuna caught near FADs using appropriate sampling gears, such as trolling, long-line, or from national observers program

stock assessment; (iv) identification of the tuna spawning grounds; and (v) assessment of FADs used for tuna fisheries (**Box 2**). In addition, sub-regional meetings and technical consultations would be convened to discuss the results of the Joint Program cruise surveys. The working mechanism agreed upon by the participating countries is shown in **Box 3**.

## Results and Discussion

In order to facilitate the conduct of the activities in the Joint Program, the participating countries adopted the Standard Operating Procedures (SOPs) for data collection under the research areas to be carried out in SSS (**Box 4**) as well as the final cruise plan of the M.V. SEAFDEC 2 during the survey from 17 October to 8 December 2014 (**Box 5**). The participating countries are responsible in analyzing their respective data. The preliminary findings from the surveys on data collection at the selected landing

**Box 3.** Working mechanism for the participating countries in the Joint Program on Tuna Research in SSS

- Identify and nominate the country experts responsible for stock assessment, larval fish identification, FADs, and genetics
- Collect catch and effort data from the landing sites (and information from observer program) and undertake the first level analysis
- Share information based on results from the findings of the survey for regional analysis through working group meetings
- Co-finance the use of the M.V. SEAFDEC 2 for cruise surveys in SSS
- Cost-share the expenses including travel costs of country experts joining the meetings
- Designate technical staff to participate in relevant cruise surveys of the M.V. SEAFDEC 2, and undertake the first level analysis of all data compiled and specimens collected
- Participate in sub-regional working group meetings for analyzing specific issues, *e.g.* stock assessment, identification of tuna spawning grounds

**Box 4.** SOPs for data collection under the Joint Program on Tuna Research in SSS

**Tuna Stock Assessment**
- **Tuna fishery profile in SSS:** total no. of tuna catchers, total no. of fishing gear, major landing sites, etc.
- **Catch landing:** monthly total weight by species and gear
- **Length frequency:** monthly length distribution by species and gear
- **Weight frequency:** monthly average weight distribution by species and gear
- **Growth pattern:** monthly length frequency by species
- **Gonad:** monthly stage of maturity by species

The following information may be also collected, if the country can support such scientific data collection:
- **Stomach contents:** stomach content by species
- **Genetic:** tissue sampling

**Tuna Spawning Ground**
Horizontal towing by Neuston net and oblique by Bongo net (500 micro m) will be carried out onboard the M.V. SEAFDEC 2 during the survey in SSS. Details of the data collection are as indicated in the SOPs.

**On FADs**
Only man-made FADs will be considered, and the major activities include: (i) determining the species composition and size of tuna caught in the FADs area using binocular observation and radar recording; and (ii) catch data using log-sheets.

**Genetic Study for Tuna Resources**
Each country is responsible for genetic data collection and analysis of a species of tuna, *i.e.* Indonesia (bigeye tuna); Malaysia (skipjack tuna); and Philippines (yellowfin tuna). Tissue samples of each leg of the cruise survey of the M.V. SEAFDEC 2 should be taken from about 20~30 specimens for one (1) species, samples from landing sites could also be used in case specimens from onboard data collection using the M.V. SEAFDEC 2 are not sufficient.

sites and the cruise survey of the M.V. SEAFDEC 2 carried out in the SSS in 2014 were reported and discussed during the Working Group Meeting in February 2015. In order to assist the participating countries in the process of selecting appropriate methodology for analysis as well as in analyzing all data collected from the cruise surveys, the JTF provided technical support for the secondment of an international expert on tuna stock assessment. The subsequent survey cruise in 2015 (**Box 6**) was also agreed upon and as finally decided, results for the Joint Program would be reported through an end-of-program Meeting before the end of 2015.

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**Box 5.** 2014 Cruise Plan for the M.V. SEAFDEC 2 under the Joint Program on Tuna Research in SSS

**Duration:** 17 October – 8 December 2014 (52 days)
**Ports of Call:** Puerto Princesa (Philippines), Zamboanga City (Philippines), Sandakan (Malaysia), Bitung (Indonesia)
**Area of Operations**: Sulu Sea and Sulawesi Sea (63 survey stations in 3 legs)
Leg 1: Puerto Princesa-Zamboanga City (25 Oct-2 Nov 2014: 25 stations)
Leg 2: Zamboanga City-Sandakan-Bitung (5-13 Nov 2014: 21 stations)
Leg 3: Bitung (22-28 Nov 2014: 17 stations)
**Objectives:** To undertake activities on: (1) oceanographic survey (ICTD, bongo net, Neuston net, current indicator) in 63 stations; (2) hydro-acoustic survey using scientific echo sounder, echo sounder and full circle scanning sonar (scientific echo-sounder to be operated along the sailing track); and (3) conduct fishing trials by trolling, handline and short "longline" at any survey stations or where convenient or appropriate.

**Box 6.** 2015 Cruise Plan for the M.V. SEAFDEC 2 under the Joint Program on Tuna Research in SSS

**Duration:** 20 March – 11 May 2015 (52 days)
**Ports of Call:** Puerto Princesa (Philippines), Zamboanga City (Philippines), Sandakan (Malaysia), Bitung (Indonesia)
**Area of Operations:** Sulu Sea and Sulawesi Sea (63 survey stations in 3 legs)
Leg 1: Puerto Princesa-Zamboanga City (28 Mar-5 April 2015: 25 stations)
Leg 2: Zamboanga City-Sandakan-Bitung (8-16 April 2015: 21 stations)
Leg 3: Bitung (25-30 April 2015: 17 stations)
**Objectives:** To carry out activities on: (1) oceanographic survey (ICTD, larvae and plankton net, bongo net, Neuston net, temperature-depth sensor (TD), current indicator) in 63 stations; (2) hydro-acoustic survey using scientific echo sounder, echo sounder and full circle scanning sonar (scientific echo-sounder to be operated along the sailing track); and (3) fishing trials by trolling, handline and short "longline" at any survey station or where convenient or appropriate (in some stations, small boat equipped with portable echo sounder may be used to determine fish schools near payaos).

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# Viability of Traps for Efficient Utilization of Deep-sea Shrimp Resources in Philippine Waters

*Evangeline S. Sapul, William S. Dela Cruz, Remar P. Asuncion,* and *Rafael V. Ramiscal*

Deep-sea trap exploratory fishing operations were conducted in the continental slopes and seamounts in the waters off Bataan and Batangas, and approaches of Manila Bay, such as in Zambales and Ilocos Provinces, and Polillo Island, in the Philippines from 2011 to 2013, under the project of the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) on optimum utilization of fishery resources in the exclusive economic zone (EEZ) of the Philippines. The exploratory trap fishing operations examined the efficiency of various designs of traps, fishing depths and fishing grounds for catching deep-sea shrimps through exploratory fishing operations in sixteen (16) trap stations with depths ranging from 69 to 800 meters. The findings which included catch rates, species and size composition, catch variation by trap design, fishing depth and fishing ground, could serve as basis for recommending the most appropriate trap designs and fishing depths for catching deep-sea Pandalid shrimps as well as for formulating management plan for deep-sea fisheries taking into account the need to ensure that the ecosystem is not adversely affected during deep-sea fishing operations.

Optimum utilization of offshore and deep-sea resources in Philippine waters, more particularly in non-traditional fishing grounds is embodied in Philippine R.A. 8550 or what is known as the Philippine Fisheries Code of 1998. It is in this light that the Bureau of Fisheries and Aquatic Resources (BFAR) through the use of its 1186 gross tonnage multi-purpose vessel, the M.V. DA-BFAR has been conducting exploratory and assessment surveys of available resources in the country's deep-sea areas starting in 2008. Results from previous cruise surveys in the continental slopes of western Luzon in the Philippines indicated the presence of potential deep-sea species, particularly deep-sea shrimps belonging to the Family *Pandalidae* (Nepomuceno *et al*., 2013). Consequently, it has become necessary to develop efficient methods of catching these shrimps to ensure that the ecosystem is not adversely affected or at the least, certain effects of the fisheries could be minimized. Nepomuceno *et al*. (2013) also observed that the catch rate of Pandalid shrimps could have been influenced by the zonation behavior of the species aggregating in the western seas of the Philippines (De la Cruz *et al*., 2014), as well as the optimum depth of deployment of the traps which should be around 400-500 m. Considering therefore that Pandalid shrimps has great potential for fisheries development, there is a need to develop appropriate and concrete framework in order that this resource is sustainably managed.

## Exploratory Trap Fishing Operations by BFAR

The aforementioned scenario has prompted BFAR to conduct a subsequent cruise survey using the M.V. DA-BFAR to conduct exploratory fishing operations using traps in the continental slopes and seamounts off Bataan, Batangas, Zambales, Ilocos Norte and Polillo waters (**Fig. 1**). Utilizing sixteen (16) stations with depths that range from 69 to 800 m (**Table 1**), the exploratory trap fishing operations made use of traps with three varying designs.

The deep-sea traps used are passive gears and had been designed to catch species that are attracted to baits like the Pandalid shrimps. Nepomuceno *et al*. (2014) reported that traps are considered the most suitable gear to harvest the deep-sea shrimp resource. The traps which are cylindrical in shape and constructed with metal frame enclosed with polyethylene screen, had therefore been used in the current exploratory trap fishing operations that mainly aimed to determine the catch rate, species and size composition of the deep-sea trap fisheries. It is expected that this environment-friendly trap fisheries could be promoted as means of addressing the concern on the sustainable utilization of offshore and deep-sea resources.


**Fig. 1.** Locations of the trap fishing stations in north-western Philippines

**Table 1.** Fish trapping stations with corresponding depth ranges

| Station Code | Depth Range (m) |
|---|---|
| TRA-556 | 285-293 |
| TRA-558 | 602-651 |
| TRA-559 | 780-800 |
| TRA-562 | 296-330 |
| TRA-564 | 320-564 |
| TRA-565 | 235-254 |
| TRA-567 | 280-298 |
| TRA-569 | 567-593 |
| TRA-571 | 609-770 |
| TRA-573 | 69-070 |
| TRA-618 | 407-555 |
| TRA-623 | 439-480 |
| TRA-624 | 607-653 |
| TRA-626 | 353-490 |
| TRA-628 | 320-529 |
| TRA-662 | 424-553 |

Measuring 30 cm in diameter and 60 cm long, the traps have both ends provided with funnel valve for easy entrance but difficult exit, as well as with a 2 m long branch-line attached to a mainline using snap clip at 30 m interval, and baited with chopped fish to attract shrimps. Three variations of the traps had been adopted with the use of V-net as trap cover, *i.e.*: FC or fully-covered (body and funnel), PC or partially covered (body only), and UC or uncovered trap (**Fig. 2**). Depth sounder was used to determine the desired depths and types of substrates. After establishing the trapping sites, 29-45 sets of baited trap variations were dropped alternately and soaked for 8-12 hours.

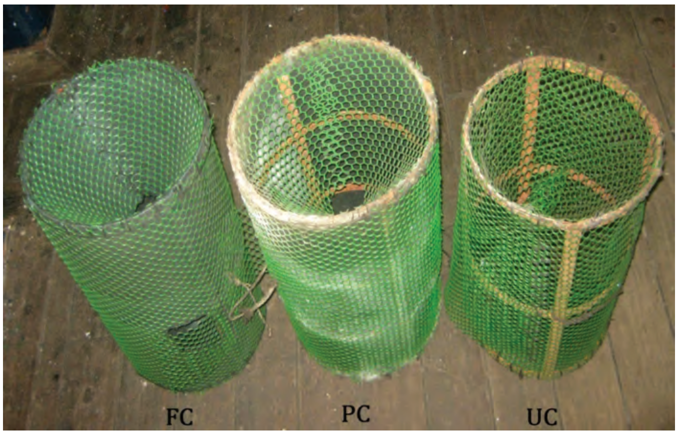


**Fig. 2.** Variations of traps used: fully covered (FC), partially covered (PC) and uncovered (UC)

## Results and Discussion

After each fishing operation, the traps were emptied of the catch, and then classified by species, counted, measured, weighed, and recorded. Catch per unit effort (CPUE) was computed as weight of catch in grams per trap (g/trap). The trap exploratory fishing operations in all stations resulted in the total catch of 124.9 kg or 7.88 kg/set with mean catch rate of 191 g/trap. The total catch comprised 36% fish, 54% deep-sea shrimps, 7% crabs, 2% isopods, and 1% other specie (**Fig. 3**). The most commonly caught fish were the hagfishes (*Myxinidae*) and swell sharks (*Scyliorhinidae*) in deeper areas, and cardinal fishes (*Apogonidae*) in shallower stations. Crabs belonging to genus *Homola*, *Charybdis*, *Pulcratis*, *Goneplax*, *Kandalin*, *Nepinnotheres*, *Carcinoplax* and some unidentified species of deep-sea crabs were also caught. The deep-sea shrimps all belonged to the family *Pandalidae*.

Of the total catch of 124.9 kg, 67.9 kg were deep-sea shrimps (4.2 kg/set) with CPUE of 101 g/trap. Nevertheless, the catch was highly variable depending on the depth and fishing ground, giving negative catch at <100 m in Mariveles, Bataan to 16.3 kg/set at 400-600 m in Polillo Island. Thus, the CPUE ranged from 0 g/trap to 562 g/trap. As shown in **Fig. 4**, the deep-sea shrimp caught belong to two genera: *Heterocarpus* and *Plesionika* which had been classified as *Heterocarpus dorsalis* (31%), *H. hyashii* (25%), *H. sibogae* (24%), *H. gibbosus* (14%), *H. laevigatus* (5%), and *Plesionika edwardsii* (1%).

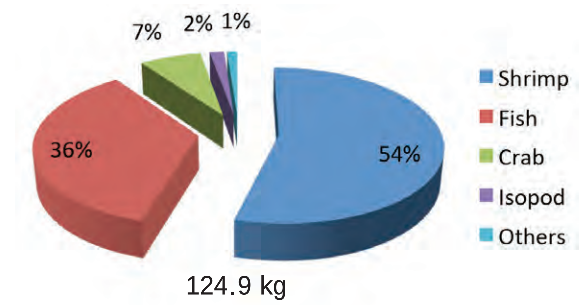


**Fig. 3.** Composition of deep-sea catch using traps

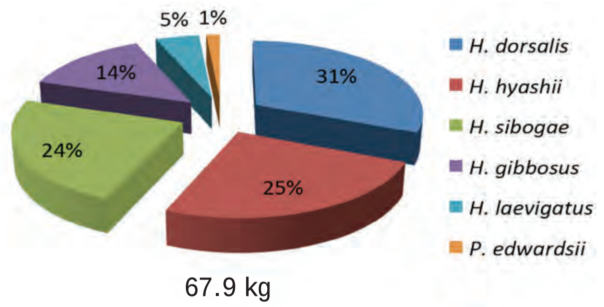


**Fig. 4.** Species classification of deep-sea shrimp catch using traps

The results also showed that variations of the traps in terms of design, the locations and depths of the fishing ground affected the catch of Pandalid shrimps. Although 54% of the total catch from the exploratory fishing operations as shown in **Fig. 3**, the average shrimp catch among the three designs of the trap significantly varied with the partially covered trap producing higher catch rate at 165 g/trap than the fully covered traps at 34 g/trap, and uncovered traps at 62 g/trap. The cover net of the partially covered trap may have added to the efficiency of the trap, not only by providing shade to the trap but also leading the shrimps to smell the bait at the entrance of the funnel. For the fully covered trap on the other hand, the efficiency could have been reduced due to the restricted vent for smelling the bait. In addition, the trap also holds much water inside that causes the funnel to flip and spill out some of the catch during hauling. Meanwhile, for the uncovered trap, the smell of the bait comes from all over the trap reducing the chance for the shrimp to get attracted to the funnel entrance.

The catch had also been observed to have varied according to the depth of the fishing ground. Analysis of the relationship of the water depths to the catch rates of deep-sea shrimps indicated that the average catch rate was significantly higher in depths from 300 to 600 m (195 g/trap) compared with the catch at depths less than 300 m and more than 600 m which were at 24 g/trap and 42 g/trap, respectively. In terms of locations of the fishing grounds, the analysis also suggested that the catch rate in five stations in Ilocos Norte and Zambales was 131 g/trap compared with that of the other stations in the approaches of Manila Bay which yielded 57 g/trap (**Fig. 5**). On the other hand,

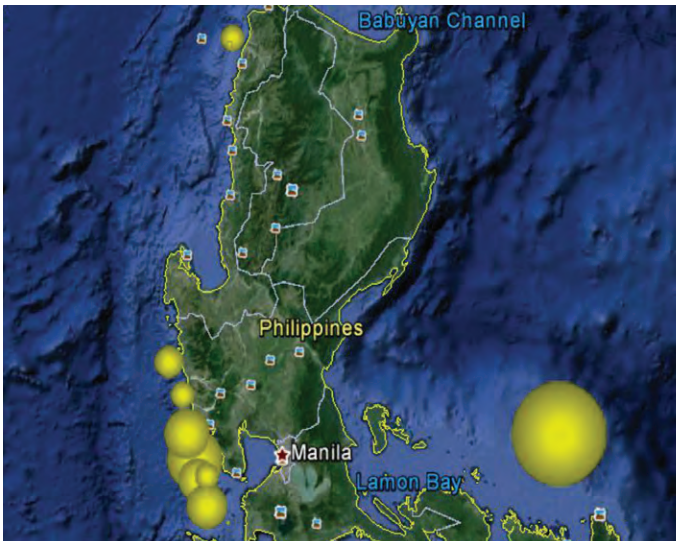


**Fig. 5.** Catch rate of deep-sea shrimps using traps from all stations

the catch rate in the station off Polillo Island in northeastern Philippines was significantly higher at 562 g/trap. However, the seas around Polillo Island could not be easily accessed especially during inclement weather conditions.

## Conclusion and Way Forward

Deep-sea exploratory fishing using traps provided the opportunity to collect information on the species that inhabit the continental slopes and seamounts, and distribution of such species with respect to fisheries. Deep-sea shrimps are among the promising fishery resources that can be an alternative to the declining fisheries especially in the near-shore areas. As established earlier by Nepomuceno *et al*. (2013), deep-sea shrimps of family Pandalidae which has great potential for fisheries development flourish in the continental slopes and seamounts in the north-western part of Philippine Sea. Deep-sea shrimps may be commercially exploited in some Pacific island countries but in the Philippines, the deep-sea shrimp resource is still undeveloped due to inadequacy of the capacity of fisherfolks to explore the high seas and insufficiency of economic information about the species.

The information compiled through this study, especially on catch composition, catch rate and variations according to gear type, location and depth of fishing ground therefore provided baseline information, *i.e.* appropriate gear designs, fishing depths and potential fishing grounds, that could be used as reference in the formulation of the country's National Deep-sea Fisheries Management Plan that would serve as guide for the sustainable development of deep-sea fisheries not only for the Philippines but also for other countries in the Southeast Asian region having similar characteristics as that of the Philippines.

In pursuing further research on this aspect, a pilot project could be considered to determine the viability of the fisheries based on the recommended designs of the gear as well as the depths and locations of the fishing grounds. In this connection, more surveys of other areas and further studies on trap designs, *e.g.* shape, size, number of funnels, would be conducted in the future using the M.V. DA-BFAR and in conjunction with existing national survey program and framework.

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# Benefits of Using LED Light for Purse Seine Fisheries: A Case Study in Ninh Thuan Province, Viet Nam

*Nguyen Quoc Khanh* and *Tran Duc Phu*

Fishers from Ninh Thuan Province, Viet Nam had been using two main kinds of lamps on their purse seine vessels, namely: fluorescent tube and metal-halide lamps. It was not until recently that the use of light emitting diode (LED) light for purse seiners was practiced in Ninh Thuan. Thus, a case study was carried out in the Province, the initial results showed that LED light achieved salient advantages in fishing. Although the power of LED light used on the experimental vessel was relatively lower than that of the control vessel (3 *vs.* 12 kilowatts), illumination and useful light areas increased by about 1.4 and 2.3 times, respectively. The total catch of purse seine vessel using LED light was significantly greater than that of the control, *i.e.* 59.2 MT from purse seine vessel with LED light and 51.9 from the control vessel. Catch from these vessels comprised scads (37.4%), skipjack tuna (33.8%), Indian mackerel (7.3%), largehead hairtail (6.0%), squid (4.3%), and other species (11.2%). The purse seine using LED light used 1,544 liters of fuel at appropriately 34,687,224 VND for three fishing trips while the control vessel consumed 4,680 liters for about 105,112,800 VND. The use of LED light for purse seine fishery is therefore considered efficient and cost-effective, especially in purse seine fisheries.

Located in the south-central part of Viet Nam, Ninh Thuan Province has a coastline of approximately 105 km and large fishing ground embracing an area of thousands km$^2$ with annual total available catch of about 50,000 metric tons (MT) comprising mostly high economic species, such as mackerel, tuna, horsehead fish, hairtail, red snapper, Indian mackerel, lobster, squid, cuttlefish, among others (Si, 2006). The fisheries sector is a very important source of income in Ninh Thuan, contributing about 20% of the gross domestic product (GDP), making this sector one of the most dynamic and fastest growing economic sectors of the Province. Its total catch of 64,069 MT in 2014 amounted to an export value of 17.5 million USD (Ninh Thuan Department of Capture Fisheries and Resources Protection, 2014).

Based on its fisheries development plan, Ninh Thuan Province intends to invest in offshore fishing fleet development to decrease inshore fishing pressure. In order to increase total catch to around 60,000 MT per year and improve the quality and value of its fishing products, the fisheries authorities of Ninh Thuan had recommended the use of newer technologies in fishing and fish handling (Decission No 1222/QĐ-TTG). Of the total number of 2,853 fishing vessels in Ninh Thuan Province, approximately 46% or 1,304 are purse seine vessels with light (Ninh Thuan Statistics Office, 2014), and the biggest challenge for purse seiners with light is fuel cost which accounts for 60% of the total cost per fishing trip (Thuy *et al.*, 2013).

Considering that each purse seine vessel spends between 50 to 150 liters of fuel per night (depending on engine capacity), the total fuel cost for purse seine vessel fleet in Ninh Thuan could range from 25 to 75 billion Vietnamese Dong (VND: 1 USD = 21,160 VND) per year. If fuel cost is reduced by 50-60 %, fishers could save 15-40 billion VND per year. In addition, using much fuel would not only increase the fishing cost, but also increases the emission of greenhouse gas (GHG) into the environment. According to Ozaki (2004), each kg of fuel an engine uses produces 3.19 kg of $CO_2$. This implies that purse seine vessel fleet in Ninh Thuan annually releases between 25,120 and 75,360 tons of $CO_2$ into the environment. Although, there had been no specific researches on air pollution due to fishing activity, environmental researchers affirmed that navigation and fishing activities emit 1.12 billion tons of $CO_2$ into the environment every year worldwide (Thuc, 2012).

Although the total fish catch in Ninh Thuan Province increased by approximately 7% annually from 2000 to 2013 (Ninh Thuận Statistical Yearbook, 2014), catch per unit of effort (CPUE) reduced from 0.71 tons/horsepower (HP) in 1995 to 0.46 tons/HP in 2001, to 0.31 tons/HP in 2010, and 0.26 tons/HP in 2013 (Son, 2011). On the contrary, the

total cost of fishing is continually increasing. For example, the cost of one fishing trip was only 55,000,000 VND in 2005 (Si, 2006) but in 2012 the cost per fishing trip was reported to rise to 85,000,000 VND (Son, 2011). Applying recent fishing technologies, such as the use of LED light in fishing could help reduce the cost while increasing fishing efficiency, and could economically benefit the fishers. LED light provides high illumination and is environmentally friendly, and could get 200 lumen/W at room temperature with typical lifetimes of 25,000-100,000 hours (US Department of Energy, 2006), 5 to 10 times higher than the lifetime of compact lamps, fluorescent tube, metal-halide and incandescent lamps which could be from 2,500 to 10,000 hours (Fink, 1978).

Other countries and some international organizations have encouraged the use of LED lights in fishing and other related sectors that spend much fuel (Kinh and Khoi, 2010). Matsushita (2012) reported that using LED light in squid jigging boats saved fishers about 46% of fuel, compared to halogen and metal-halide lamps. Furthermore, some researchers have shown that catch performance is not dependent on the type of lamps used, but on the scale of fishing gear, vessel capacity, density of fish, as well as light illumination and frequency (Yamashita, 2012). Using a suitable frequency of LED light could therefore increase fish catch by 15% saving about 65% on fuel compared to neon lights and metal-halide lights (Fang, 2011).

## The Case Study

The case study which deals with the application of LED light source in fishing, present the status of light source equipping, initial efficiency of LED light usage in off-shore purse seince fishing vessels, including an evaluation of fuel usage, as well as fishing and environmental efficiencies. These results could fill whatever gaps that still exist on the advantages of using LED light in fishing.

Installing LED light in purse seine vessels in Ninh Thuan, Viet Nam

**Survey of light sources of purse seines equipped with light in Ninh Thuan Province, Viet Nam**

Data were collected through face-to-face interviews with fishers and owners of purse seine vessels using a questionnaire that includes basic information (*e.g.* name, address, position), fishing vessel information (*i.e.* name of ship, registration number, capacity), source of light used (*i.e.* power, light type, arrangement method, dynamo). Fishers were interviewed either as individuals or groups in their homes or onboard fishing boats, and selected at random. Onboard, the interviews were conducted in My Tan Fishing Port, where most purse seine vessels in Ninh Thuan Province are anchored.

**Designing, installing the LED light system and experimental fishing**

Two common types of lamps, *i.e.* fluorescent tubes and metal-halide lamps were installed on a purse seine vessel in Ninh Thuan Province (control vessel). The fluorescent tubes were fixed into troughs, each trough has five fluorescent tubes (40 W per tube) and each vessel carried between 12 and 14 troughs. In addition, 10 to 14 metal-halide lamps were alternately placed with the fluorescent tubes in the troughs. The total wattage of the light sources for offshore purse seine vessels ranged from 12.4 kW to 16.8 kW, the numbers of lamps and corresponding wattage depend on the vessel capacity and fishers' experience.

The light sources were installed at a height of 2.3-2.5 m with an inclination of 22.1°-51.3° (Son, 2011). In the experimental vessel, LED lights were installed using the same properties (*e.g.* illumination, light height and inclination) as those used for regular lighting systems in vessels as control. The same technical parameters (*e.g.* similar engine power, structure of fishing vessel, purse seine length and height) as those of the control were also used in the LED light experimental vessel. Moreover, these fishing vessels had to catch in the same fishing ground, using similar lighting and spend the same fishing time. The basic information of the experimental and control purse seine vessels are shown in **Table 1**.

**Table 1.** Characteristics of the experimental and control vessels

| Categories | Experimental vessel with LED light | Control vessel |
|---|---|---|
| Registration number of vessel | NT 90578 TS | NT 90573 TS |
| Length of vessel (m) | 19.50 | 19.30 |
| Breadth of vessel (m) | 5.50 | 5.20 |
| Depth of vessel (m) | 1.80 | 1.75 |
| Horsepower of engine (HP) | 370.00 | 350.00 |
| Power of diesel generator (HP) | 20.00 | 4.00 |
| Number of crew in vessel (people) | 16.00 | 16.00 |
| Hung length of net (m) | 515.00 | 510.00 |
| Stretched depth of net (m) | 150.00 | 150.00 |
| Mesh size at bunt (mm) | 21.00 | 21.00 |
| Total light source (power) | 3 kW (total LED light power) | 12 kW (50 fluorescent tubes and 10 metal-halide lamps) |

Purse seiners: *(above)* installed with common types of lamps (fluorescent bulbs and metal-halide lamps; and *(right)* installed with LED lights

Three experimental fishing activities were conducted: once in August 2013 corresponding with the southern fishing season (from October to May), another in October 2013 and the third in January, 2014, middle of the northern fishing season (from April to September). During the experimental fishing, fishing logbook was used to record the fishing trips' information, such as fishing position, casting time, net pulling time, fish species, total catch, and fuel consumed.

**Measuring illumination on sea surface, transparency of sea water, and useful light area**

Measurement of the llumination were taken on sea surface at the freeboards (0 m), in multiples of 5 m at varying distances from the freeboards, up to 1 lux (**Fig. 1**). At each position, 30 measurements were taken (Si, 2006) at the same positions where the illuminations were measured. Using a Secchi disc, the transparency of seawater was determined by the depth (distance) at which the disc disappears from sight (Ben Yami, 1987).

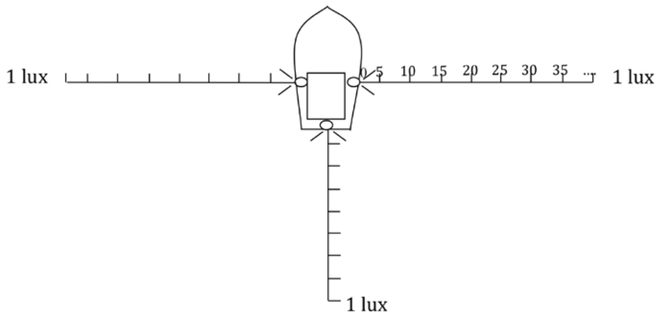


**Fig. 1.** Measuring the illumination of sea surface

Useful lighted areas are the lighted sea surface areas around the vessel where the extensibility is determined until illumination equals one lux. Since the LED light sources were installed on the left side, the light was distributed on the right and back sides of the cabin as shown in **Fig. 2**. Assuming an equal distribution of light and the circular area of the lighted areas, the total useful lighted areas was caculated using the following formula:

$S = S_1 + S_2 + S_3$, where:

S: useful lighted area

$S_1 = \Pi.R12$

$S_2 = \Pi.R22$

$S_3 = \Pi.R32$

$R_1$, $R_2$, $R_3$: radii of lighted areas on the left, right and back sides of the vessel, respectively.

$R_1 = ½ D_1$; $R_2 = ½ D2$; $R_3 = ½ D_3$

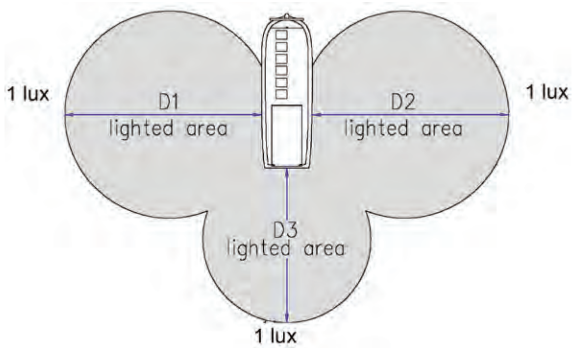

**Fig. 2.** Distribution of lighted areas around the vessel

## Results and Discussion

### Light sources of purse seiners equipped with light in Ninh Thuan Province, Viet Nam

Results from the survey of 35 purse seine vessels equipped with light indicated that two main types of light have been commonly used, namely: fluorescent and metal-halide lamps (**Table 2**). Usage of fluorescent and metal-halide lamps was from 20% to 33% and from 66% to 80%, respectively. The total light power on vessels with engine capacity of 75 and 89 HP was around 4.7 kW. For vessels with engine capacity ranging from 90 to 149 HP and from 150 to 249 HP, the light power was 6.84 kW and 10.14 kW, respectively. By contrast, the total light power of vessels with engine capacity of 250 HP dramatically increased to 16.8 kW.

Fishers have been using metal-halide and fluorescent lamps for quite some time as these are cheap; color temperature corresponds with sunlight (*i.e.* ~ 6,000K); and lamps could remain functional in the highly saline environment (Si, 2006). However, the use of metal-halide and fluorescent lamps has some advantages as well as disadvantages. Despite the aforementioned advantages, metal-halide and fluorescent lamps have some shortfalls (Si, 2006), which include having short lifespan (*i.e.* < 10,000 working hours); lamps usually have low luminescent output, *i.e.* < 60 Lumen/W for fluorescent lamp and 100 Lumen/W for metal-halide lamp (Grondzik, 2009); need many auxiliary spare parts (*e.g.* ballast, starter); require a stable electric power source; and light emitted could be harmful to users' eyes.

### Illumination of the vessel with LED light and control vessel

Although total LED light power was 4 times less than the lights installed in control vessel (3kW in LED light versus 12kW in control vessel), illumination of LED light increased by 1.41 times. The maximum illumination produced by the LED light was 1,753 lux while it was only 1,252 lux in the control vessel (**Table 3**). Lighted areas following horizontal direction of the vessels, in LED light and control vessels were 65 m and 45 m, respectively. At equal inclinations, the total lighted area of the vessel with LED light was 9,459.25 $m^2$, whereas it was 3,885.75 $m^2$ in the control vessel. Due to the equal numbers of LED lights in the port and starboard (11 LED lights for each side), illumination, total lighted areas and volume were similar. Since there were 8 LED lights in the stern, illumination and total lighted areas were relatively lower than those in the freeboards.

### Visibility of the Secchi disc

Results showed that the LED light could illuminate at greater depths than the fluorescent and metal-halide lamps. Specifically, the greatest depth at which the Secchi disc could be seen with LED light vessel was -40.6 m deep, while under the same condition, that of the control vessel measured -35.6 m deep (**Fig. 3** and **Fig. 4**). Considering that the lights have been blocked by the hull of the vessel, the depths at which the Secchi disc could be seen from the freeboards were low, *i.e.* 5.3 m for the LED light vessel and 4.3 m for the control vessel (**Fig. 3**). The greatest depth at which the Secchi disc could be seen from the sterns was at 5.0 m distance from the vessel, and its visibility decreases the further the vessels move (**Fig. 4**).

### Total catch by species

From the three experimental fishing trips carried out, the total catch of the vessel equipped with LED light was approximately 1.2 times higher than that of the control vessel (**Fig. 5**). The total catch was 59.166 and 51.930 tons for the LED light-equipped and the control vessels, respectively, implying that the LED light was able to attract fishes better than the fluorescent and metal-halide lamps.

**Table 2.** Light source of purse seine vessels in Ninh Thuan Province

| Type of light | | Vessel capacity (HP) | | | |
|---|---|---|---|---|---|
| | | 75 - 89 | 90 - 149 | 150 - 249 | ≥250 |
| Fluorescent lamp | Ave power (kW) | 0.99 | 1.54 | 1.61 | 5.60 |
| | Rate (%) | 20.97 | 22.50 | 22.52 | 33.33 |
| Metal-halide lamp | Ave power (kW) | 3.72 | 5.30 | 5.53 | 11.20 |
| | Rate (%) | 79.03 | 77.50 | 77.48 | 66.67 |
| **Total average light power (kW)** | | **4.70** | **6.84** | **10.14** | **16.80** |

**Table 3.** Average illumination by vessel with LED light and control

| Horizonal distance from vessel (m) | Average illumination by control vessel (lux) | | | Average illumination by vessel with LED light (lux) | | |
|---|---|---|---|---|---|---|
| | Starboard ± SD | Port ± SD | Stern ± SD | Starboard ±SD | Port ± SD | Stern ± SD |
| 0 | 1,251 ± 3.1 | 1,252 ± 2.2 | 960 ± 1.6 | 1,751 ± 3.1 | 1,753 ± 2.5 | 1,346 ± 4.6 |
| 5 | 1,237 ± 2.5 | 1,235 ± 3.4 | 875 ± 2.3 | 1,736 ± 2.3 | 1,733 ± 3.2 | 1,232 ± 2.1 |
| 10 | 1,128 ± 1.5 | 1,126 ± 2.4 | 689 ± 4.7 | 1,579 ± 4.2 | 1,577 ± 2.1 | 1,143 ± 2.5 |
| 15 | 960 ± 2.8 | 962 ± 4.1 | 525 ± 3.6 | 1,428 ± 3.5 | 1,429 ± 4.5 | 979 ± 4.3 |
| 20 | 853 ± 3.2 | 856 ± 2.7 | 375 ± 3.1 | 1,325 ± 2.6 | 1,321 ± 4.2 | 850 ± 4.7 |
| 25 | 712 ± 4.2 | 714 ± 3.6 | 157 ± 2.5 | 1,192 ± 1.9 | 1,198 ± 2.8 | 730 ± 2.6 |
| 30 | 526 ± 3.5 | 528 ± 4.3 | 67 ± 2.7 | 982 ± 2.7 | 980 ± 3.8 | 613 ± 2.2 |
| 35 | 215 ± 2.9 | 215 ± 2.8 | 1 ± 0.6 | 761 ± 1.7 | 760 ± 2.5 | 467 ± 2.8 |
| 40 | 49 ± 4.6 | 47 ± 3.1 | - | 534 ± 2.4 | 530 ± 4.1 | 312 ± 3.4 |
| 45 | 1 ± 0.4 | 1 ± 0.3 | - | 384 ± 4.2 | 387 ± 3.3 | 204 ± 2.9 |
| 50 | - | - | - | 220 ± 2.6 | 221 ± 4.3 | 79 ± 1.8 |
| 55 | - | - | - | 100 ± 1.3 | 103 ± 1.9 | 20 ± 2.1 |
| 60 | - | - | - | 54 ± 2.2 | 54 ± 2.7 | 1 ± 0.5 |
| 65 | - | - | - | 1 ± 0.7 | 1 ± 0.4 | - |

Both the LED light-equipped and control vessels caught similar species of fish (**Fig. 6**). The catch included scads (38.13% for control vessel; 37.39% LED light-equipped vessel), skipjack tuna (33.24% for control; 33.80% for

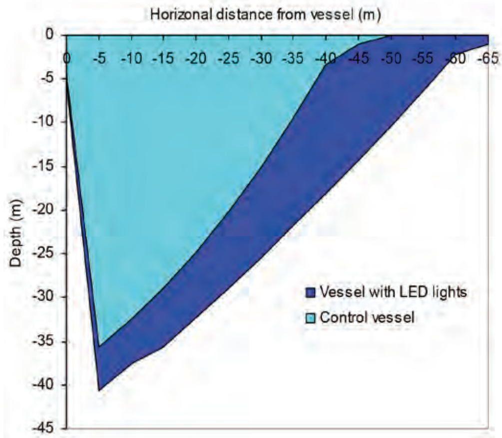


**Fig. 3.** Average depth at which Secchi disc was visible from the freeboards

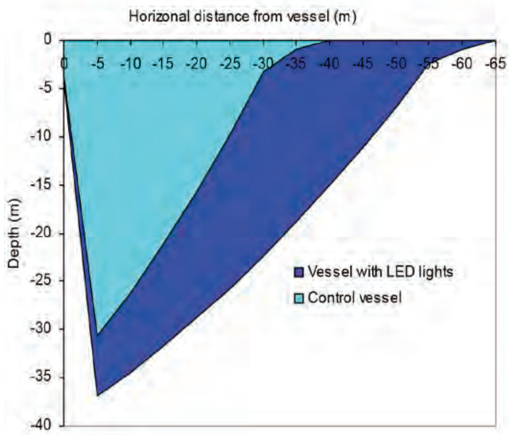


**Fig. 4.** Average depth at which Secchi disc was visible from the sterns

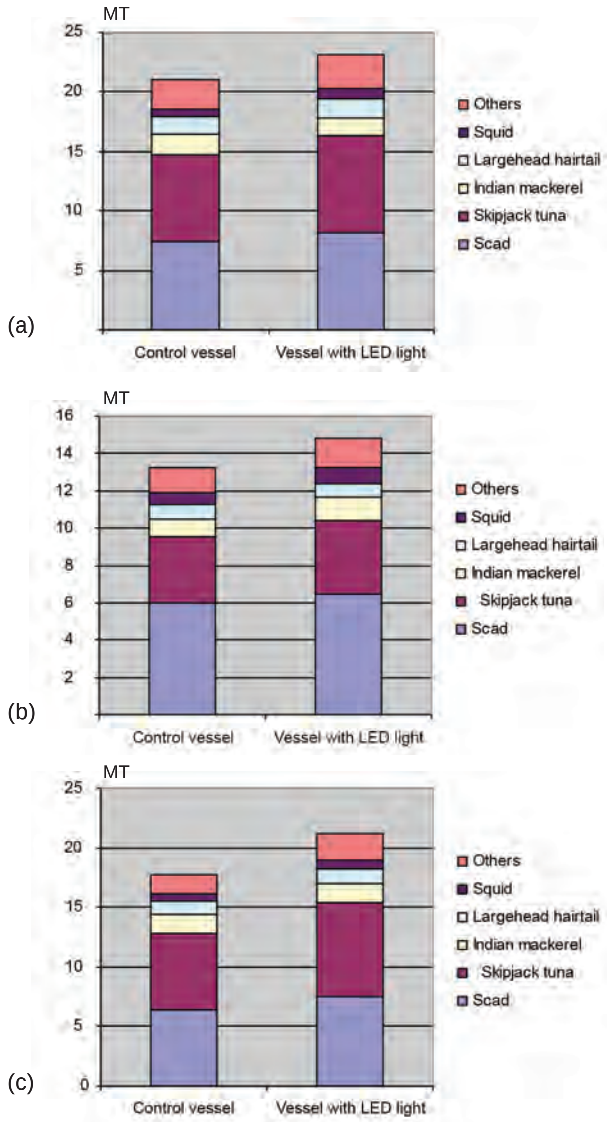


**Fig. 5.** Total catch of LED light equipped and control vessels: **(a)** fishing trip 1, **(b)** fishing trip 2, and **(c)** fishing trip 3

LED light), Indian mackerel (8.08% for control; 7.33% for LED light-equipped), largehead hairtail (6.66% for control and 5.96% for LED light-equipped), squid (3.67% for control; 4.29% for LED light-equipped), and other species (10.23% for the control vessel and 11.23% for the LED light-equipped vessel).

The results also indicated that in terms of fishing time, 80.0% sets from the LED light-equipped vessel was able to catch fish from 22:00 to 24:00 hours whereas 92.1% sets from the control vessel fished only after 23:00 hours. This means that the LED light-equipped vessel was quick enough to attract fish than the fluorescent and metal-halide lamps. In other words, the fish attraction time of LED light was about five hours, while fish attraction time of fluorescent and metal-halide lamps was six hours.

**Cost of fuel used**

Based on information from the three experimental fishing trips, the control vessel used a total of 4,680 liters of fuel which is equivalent to 105,112,800 VND, while the purse seine with LED light used only 1,544 liters equivalent to 34,687,224 VND, which is about 33% of the fuel used by the control vessel (**Table 4**). Fuel used during fishing trips includes fuel for the main engine and for the power generator. It should be noted that the experimental and control vessels operated at the same time and in the same fishing ground. The main engines of the vessels have similar power (370 HP for the experimental vessel and 350 HP for the control vessel). Therefore, the difference of fuel usage was from the power generator. The results therefore showed considerable amount of savings when fishers equip their vessels with LED light compared with using fluorescent and metal-halide lamps. In addition, saving 3,136 liters of fuel from three fishing trips is environmentally significant because the LED light-equipped purse seine vessel could decrease the amount of $CO_2$ emissions into the environment by 8.4 tons, since 1.00 kg of diesel fired would produce 3.19 kg of $CO_2$ (Ozaki, 2004).

In terms of total catch, the fishing trips caught almost the same quantity, thus, there is no need to increase the catch per unit of effort. Therefore, fishing efficiency in this case would depend largely on the cost of operation, especially

**Table 4.** Total cost of fuel used during the three experimental fishing trips

| Fuel information | Control vessel | Vessel quipped with LED light |
|---|---|---|
| Total consumed fuel (liters) | 4,680 | 1,544 |
| Price (VND) | 22,460 | 22,460 |
| Total cost of fuel (VND) | 105,112,800 | 34,687,224 |

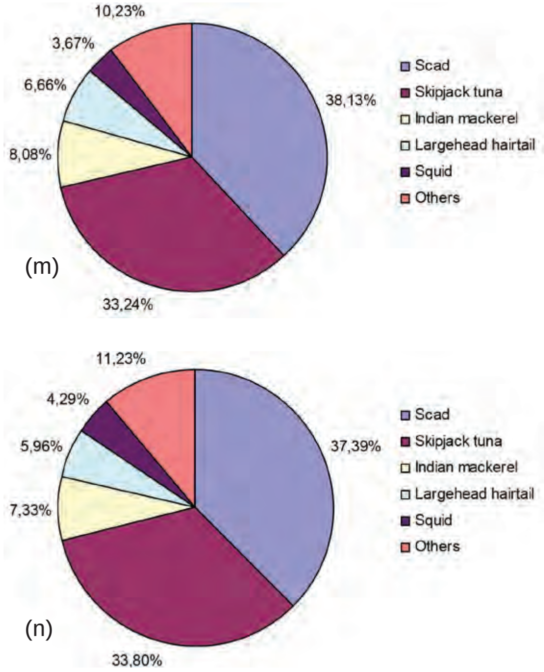


**Fig. 6.** Species composition of fish catch: **(m)** control vessel, and **(n)** vessel with LED light

fuel cost because fuel alone accounted for 60% of the total fishing operation costs. Furthermore, the price of diesel which is continually increasing should be taken into account. Considering that the use of LED light in fishing relatively decreases the volume of fuel consumed, such practice could be promoted as it is beneficial for the fishers through decreased operating costs that eventually leads to increased incomes, and less $CO_2$ emitted to the atmosphere.

## Conclusion

This case study was the first attempt to apply LED light as source of light for purse seine vessels in Viet Nam. Although the initial research results are promising in terms of illumination, catch and fuel expenses, other factors such as structure, illumination, color and index protection of LED light need to be considered in future studies. Furthermore, the price of LED light is about 8-10 times higher than fluorescent and metal-halide lamps and fishers might be hesitant to use LED light as its initial cost is quite exorbitant. Besides, fishers are not yet familiar with the use of LED light in fishing and might not be willing to adopt it immediately. However, there is a need to make the fishers aware that in the long term, using LED light in fishing could be economically and environmentally profitable. Although the initial cost of installing the LED light is high, the cost of operating and maintaining it is low, particularly because the LED light has a relatively longer lifespan than that of compact, fluorescent and metal-halide lamps. Nevertheless, the type of lamps that fishers install on purse seine vessels in Ninh Thuan Province also depends on their habits, which indicated that fluorescent tubes and metal-halide lamps are the most common types of lamps that fishers install on vessels. Even if the cost of these lamps is cheap but the lifespan is shorter than LED lights and more fuel is utilized. The initial results also showed that the use of LED light in fishing improves fishing efficiency. Luminescent outputs and fish attractions of LED lights are relatively higher than that of fluorescent and metal-halide lamps. Moreover, purse seine vessels with LED light saved 77% of fuel consumed compared to the control vessel, while the total catch of the vessel with LED light increased by 12.23%. The species caught by the purse seine vessels with LED light were identical to that of the control vessel, and included scads, skipjack tuna, Indian mackerel, largehead hairtail, squid, and other species that were not identified.

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# Rural Coastal People are at Risk of Seawater Inundation in the Future: A Case Study in Chanthaburi Province, Thailand

*Puvadol Doydee* and *Jirawat Panpeng*

Rural coastal areas in Laemsing District, Chanthaburi Province, Thailand have been experiencing tidal flooding, and most communities are settled in the District's areas with geographical characteristics susceptible to sea level rise. In line with the efforts of the Government of Thailand to raise awareness on the impacts of climate change and understand climate change vulnerability, this study was conducted to link the impacts of sea level rise and its consequences with the lives of rural coastal people, and affirm that this particular District has the highest risk of sea level-relevant events in the future. Scientific tools and techniques including climate models, GIS and remote sensing as well as simple techniques for inundation mapping were applied to pursue the objectives of the study. Results of the analysis based on A1B, csiro_mk30 and best estimates suggested that the total sea level rise in the study area from 2000 to 2045 would be 43.69 cm leading to land loss of around 19,507.50 rais and affecting 2881 persons. The District's aquaculture areas would be most affected, especially in Bangkachai Sub-district with its land and people bearing the brunt of seawater inundation. Reducing the utilization of artesian well water, integrating climate change adaptation into the integrated coastal management (ICM) approach, and implementing the ICM approach in all coastal areas are among the possible solutions that could mitigate the impacts of seawater inundation on the concerned rural coastal people.

Coastal areas importantly link the complexity of environmental systems with people's livelihoods. Many countries worldwide, including Thailand are now being confronted with coastal degradation and its severity is attributed to the influence of climate change. In fact, climate change which is now a severe global problem leads to rising land and sea surface temperatures, and sea level among others. The event is obviously now occurring on Earth, creating adverse impacts that seriously affect coastal systems (Snoussi *et al*., 2008). A climate-relevant phenomenon, sea level rise creates important stress on the coastal areas of Thailand mostly distressing the quality of life for many people living along the country's coastline of approximately 2600 km, in 23 provinces of the Andaman Sea and Gulf of Thailand. Records have shown that the sea level of these two seacoasts had significantly risen at an average rate of 3.00-6.00 mm per year from 1981 to 2006 (Neelasri, 2008), and was anticipated to be worse in the near future (NREPP, 2011). Southeast Asia START (2010) also reported that the average increase of sea level in 2030-2049 relative to that of 1980-2000 would be 13.26 and 10.89 cm for the southeastern coast and southern coast of the Gulf of Thailand, respectively. Many economic sources, particularly shrimp farms in the proximity of the coastline are also susceptible to inundation due to the yearly expected sea level rise of 1.00 cm (START, 2008). Coastal areas in Thailand are therefore vulnerable to and are at risk of the impacts of sea level rise, and are also expected to experience increasing coastal degradation. One of the several coastal provinces in Thailand, Chanthaburi Province has been experiencing frequent tidal flooding that threatens the coastal lands and affects the local people's livelihoods. More particularly, Laemsing District which is one of the four districts of Chanthaburi Province had been confronted with temporary sea level floods that negatively affected its people's livelihoods. The geographical conditions of most of the areas in this District are flat and low-lying, making these areas vulnerable to sea level rise.

## The Case Study

Climate change and its consequences which had created significant burdens on peoples around the world including those in Thailand, had been taken into account in the Third Sub-guideline of the Second Guideline on "Upgrading the capacity of climate change coping and adaptation to immune society", specifically in the Six$^{th}$ Strategy of the Eleventh National Economic and Social Development Plan (NESDB, 2011). In order to develop adequate climate adaptation plans and public policy interventions, understanding about the nexus of the impacts of climate change and its consequences, as well as the risks of people is necessary.

This study has the main objective of promoting enhanced understanding of the relationship among the status of potential sea level change, physical degradation and the people affected which could be represented in terms of accuracy. Sufficient data and information is necessary for decision makers in all levels, as they could help the vulnerable people survive in the midst of possible severity of sea level rise. In addition, this study is aimed at affirming the results of the previous studies on vulnerability assessment to climate-relevant phenomena which indicated that Laemsing District is highly vulnerable to potential sea level change.

| Box 1. Emissions Scenarios of the Special Report on Emissions Scenarios (SRES) |
|---|
| The SRES scenarios are grouped into four scenario families (**A1, A2, B1 and B2**) that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. |
| **A1.** The A1 scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (**A1B**) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end-use technologies). |
| **A2.** The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines. |
| **B1.** The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives. |
| **B2.** The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the A1 and B1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels. |

*Source: Adapted from IPCC (2007)*

This case study was conducted with the application of scientific tools in order to specifically attain its goal of clarifying sea level change in the future; identifying possible inundated areas and affected people; and charting precise solutions for affected people to cope with the severity of the impacts of sea level rise. The case study made use of scientific models based on two emissions scenarios, namely: A1B and B2 **(Box 1)** as these were considered appropriate for the study area. In modeling for projected future climate change, the Special Report on Emissions Scenarios (SRES) should be used, where the SRES refers to the scenarios described in the IPCC Special Report on Emissions Scenarios (IPCC, 2000). The SRES scenarios are grouped into four scenario families (A1, A2, B1 and B2) that could be used to explore alternative development pathways that cover a wide range of demographic, economic and technological driving forces that result in greenhouse gas (GHG) emissions (IPCC, 2007). Any of the four emissions scenarios could be used in projecting future climate change and its impacts to the socio-economic and demographic conditions of an area under study, which in this case is Laemsing District in Chanthaburi Province, Thailand. The results could also be used as inputs in assessing the climate change vulnerability of a particular area.

## The study area and data gathering

Laemsing District in Chanthaburi Province was considered for the case study as it is the most vulnerable area having frequently experienced sea level rise and its adverse consequences. While most of its areas are geographically vulnerable, so are most people living in the District's coastline and dependent on the natural resources for their livelihoods.

Chanthaburi Province is one of the 17 coastal provinces in the Gulf of Thailand with coordinates at 12.6084 (North) and 102.2706 (East) on the east coast. Situated in a tropical monsoon climate area, this Province can be divided into three areas based on geographical conditions, *i.e.* mountainous area, plateau and low-lying flat land adjacent to a river and coastal zone (Chanthaburi Office, 2013). One of the four districts of Chanthaburi Province is Laemsing District which has a coastline and accounted for the aforesaid third geographical condition. As a matter of fact, most of its areas have elevation of below 10.00 m

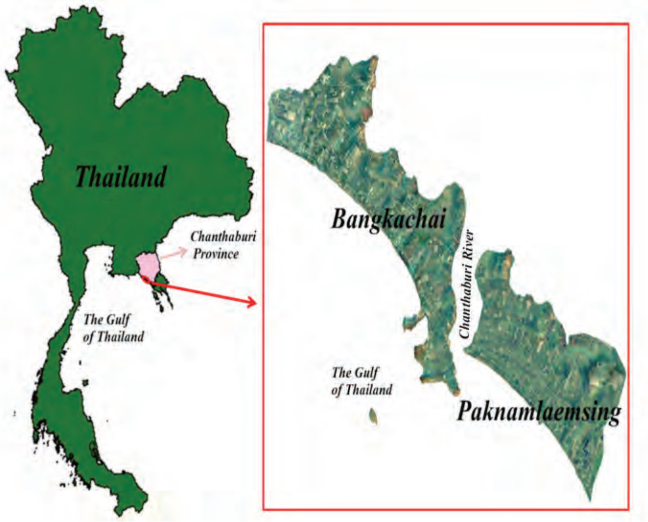


**Fig. 1.** Map of Thailand showing Chanthaburi Province and the two sub-districts that comprised the entire study area

**Table 1.** Categories of land use in the entire study area (areas in rais: 1.0 rai = 0.16 ha)

| Study Sites | Aquaculture area | Agriculture area | Community area | Infrastructure area | Vegetation area | Water area | General area | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Bangkachai | 11,444.72 | 184.95 | 1,031.26 | 19.27 | 4,564.18 | 2,426.40 | **70.81** | **19,741.59** |
| Paknamlaemsing | 8,559.21 | 1,608.18 | 2,529.29 | 116.13 | 797.73 | 1,555.66 | **235.12** | **15,401.33** |
| **TOTAL** | **20,003.93** | **1,793.13** | **3,560.55** | **135.41** | **5,361.91** | **3,982.06** | **305.93** | **35,142.91** |

*Source: Calculations from land use shape file provided by Thai LDD (2010)*

above the mean sea level and connected to the shoreline (Mcgranahan *et al*., 2007), making Laemsing District at high risk of sea level rise. This District has seven Sub-districts, of which Bangkachai and Paknamlaemsing had been selected as the study area for this case study (**Fig. 1**).

These two Sub-districts as the study area have coastlines that are connected to the Gulf of Thailand and located close to Chanthaburi River, and also host a network of brackishwater canals. Most areas in these Sub-districts have very low elevations and mostly occupied by aquaculture farms while the people are mostly involved in exploiting the natural resources. Altogether, aquaculture occupies about 57% of land in the entire study area, of which approximately 57% of the land in Bangkachai Sub-district alone is used for aquaculture. Both aquaculture and water areas cover about 68% of the entire study area (**Table 1**), thereby the entire study area is not only in vulnerable geographical locations but is also having high risk of land inundations.

In order to identify the potential sea level change as hazard, and the land loss and numbers of people affected from the adverse impacts of inundation due to rising sea water, the study adopted the risk-hazard approach described in Eakin and Luers (2006). The collaboration of various stakeholders had been sought for the study which availed of various scientific tools, such as climate models, satellite imageries, Digital Elevation Model (DEM), and Geographic Information System (GIS). A mixed descriptive and explanatory research was applied to illustrate the risk of rural coastal communities to sea water change and its impacts, and on how it could be alleviated. The data collected from primary and secondary sources had been analyzed and assessed from every view point to achieve the research objectives. The data in the form of both qualitative and quantitative have created a wide and deep knowledge of the situation which is crucial for the study. Daily, weekly, monthly and yearly reports and other documents were reviewed and extracted as secondary data as well as those from the focus group discussions adopting some techniques from Daze *et al*. (2009), while inputs from key informants' interviews, questionnaires, and field measurements served as primary data that play important role in explicitly characterizing the entire study area (**Fig. 2**).

**Potential sea level change as climate-relevant stressor or hazard in the entire study area**

For this study, future sea level change was assessed using SimCLIM Software, a commercial package and an open-framework computer model system which is user-friendly and allows users to import their own data and examine or customize their climate-proposed study based

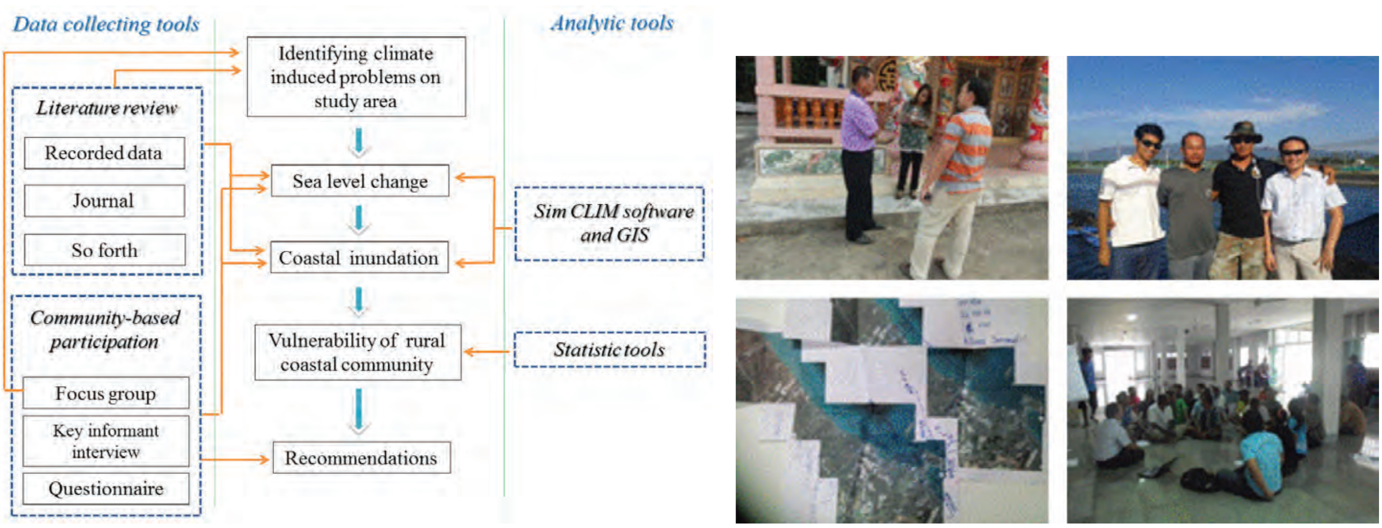


**Fig. 2.** Data collection for the case study: data collecting and analytical tools used *(left)*; and key informants' interview, questionnaire surveys and field measurements *(right)*

on specific greenhouse gas emissions scenarios (Special Report on Emissions Scenarios in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (AR4)), General Circulation Model (GCM), times and areas (Iglesias-Campos *et al*., 2010). The study therefore simulated the potential sea level change in three years of interest, such as that of 2025, 2035 and 2045, based on a combination A1B and B2 Scenarios accounted in AR4 and GCM of csiro_mk30 in the Coupled Model Inter-comparison Project Phase 3. Two assumptions of man-induced GHG emissions scenarios, *i.e.* A1B and B2 were used and the important inputs were incorporated for the simulation of potential sea level change in the entire study area.

Csiro_mk30 which is a selective GCM was used considering its accuracy in analyzing the observed and simulated data. Moreover, two statistical tools, *i.e.* sample correlation coefficient and standard deviation were used to measure the accuracy (Smith and Hulme, 1998).

**Mapping sea level inundations in years of interest and quantifying its negative impacts**

Assessment of the inundation was carried out using mostly the techniques provided by the Coastal Service Center of NOAA (2012), with several data inputted such as the volume of potential sea level change in the three years of interest and the DEM which were provided by Land Development Department of Thailand (Thai LDD). These data were necessary to be able to create the inundation map for quantifying the inundated land and the people affected in the years of interest. The inundation-mapping approach and interpretation of the inundated areas were processed by Arc Map 10.1 and illustrated in **Fig. 3**.

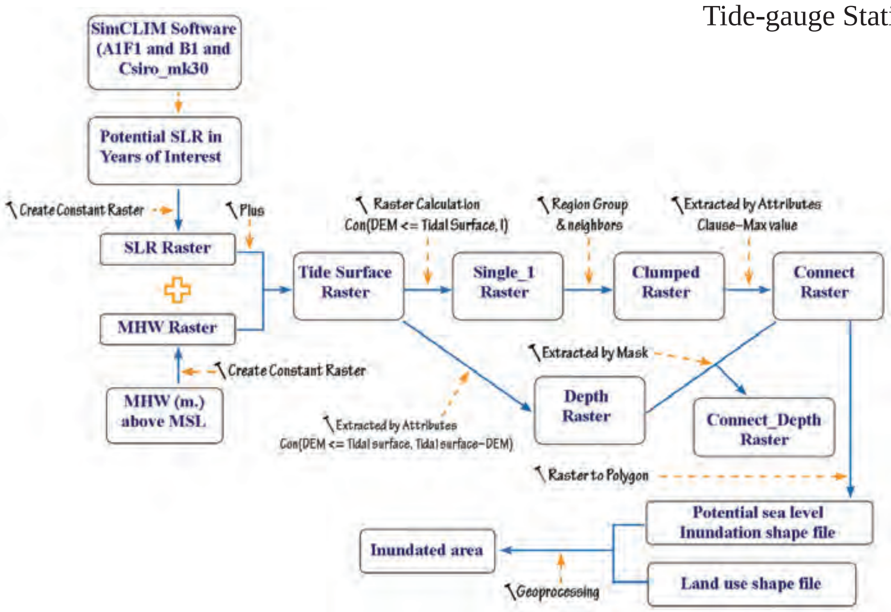


**Fig. 3.** Approach used to map sea level inundations *(Adapted from approach of NOAA)*

In order to evaluate the number of people affected by sea water inundation in each Sub-district under each year of interest, the study firstly calculated the rate of community-inundated areas and quantified the affected households by multiplying the above calculated rate with the entire number of households in each Sub-district. Finally, the affected people were quantified by multiplying the affected households of each Sub-district with the household size.

## Results and Discussion

Relative sea level or total sea level which is an accumulation of global and regional sea levels as well as the local conditions has been projected year by year within the 21$^{st}$ century. The total sea level change was measured in terms of different sea levels in 2025, 2035 and 2045 relative to 2000, and presented as cm in three sensitivities: low, medium and high. For simulating the total sea level change, the study made use of the GCM, two GHG emissions scenarios and an observed volume of local sea level change, the latter of which was measured at 10.50 mm/year from the Laemsing Tide-gauge Measuring Station (coordinates: 102.07, 12.4654) during 1993 to 2004. The potential total sea level change was quantified at the same coordinates of the Laemsing Tide-gauge Station and positioned on the same line along the seafront areas in the entire study area. Projection of the volumes of sea level rise made use of the said potential sea level change in the entire study area and calculated using the same position as that of the Laemsing Tide-gauge Station.

**Table 2.** Simulated volumes of potential total sea level change (cm) based on combination of csiro_mk30 and both emission scenarios at Laemsing District

| Year | Low Sensitivity | | Medium Sensitivity | | High Sensitivity | |
|---|---|---|---|---|---|---|
| | A1B | B2 | A1B | B2 | A1B | B2 |
| 2000 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 |
| 2025 | 20.72 | 20.88 | 23.22 | 22.71 | 25.71 | 24.54 |
| 2035 | 29.14 | 29.27 | 33.28 | 32.42 | 37.39 | 35.56 |
| 2045 | 37.58 | 37.70 | 43.69 | 42.45 | 49.79 | 47.19 |

Increase of sea level in Laemsing District is not skeptical in both GHG emissions scenarios, potentially and inevitably affecting the people in such areas. Over the first 45 years of the 21st century (from 2000 to 2045), based on A1B Scenario and best estimates, Laemsing District will experience 11.00 mm/year sea level rise which is higher than that of B2 at the same estimate, and 12-year rate of observed sea level rise by about 1.54 and 0.50 mm/year, respectively. The total sea level in the whole District would continuously increase and creep from 2000 to 2025, 2035 and 2045 by 23.22+1.97, 33.28+4.13 and 43.69+6.11 cm, respectively.

Likewise, based on the B2 Scenario, the total sea level would also continuously rise in line with the sea level simulation based on the A1B Scenario. The rising volumes of the total sea level could be anticipated at 22.71+1.83, 32.43+3.15 and 42.45+4.75 cm by 2025, 2035 and 2045, respectively (**Table 2**).

In the 21st century, the simulated changing volume of total sea level in Laemsing District, based on A1B Scenario is higher than that of B2 Scenario by about 3.43%. Considering the first 45 years of this century, the total sea level based on A1B is not significantly different from B2 Scenario by 2.92% while a higher difference of about 3.62% during the last 45 years of the century (**Fig. 4**) could occur. In determining the coastal inundation-relevant impacts, the inundated areas and affected people in each aforementioned year of interest were considered based on the above anticipated volumes of total sea level change, the DEM and land use shape file provided by Thai LDD. Overall, the entire study area will continuously face the

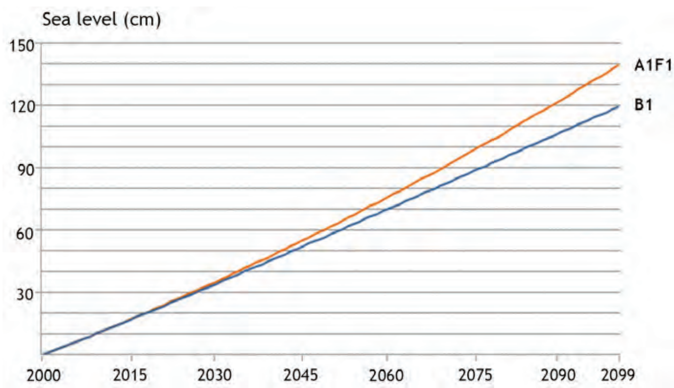


**Fig. 4**. Trend of the total sea level change in Laemsing District based on csiro_mk30 and both A1B and B2 Emissions Scenarios, in medium sensitivity

severity of inundation associated with increasing total sea level in each year of interest (**Table 3** and **Fig. 5**).

Specifically, aquaculture lands in the study areas are anticipated to be mostly inundated by about 65% (**Fig. 6**) affecting about 12,513.62 rais during 2000-2045 with most of the land loss and affected people occurring in Bangkachai Sub-district. However, the inundation-relevant impacts associated with A1B Scenario are expected to be slightly severe than that of the B2 Scenario.

Based on A1B Scenario, 65% of the total area of Bangkachai Sub-district will be submerged by 2045 while sea level will envelop 44% of the land area in Paknamlaemsing Sub-district. Thus, people in the study areas would be continuously confronted with the worse impacts of potential inundation in line with the inundated lands (**Table 3**).

**Table 3.** Areas and people affected by seawater inundation in the two Sub-districts in all years of interest

| Year | A1B emission scenario | | | | | | B2 emissions scenario | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inundated areas (rais) | | | Affected people (individuals) | | | Inundated areas (rais) | | | Affected people (individuals) | | |
| | 2025 | 2035 | 2045 | 2025 | 2035 | 2045 | 2025 | 2035 | 2045 | 2025 | 2035 | 2045 |
| Bangkachai | 11,752.34 | 12,439.06 | 12,787.91 | 1,220 | 1,358 | 1,497 | 10,933.61 | 12,415.60 | 12,722.73 | 1,185 | 1,351 | 1,455 |
| Paknamlaemsing | 6,101.13 | 6,459.56 | 6,719.59 | 1,063 | 1,231 | 1,384 | 6,079.49 | 6,405.69 | 6,678.06 | 1,044 | 1,211 | 1,357 |
| Entire study area | 17,853.47 | 18,898.62 | 19,507.50 | 2,283 | 2,589 | 2,881 | 17,013.10 | 18,821.29 | 19,400.79 | 2,229 | 2,562 | 2,812 |

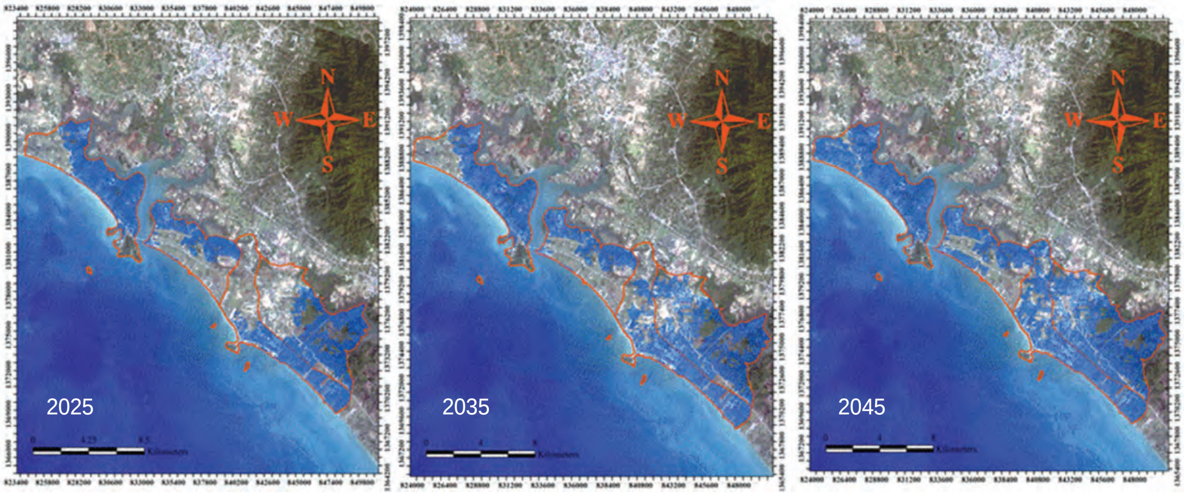


**Fig. 5.** Inundation maps of the study areas in all years of interest based on csiro_mk30 and A1B Scenario

Over the first 45 years of the century, the number of affected people in Bangkachai Sub-district will be higher than that of Paknamlaemsing Sub-district. During this period, the total sea level which was simulated based on the A1B Scenario will engulf many community areas and affect around 1,497 individuals in Bangkachai Sub-district or about 37% of its total population. In other words, during 2000-2045, around 11 households or 33 individuals will annually bear the brunt of the impacts of inundation. Meanwhile, 1,384 individuals in Paknamlaemsing Sub-district (16% of its total population) will experience sea water inundation or around 31 individuals per year, during the same period.

## Conclusion, Recommendations and Lessons Learned

Although preliminary, the study was able to link the potential sea level change and its consequences with the biophysical impacts on people in Laemsing District which has demonstrated the high risk from sea water-relevant events, especially inundation. Using a combination of quantitative and qualitative data and information in regional and local scales, and scientific tools and techniques in climate modeling, GIS and remote sensing and simple techniques for inundation mapping, the study indicated that increase of the total sea level in Laemsing District would be quite inevitable over the 21st century, as simulated using a combination of the GHG emissions scenarios A1B and B2, and csiro_mk30. Based on B2 scenario, the total sea level was anticipated to rise by 42.45 cm and increasing up to 43.49 cm considering the A1B scenario. The continuing and gradually increasing sea level will create creeping impacts to and threaten the rural coastal people in Laemsing District in the future. Based on A1B scenario, approximately 19,507.50 rais or 56% of its entire area will be affected by sea water inundation while about 2881 persons will also affected within 2045. Aquaculture farms which comprise the largest land utilization in the study areas will be largely inundated especially that these

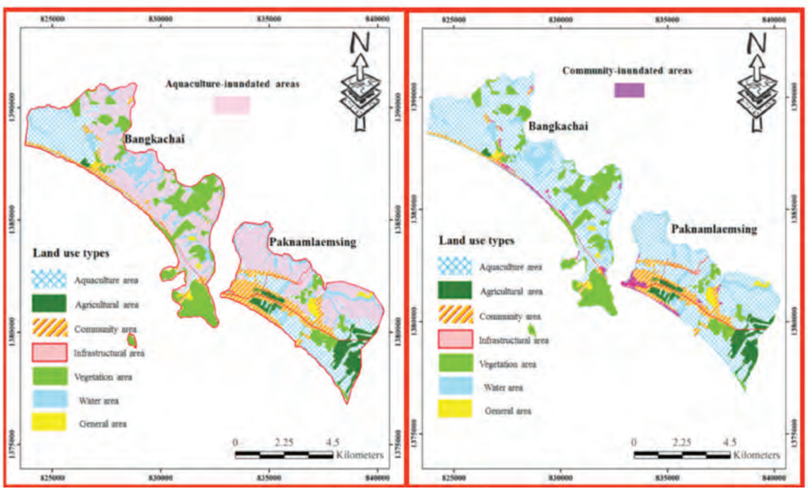


**Fig. 6.** Inundation maps of aquaculture areas *(left)* and communities *(right)* based on estimates of sea level change from 2000 to 2045

are located in low elevation areas and close to the sea and brackish canals. Bangkachai Sub-district will mostly bear the risk of the potential impacts of sea level change based on both measuring factors, where around 12,787.91 rais will be submerged within 2045 affecting about 1497 individuals. As suggested from the results of the analysis, the impacts of sea level change taking into consideration the A1B scenario would be slightly higher than that of the B2 scenario.

The results therefore indicate that the entire study area is susceptible to sea water inundation. Based on the inputs from the questionnaire survey and key informants' interview, there are several possible solutions that could reduce the risk of sea level change and its impacts. These could include: promoting reduced utilization of artesian well water; enforcing strictly the town's development plans; regular monitoring and maintenance of existing coastal protectors; creating evacuation plans and provisions of resettlement areas; conducting studies on integration of climate adaptation into the integrated coastal management (ICM) approach; and implementing the ICM approach in all coastal area. From the experience obtained from the case study, the application of simple tools and techniques to assess sea level impacts, as well as sophisticated scientific techniques, modeling tools and adequate techniques could provide the insights for developing prioritized options as means of mitigating the impacts of sea level change.

## Acknowledgement

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# CALENDAR OF EVENTS

| Date | Venue | Title | Organizer(s) |
|---|---|---|---|
| | | 2015 | |
| 22-23 April | Yogyakarta, Indonesia | 6th RPOA Sub Regional Meeting in the Southern Eastern Areas of the South China Sea and the Sulu-Sulawesi Seas | RPOA-IUU |
| 22-24 April | Phu Quoc, Viet Nam | National Workshop and Training of Enumerators for Data Collection for Transboundary Fisheries and Habitat Management in the Gulf of Thailand: Cambodia-Thailand-Viet Nam | SEAFDEC-Sweden Project |
| 27-30 April | Lao PDR | Training of Trainers (ToT) on Facilitating Fisheries Information Gathering through Introduction of Community-based Fisheries Management: Effective Implementation and Extension of the Co-management and CBFM in Lao PDR | SEAFDEC/TD |
| 28 April | Bangkok, Thailand | SEAFDEC-Sweden Project Annual Review Meeting | SEAFDEC-Sweden Project |
| 28-29 April | Indonesia | 2nd Regional Meeting of the Protection of Migrant Fishers: ASEAN Review of "Guidelines on Flag State Inspection of Working and Living Conditions on Board Fishing Vessels" | ILO |
| 5-7 May | Bali, Indonesia | 26th Meeting of NACA Governing Council | NACA |
| 6-8 May | Siem Reap, Cambodia | Training on Community-based Fisheries Management in Cambodia | SEAFDEC/TD |
| 7-8 May | Brunei Darussalam | 11th Meeting of ASEAN Expert Group on CITES | ASEAN |
| 12-14 May | Viet Nam | Training of Trainers (ToT) on Facilitating Fisheries Information Gathering through Introduction of Community-based Fisheries Management: Role and Function of Fishers Organization in the Implementation of CBFM in Viet Nam | SEAFDEC/TD |
| 15-16 May | Calbayog, Philippines | REBYC-II CTI Project Planning Meeting (for June-December 2015) | SEAFDEC/TD |
| 18-19 May | Calbayog, Philippines | 3rd Steering Committee Meeting for the REBYC-II CTI Project | SEAFDEC/TD |
| 25-27 May | Langkawi, Malaysia | Expert Group Meeting on ASEAN Catch Documentation Scheme | SEAFDEC Secretariat & MFRDMD |
| 25-27 May | Colombo, Sri Lanka | FAO/APFIC Regional Consultation on Improving the Contribution of Culture-based Fisheries & Related Fishery Enhancements in Inland Waters to Blue Growth | APFIC/FAO |
| 26-28 May | Bangkok, Thailand | Regional Technical Meeting on Sharks and Rays Data Collection Project Planning Year 2015-2016 | SEAFDEC/TD |
| 2-4 June | Pattaya, Thailand | Regional Technical Consultation on the Regional Fishing Vessels Record (RFVR): Use and Way Forward of RFVR Database as a Management Tool to Reduce IUU Fishing in the Southeast Asian Region | SEAFDEC/TD |
| 3 June | Singapore | Roundtable Discussions at the ASEAN Aquaculture Industry Summit | ASEAN |
| 8-9 June | Myanmar | 7th Meeting of the ASEAN Fisheries Consultative Forum (AFCF) | ASEAN |
| 10-12 June | Myanmar | 23rd Meeting of the ASEAN Sectoral Working Group on Fisheries (ASWGFi) | ASEAN |
| 15-17 June | Viet Nam | 2nd Meeting of the Scientific Working Group for Stock Assessment of Neritic Tunas in the Southeast Asian Region | SEAFDEC Secretariat & MFRDMD |
| 27-30 July | Pattaya, Thailand | Symposium on Strategy for Fisheries Resources Enhancement in the Southeast Asian Region | SEAFDEC/TD & AQD |
| 18-20 August | Thailand | Expert Group Meeting on Drafting the RPOA-Capacity | SEAFDEC Secretariat |
| 27-29 August | Bali, Indonesia | 4th CTI-CFF Regional Business Forum | CTI-CFF |
| 17-18 November | Bangkok, Thailand | International Conference on Underwater Acoustics for Sustainable Fisheries in Asia | AFAS |
| 23-25 November (Tentative) | Philippines | 38th SEAFDEC Program Committee Meeting (PCM) | SEAFDEC Secretariat & AQD |
| 26-27 November (Tentative) | Philippines | 18th Meeting of the Fisheries Consultative Group of the ASEAN-SEAFDEC Strategic Partnership (FCG/ASSP) | SEAFDEC Secretariat & ASEAN |

## 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.

**Mandate**

To develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies, research and information dissemination activities

**Objectives**

- To promote rational and sustainable use of fisheries resources in the region
- To enhance the capability of fisheries sector to address emerging international issues and for greater access to international trade
- To alleviate poverty among the fisheries communities in Southeast Asia
- To enhance the contribution of fisheries to food security and livelihood in the region

**SEAFDEC Program Thrusts**

- Developing and promoting responsible fisheries for poverty alleviation
- Enhancing capacity and competitiveness to facilitate international and intra-regional trade
- Improving management concepts and approaches for sustainable fisheries
- Providing policy and advisory services for planning and executing management of fisheries
- Addressing international fisheries-related issues from a regional perspective


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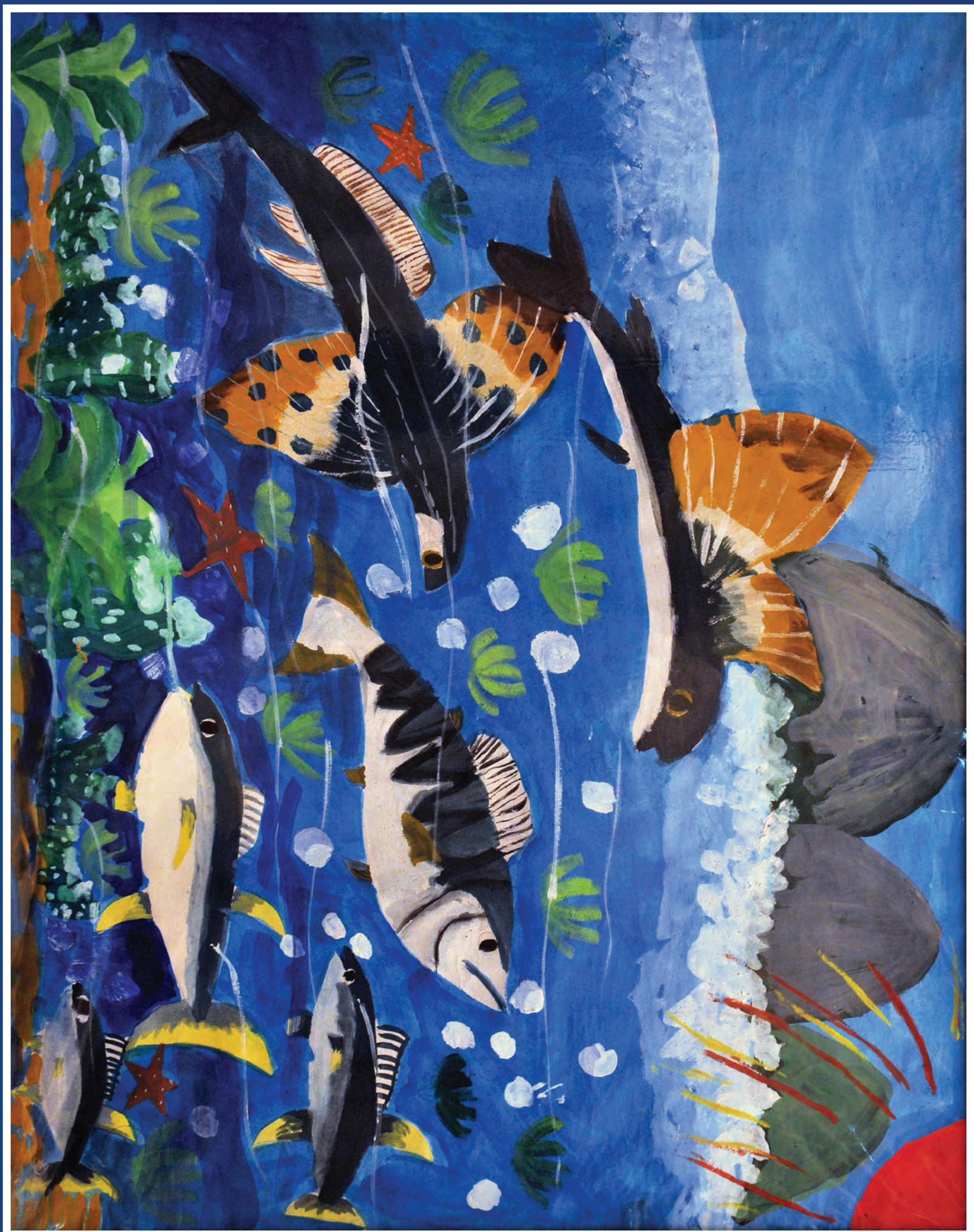

**The first prize drawing winner, *Le Thanh Thao*, from the national drawing contest in Viet Nam**

*National Drawing Contests were organized in all ASEAN-SEAFDEC Member Countries as part of the preparatory process for the ASEAN-SEAFDEC Conferene 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.*