Following-up on the Conservation of Sea Turtles in Southeast Asia: DNA Study

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Efforts in the conservation and management of sea turtles in Southeast Asia have been carried out by SEAFDEC through the MFRDMD from 1998 to the present, with funding support from the Japanese Trust Fund.

The increasing number of endangered aquatic species including the sea turtles has become a global concern knowing that the indiscriminate exploitation by man of the aquatic species' populations for commercial gains has led to the species' decreasing populations. Since the International Union for Conservation of Nature (IUCN) Red List of Threatened Animals of 1996 has indicated that all species of sea turtles are classified as endangered, SEAFDEC as a regional organization has been doing its part to conserve the endangered sea turtles. With funding support from the Japanese Trust Fund (JTF) Program of the Government of Japan through its Fisheries Agency, the SEAFDEC Marine Fishery Resources Development and Management Department (MFRDMD) based in Terengganu, Malaysia has implemented a program on the Conservation and Management of Sea Turtles initially from 1998 to 2004, and extended until 2008. The program was aimed at compiling information on the status of research, conservation and management activities of sea turtles in Southeast Asia, and establishing a mechanism for regional collaboration in the research and conservation of the sea turtles.

SEAFDEC Program on Conservation and Management of Sea Turtles

Spearheaded by MFRDMD and with the collaboration of the ASEAN Member Countries as well as the SEAFDEC Training Department (TD) in Samut Prakan, Thailand, various regional researches and development programs have been successfully conducted in the region in addressing the need to conserve the region's sea turtles species (**Table 1**). Parallel with the efforts of SEAFDEC, the ASEAN Member Countries have also been serious about strengthening their conservation measures on the sea turtles (Fish for the People, Vol. 1 No. 3: 2003). Turtle hatcheries have been set up in many countries as these are considered the most important conservation tools in order that sea turtle eggs have better chances of hatching. Considering that sea turtles are highly migratory, the ASEAN countries also collaborated with MFRDMD's sea turtle tagging activities where the results provided them with considerable ecological information, including information on geographical range and migratory path,

Table 1. SEAFDEC Program on Conservation and Management of Sea Turtles in Southeast Asia (1998-2004)

Project Activities/Objectives	Accomplishments
Sea Turtle Hatchery Management To develop a common tool in conserving sea turtles through sustainable hatchery management focusing on the green turtle, *Chelonia mydas*	Results were published in: *A Guide to Set and Manage Sea Turtle Hatcheries in the Southeast Asian Region*. The book provides useful information and guidelines in setting up and management of sea turtle hatcheries based on knowledge established on-site in Malaysia and experiences of other countries. Using this book as guide, turtle hatcheries in the region would be able to continuously produce hatchlings in order to enhance sea turtle conservation activities.
Tagging Survey To gather information on migration pattern, growth and mortality rates, reproduction and population estimates, etc.	Results of the survey were included in: *Conservation and Enhancement of Sea Turtles in the Southeast Asian Region*. The book highlights on the measures undertaken by the ASEAN countries in conserving and managing sea turtles including laws and enforcements on conservation, establishment of sea turtle sanctuaries and hatcheries, tagging and satellite telemetry, training and public awareness. *A Guide for Tagging Sea Turtles in the Southeast Asian Region* was also published to help the countries in the region in standardizing their own turtle tagging activities.
Development of Turtle Excluder Devices To develop Turtle Excluder Devices (TEDs) suitable for the ASEAN countries in response to the US embargo on shrimps caught by gear not equipped with means to prevent sea turtle by-catch, which was also imposed on the Southeast Asian countries posing threat to the livelihood of the fishers in the region.	Awareness by the region's fishermen on TEDs was promoted through a series of demonstrations conducted in Thailand, Malaysia, Philippines, Brunei Darussalam, Indonesia, Myanmar, Cambodia, and Vietnam. The use of TEDs has already been advanced by many countries in the region.
Collaboration and Partnership To enhance regional collaboration and partnerships in sea turtle conservation and management	MOU on ASEAN Sea Turtles Conservation and Protection was adopted at the 9th AMAF Meeting in 1997 The ASEAN Network on Sea Turtles was established as a regional taskforce in the promotion of conservation and management of sea turtles in the region Development of Turtle Research Database System promoted by Western Pacific Regional Fisheries Management Council in collaboration with Department of Fisheries Malaysia Cooperation with SEASTAR2000 finalized for the satellite tracking of sea turtles

breeding and inter-nesting frequencies, growth rates and population size, etc.

Stock Enhancement of Sea Turtles

Recognizing the need to broaden regional activities into an integrated management approach for future efforts in the conservation of sea turtles, SEAFDEC with support from the JTF Program, pursued further its efforts in the conservation and management of the sea turtles by implementing the Program on Stock Enhancement of Sea Turtles in the Southeast Asian Region from 2005 to 2008 (**Table 2**). Conducted by MFRDMD and TD in collaboration with the SEAFDEC Member Countries, the program aims to advance the conservation and management of sea turtles by incorporating all possible approaches through collaborative efforts of the ASEAN countries in order to make the conservation effort of the sea turtles a "regional success story" and to ensure the long-term survival of these endangered species.

Determining Population Structure of Sea Turtles through DNA Study

Identification of the stock/population of sea turtles is a very essential ecological aspect to promote their conservation. Enhancement of the sea turtle resources requires ecological and physiological knowledge throughout the sea turtles' life. Sea turtle conservation and enhancement could be promoted by determining their subpopulations because the resources-protect schemes should correlate to each population unit. Understanding the discreteness of sea turtle stocks and on how the stocks relate to each other is therefore important for the conservation of the sea turtle resources.

In the DNA study conducted by MFRDMD, the population genetics of the green and hawksbill turtles were analyzed using mitochondria (mt) DNA. Using the 300 samples of green turtles collected from 16 sampling sites throughout the Southeast Asian Region, initial results indicated that

Table 2. SEAFDEC Research Projects on Stock Enhancement of Sea Turtles in Southeast Asia (2005-2008)	
Project Activities/Objectives	**Progress of the Activities as of 2007**
Tagging and Satellite Telemetry To enhance the sea turtle migration studies in the region, specifically in countries where turtle rookeries are concentrated.	Tagging of sea turtles (green turtles, hawksbill and Olive Ridley), using inconel tags was conducted in participating ASEAN countries. Posters highlighting the SEAFDEC tagging program were distributed for public awareness. Initial reports indicated that sea turtles are sharing resources and their foraging has been confirmed in certain areas in the Southeast Asian region.
Head Starting Technique To collect information and conduct analysis on head-starting, a technique for raising sea turtles in captivity for release later to improve survival during their early years, which is still relatively new in the region.	Information collection on head starting programs in the region and other countries outside Southeast Asia was initiated.
Sea turtles – Fisheries Interactions To mitigate interaction between sea turtles and fisheries and minimize mortalities of sea turtle from fishing operations.	Assessment/evaluation of lessons learned from the introduction and promotion of TEDs in shrimp trawls was carried out taking into account the 2004 FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations. Collection of information on sea turtle interaction with fishing operations in Southeast Asia was initiated. Result of the comparative study on the efficiency of the Circle hook and the J-hook in pelagic and bottom longlines indicated that the use of Circle hook (with larger hook width which the sea turtles could not swallow) was the most suitable device for the conservation of sea turtles. *Mitigation of Fishery-Sea Turtles Interactions: Efficiency of the Circle Hook in Comparison with J-hook in Longline Fishery* was published containing the outcomes of the studies on mitigation of sea turtles and fisheries interaction. When sea turtles are caught by the Circle hook, hooking position is only around their jaws thus the hook could be easily removed. Results also showed that sea turtles caught by the Circle hook have no serious injuries and could be released safely back to the sea.
DNA Study To identify stock/population of sea turtles from the ASEAN region and detect multiple paternities for estimation of stock size of male sea turtles.	The Standard Operating Procedure: Sampling Tissue of Sea Turtles in the Southeast Asian Region to guide the countries in collecting tissue samples was published. Based on this guideline, many tissue samples of green turtles from selected nesting sites in participating ASEAN countries were collected. Tissue samples of green turtle hatchlings are being analyzed to determine multiple paternities through microsatellite markers. Symposium on Cloning of Sea Turtles was convened in March 2006 in collaboration with DOF Malaysia to discuss and compile methodologies and techniques for cloning sea turtles. The *Conceptual Framework on Cloning of Sea Turtles* and *Master Plan: Cloning of Sea Turtles* were published. The Master Plan describes the establishment of advanced reproductive biotechnology and captive breeding for the sustainable management of sea turtles.
Sea Turtle Information Dissemination To enhance awareness, knowledge and understanding of the public on sea turtles and spread awareness on the need to protect and conserve the sea turtles as well as the environment as a whole.	Five volumes of *Sea Turtle Information Kit* were published in 2006: Volume 1: Sea Turtle Evolution and Biology Volume 2: Sea Turtle Distribution Volume 3: Sea Turtle Hatchery Volume 4: Conservation Genetics of Sea Turtle Volume 5: Public Awareness on Sea Turtles

green turtles from Southeast Asia have few sub-populations or Management Units (MUs). The analysis of the hawksbill samples is still in progress.

Nonetheless, the preliminary results also showed that several sub-populations of nesting green turtles were present in Thamee Hla Island-Coco Island (Myanmar), Khram Island-Huyong Island (Thailand), Redang Island (Malaysia), Sarawak Turtle Island (Malaysia), Philippine and Sabah Turtle Island (Malaysia and Philippines) and Derawan Archipelago (Indonesia). For the hawksbill turtles, samples were also collected from 15 selected sampling sites. However, only the 100 tissue samples from two sampling sites: Melaka (Malaysia) and Segamat/Belitung (Indonesia) had been analyzed so far.

Collecting tissue samples from sea turtles at nesting locations

Generally, the population sizes of sea turtles are investigated only for adult females landing on the beach for nesting since the adult males do not land on the beach and their natural habitats have always been the sea throughout their life. Since it is also known that the adult males of sea turtles have bigamic relationships with the nesting females, multiple paternities would be determined to estimate the stock size of male sea turtles in a pilot nesting beach.

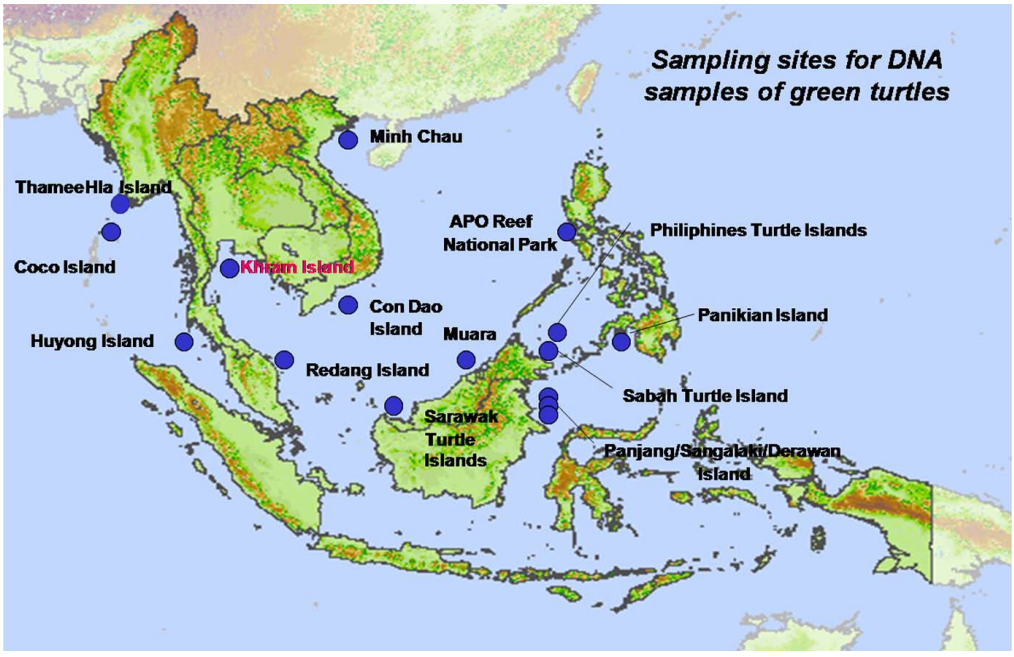
Considering the Mak Kepit Beach in Redang Island of Terengganu, Malaysia as the pilot nesting area, 300 tissue samples of hatchling green turtles from 10 nesters were analyzed. The initial findings showed that most of the females mate with only one adult male green turtle. The microsatellite DNA marker was used to identify each male individual that mates with the nesting females during the nesting season.

Issues and Concerns

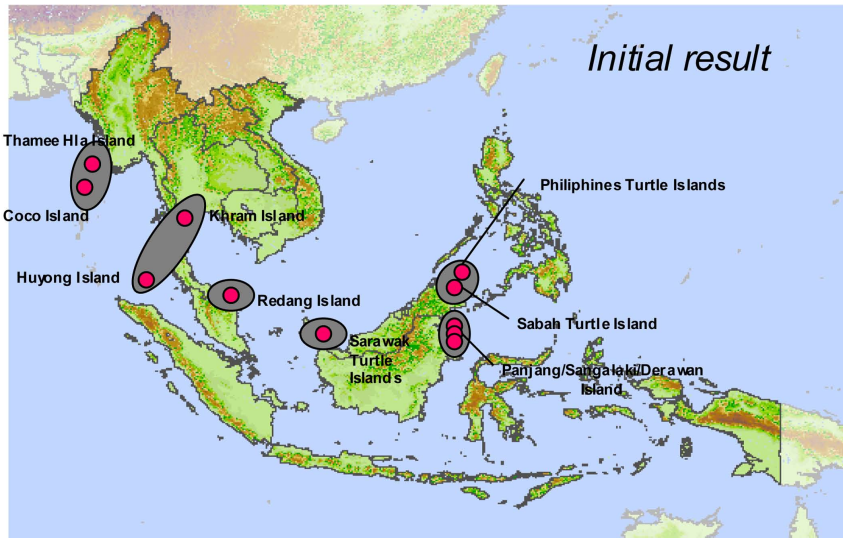
Since six of seven species of living sea turtles in the world are commonly found in the Southeast Asian waters, it is most appropriate to conduct research to conserve and enhance the sea turtles populations in these waters with a view of maintaining their biodiversity. Since sea turtles are highly migratory and share the waters of the region, regional cooperation among the Southeast Asian countries is vital to ensure their survival. Within the Southeast Asian region, conservation efforts of one country could be jeopardized by fisheries-related activities of another country. Thus, it is crucial that conservation efforts should be done in a concerted regional manner.

Conservation and enhancement of sea turtle resources requires ecological and physiological knowledge of their life and their living behavior and conditions. Since conservation and enhancement efforts should be based on scientific evidence, molecular genetic analyses are used to investigate the population genetic structure of the green and hawksbill sea turtles of Southeast Asia. During the series of consultations conducted prior to the implementation of the project activity, it was recognized that understanding sea turtle stocks and on how the stock relates to each other is crucial for the regional management of sea turtles.

Molecular biological study on DNA fingerprint was therefore pursued to determine the stock population/sub-population of sea turtles in the Southeast Asian region and to come up with guidelines for the genetic study of sea turtle management in the region. Starting with the green turtles, results showed that their frequency distributions indicated eight (8) genetically distinct breeding stocks (Management



Selected sampling sites for collecting tissue samples of green turtles in the Southeast Asian region



Several sub-populations of nesting green turtles were found in the Southeast Asian region based on DNA profiling

Units, MUs). Significant genetic differentiations in mtDNA haplotype frequencies among rookeries support the hypothesis of natal homing. This means that the female adult green turtles that lay eggs at particular nesting beaches is unique and belong to one sub-population. Several sub-populations of female green turtles have been observed in the Southeast Asian region.

Since it has also been well observed that nesting females come back to the same beach in the next nesting season at intervals of seven years, it is therefore necessary that a good number of individual tissues of females are collected from each of the focused nesting places in the region complying with the standardized sampling method used in many DNA studies. Being highly migratory species, the environmental threats occurring in the region's waters may also jeopardize the population of the sea turtles at particular nesting beaches.

The DNA study of sea turtles

What should be done to address the concerns?

Most of the female adult green turtle populations are isolated according to their nesting beaches, and since they are highly migratory, they could migrate beyond the transboundary waters. Therefore regional collaboration is very essential on any action aims to protect sea turtles. Moreover, reducing the mortality of sea turtles caused by man-induced or fishing activities is vital for enhancing the population of sea turtles in the region. Intensive education and awareness program on conservation of sea turtles as well as on maintaining environmental and ecological integrity should therefore be conducted at all levels especially in the fishing communities in the region.

Plan of Action

The observations collected from the various conservation activities make it more vital for SEAFDEC to intensify its regional program on the conservation and management of sea turtles to protect the sea turtle resource. Under the Japanese Trust Fund IV Program, regional tagging and satellite tracking activities are also being conducted by the MFRDMD. These activities aim to determine the migration routes, foraging habitat and as well as mitigate the impacts from fishing activities occurring in particular areas of the region. Under the Japanese Trust Fund V Program, MFRDMD will conduct research on management and protection the foraging habitats of sea turtles in the region. Taken together, all these activities should be appropriately supported as these are mutually important for the success of the sea turtle conservation and enhancement efforts in the Southeast Asian region.

Suggested Further Readings

Ahmad, A., Ku Kassim, K.Y., Zulkifli, T., Mahyam, M.I., and Salahuddin, A.R. 2006. A Guide for Tagging Sea Turtles in the Southeast Asian Region, SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia; 62 pp.

Ahmad, A., Zulkifli, T., Mahyam, M.I., Salahuddin, A.R.,and Nor Azam, Z. 2004. A Guide to Set and Manage Sea Turtle Hatcheries in the Southeast Asian Region, SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia; 60 pp.

Conceptual Framework on Cloning of Sea Turtles, SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia

Master Plan: Cloning of Sea Turtles, SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia

Mitigation of Fishery-Sea Turtles Interactions: Efficiency of the Circle Hook in Comparison with J-hook in Longline Fishery, SEAFDEC Training Department, Samut Prakan, Thailand

SEAFDEC Annual Report 2006

SEAFDEC Annual Report 2007

SEAFDEC MFRDMD/RM/11. June 2004. Report of the Regional Technical Consultation on Management and Conservation of Sea Turtles (Kuala Lumpur, Malaysia, 16-18 September 2003), SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia; 137 pp.

SEAFDEC MFRDMD/RM/20. August 2006. Report of the Planning Meeting by Experts on the Research for Stock Enhancement of Sea Turtles (Shah Alam, Malaysia, 21-22 December 2004), SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia; 10 pp.

SEAFDEC MFRDMD/RM/21. August 2006. Report of the Regional Technical Consultation on the Finalization of the Implementation Plan on Research for Stock Enhancement of Sea Turtles (Kuala Terengganu, Malaysia, 25-26 April 2005), SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia; 15 pp.

SEAFDEC-MFRDMD Highlights 2006

SEAFDEC-MFRDMD/DPPSPH Highlights 2007

Syed, A., Zulkifli, T., Wahidah, M.A., Yosni, B., and Rosdi, M.N. 2006. Standard Operating Procedure: Sampling Tissue of Sea Turtles in the Southeast Asian Region, SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia; 12 pp.

Zulkifli, T., Ahmad, A., Ku Kassim, K.Y., and Mahyam, M.I. (Editors). 2004. Conservation and Enhancement of Sea Turtles in the Southeast Asian Region, SEAFDEC-MFRDMD, Kuala Terengganu, Malaysia; 141 pp.

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